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| D2.3: Guidelines for the Design of Empathic Products |

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# Executive summary

This document, the Guidelines for the Design of Empathic Product, presents a synthesis of lessons learnt during the Empathic Products project in form of design guidelines, supplemented by relevant background information from scientific literature. It is based on a collection of experiences from practical cases of designing empathic products. The cases have been carried out in Empathic Products ITEA2 project during years 2013 – 2015. The practical experiences and other input were collected from the whole project consortium in workshops, by interviews of case leaders and other persons, and through other personal communications and feedback during the preparation of the document.

# Introduction

The Guidelines for the Design of Empathic Products (the Guidelines for short) is a collection of experiences from practical cases designing empathic products. The cases have been carried out in Empathic Products ITEA2 project during years 2013 – 2015.

The document makes use of the relevant knowledge and experiences accumulated during the project and in the different cycle cases. Contributions from the whole Empathic Products consortium are included. Partners have contributed by sharing various kinds of lessons learned in the cycle cases, for example, or providing other kinds of insights and examples, as well as technological or user experience expertise relevant to the design of empathic products.

The aim of this document is to provide practical guidelines that can be used as a reference in all stages of the design of different types of empathic products, from concept creation to testing and validation. The guidelines are based on underlying theoretical concepts where applicable; references to these theoretical foundations (e.g. from the field of psychology) are provided where considered useful but the emphasis is on methods, processes, approaches, and advice relevant to the design of empathic products in practice. A reader interested in a set of concise design guidelines is adviced to skip directly to chapter 7 in which a synthesis of the aspects discussed in earlier chapters is provided.

**This document presents a synthesis of lessons learnt during the Empathic Products project in form of practical design guidelines.** Throughout the chapters of this text we bring up and summarize practical designs guidelines and other points relevant to the topic being discussed in the main text in boxes such as this one.

# What is an empathic product?

## Definitions and background

Empathy is something that is typically found in smooth and successful interaction between two or more persons, in various kinds of social interaction situations. Technological advances allow us to introduce an increasing degree of empathy into different types of digital products and services, leading to the concept of empathic products.

As it turns out, empathic qualities and features may come in many different forms in different application domains, making it somewhat challenging to give a single general definition of an empathic product that would be both exact and universally applicable – a definition that could be used in deciding whether a given product or service is empathic or not. While such a canonical definition may not be strictly necessary in order to successfully introduce empathic features into products, we find it useful to start by introducing and discussing some definitions related to empathic products, for a couple of practical reasons. Defining things allows us to discuss and think about them clearly, concisely, and analytically. Talking about definitions has the potential to make us think about the concept of empathic products in more depth and from a wider perspective, increasing our understanding of the concepts and challenges involved in their design and development, and inspiring us to think of new possibilities for introducing empathy into products, now and farther in the future.

Let us first look into the concept of empathy:

*Empathy is the intellectual identification of the thoughts, feelings, or state of another person and the capacity to understand another person's point of view or the result of such understanding*. (Wiktionary)

Referring to this definition of empathy, could we define an empathic product simply as a product capable of having empathy for the user? But what would the equivalent of human empathy be in a technological system, in an empathic product? The “intellectual identification” in the above definition would perhaps suggest that some degree of artificial intelligence is required from a technical system aspiring to be empathic. Foregoing detailed discussion of what constitutes artificial intelligence, we point out that one does not necessarily need to design an intelligent machine or digital system with human-level perceptual and reasoning capabilities in order to design products that have useful empathic features.

While systems with high level of social intelligence in their interactions with their human users are a worthy long-term goal, current technology already enables implementation of different kinds of features that can be seen to introduce a degree of empathy into products and services. Again referring back to the empathy in conventional human-to-human interaction, we note that the information we need in order to be empathic is related to the other person’s state, and especially his/her state of mind (feelings and thoughts). So the capacity for gaining some kind of information about a person’s feelings and thoughts seems to be a precursor, a necessary requirement to being empathic. Based on this we can sketch a partial definition and say that *empathic products are aware of the user’s emotional state and of the user’s intentions*.

But what do the empathic products do with the information about the user’s intentions and emotional state? This has to do with *the result of such understanding* hinted at in the definition of empathy above. Often empathy is understood to imply not only understanding another person’s point of view but also being able to take that point of view into account when dealing with the person, helping the person to reach his current goal and resulting in smooth and successful interaction between persons. Successful social interaction translates to positive user experience in the world of human-technology interactions. So, incorporating the assumption that we want to use the awareness of the user’s emotions and intentions for the good of the user, we can give the following definition for empathic products:

*Empathic products are aware of the user’s emotional state, and user’s intentions. They assist the user to accomplish objectives by taking emotion and intention into account, and they actively seek to affect the user experience positively.*

While we choose to emphasize the significance of positive user experiences and the perceived value to the end-user, we note that empathy does not always necessarily imply being sympathetic to or compassionate about the needs and goals of the end-user: information of users’ emotions and intentions can be seen to have many kinds of uses to different stakeholders in the value chain of a given service or product, some of them not necessarily beneficial or immediately apparent to the persons engaged in interaction with or being observed by emotion-aware or intention-aware systems. We further examine this perspective in chapters 3 and 4 on user experiences and ethical considerations.

Calco and Peters (2014) devote a chapter of their book Positive Computing to the concept of empathy, and provide further useful perspectives to empathy in relation to technology. They cite the Social Work Dictionary (Barker, 2008) where empathy is defined as follows:

*[Empathy is] the act of perceiving, understanding, experiencing, and responding to the emotional state and ideas of another person*.

Calco and Peters (ibid.) note how this definition reveals that there are both cognitive and affective sides of empathy. *Cognitive empathy*, a “theory of mind”, is the (human) ability to recognize emotions and intentions in others. *Affective empathy* is described as the (human) ability to share the feelings of others and to react with appropriate emotion to what someone else is feeling or thinking.

The human ability of cognitive empathy is a capability that empathic products seek to have to some degree. Full-fledged affective empathy, reacting emotionally and actually *feeling* what the user feels, remains in the realm of science fiction and beyond the capabilities of empathic products in the foreseeable future. However, expression of emotions may have a role, even a central role, in some empathic products (but may be useless, or even harmful or at least risky, in others). Typically empathic products, while clearly not experiencing emotions themselves, and not always expressing emotions as such, do seek to respond appropriately to the emotions and intentions that they have detected in the user. They may directly steer their actions based on the inferred state of the user, or they may provide information, perhaps to another person, in a manner that eventually benefits the user and allows their experience to be improved – the former conforms with the idea of empathic products as interactive systems that both observe the users and respond to them, while the latter suggests a looser interpretation of empathic products as systems that use their awareness of the users to benefit the users in less direct ways. Let us note here that even when the system does not directly respond to the user, some kind of feedback loop that seeks to (positively) affect the user’s state can be found in practically all products that we consider to be empathic, even though the time scale of this feedback may be longer and the systems may involve other persons to “close the loop”, to provide feedback to the user. (Advanced surveillance systems with emotion or intention detection features are not empathic products in this sense.)

A lot of aspects has been touched above that will be discussed in the following sections on the features and categories of empathic products, and be made more concrete in the later chapters. These include the feedback loop, and also the definition of the user, which may not always be so clear in the case of empathic products. In this section we have for convenience talked generically of users, implying them to be end-users of different kinds of empathic systems, but it turns out that many empathic systems can have a number of users that can be considered to be “using” the product or service from different perspectives, as well as other stakeholders. Also, instead of a single user, an empathic systems may deal with emotions or intentions of larger audiences.

Regarding the concept of responding to the user’s emotions or intentions, let us further note here that while expressions of emotions by an empathic product are not always required or even advisable, another thing that we will return to later in the text is the aspect that it is useful if it is intuitively apparent to the user that the empathic system, indeed, is aware of their emotions or intentions. Adding this notion to the above discussion, we can write another version of the definition of empathic product:

*An empathic product is a product that is aware of the user’s or audience’s emotional or intentional state, without being explicitly instructed, and uses this awareness to steer decisions and actions, and creates an environment of perceived awareness.*

This definition puts emphasis on somewhat different things than the first definition but is not contradictory to it, rather providing a slightly different perspective to empathic products. Here we specifically emphasize the fact that an empathic product has the means (through sensing and observation and modelling, as will be discussed later) to become aware of the user’s emotions or intentions without explicit outside instructions. Thus a social media application asking for and displaying the user’s current mood is not an empathic product in this sense; these would fit in a wider category of “emotional products”, together with empathic and other products dealing with emotions.

The definition also mentions “creating an environment of perceived awareness”, referring generally to the potential of empathic products to induce in users the feeling that the system seeks to understand them and sympathizes with their feelings and goals. This relates to many aspects of empathic interaction, and how emotions and intentions are communicated and expressed in empathic products. It also has to do with giving the user an appropriate idea about the capabilities of the system they are interacting with. While building a product that responds emotionally to the user is difficult to do convincingly and is rife with potential user experience problems, appropriately implemented empathic interaction can be a big part of the success of the product: instead of a technical system that coldly observes the behaviour of the user, for seemingly hidden purposes, the product can, through empathic interaction, let the user know that it is making an effort to better understand and help them. Feeling of being understood is often a central aspect of enjoyable experiences in general, as in being given what you wanted and needed without having to ask, and empathic products have potential to introduce more of that into interactions with users.

In the second definition we also switched from “aware of user’s emotions *and* intentions” to “aware of user’s emotions *or* intentions”. While empathic products could to some degree be aware of (some) emotional states *and* intentions of the user, one should bear in mind that at the current level of technology we are still very far indeed from having anything even approaching a complete picture of the content of the user’s consciousness. In practical applications the key is often to find emotions and intentions that are relevant in a specific context and that can be recognized with reasonable accuracy, in order to take actions that help or support the user and improve the user experience.

While in this document we choose to limit the discussion on scientific background in favour of focusing more on practical guidelines, it is useful to provide a brief general background of how the concept of empathic products relates to and makes use of the developments in certain key disciplines.

The technologies and methods used in empathic products largely come from the field of *affective computing*. Affective computing is an interdisciplinary field, spanning computer sciences, cognitive science, and different branches of psychology, and is concerned with studying and developing systems and devices that can recognize, interpret, process, and simulate human *affects* (that is, moods and emotions) (Jianhua Tao and Tieniu Tan, 2005). The Affective Computing project was a pioneering attempt to address human emotions in human-computer interaction, introducing affective computing as computing that relates to, arises from, or influences emotions (Picard, 1995, 1997). Affective computing brought attention to the significance of affect and emotions in human-computer interaction in contrast to the conventional emphasis on tasks and efficiency in the field of usability. According to Hassenzahl (2006) the affective computing field predominantly, at least in those earlier days, depicted humans interacting with technology as having mostly negative emotions, and focused on detecting and undoing the negative emotions of irritated users of interactive technology. The user experience research, looking at the things from the user perspective and seeking to improve the design of products from that point of view, focuses on positive emotional outcomes such as joy, fun, and pride, as well as providing value to the user. Empathic products can be said to use affective computing technologies to improve user experience.

Another related discipline is artificial intelligence, defined as the study and design of “intelligent agents”. One type of intelligence that these agents are envisioned as having, is social intelligence, which can be described as capability for handling emotions and having a degree of social skills (Minsky, 2006). Such a socially intelligent agent is able to predict the actions of others by understanding their motives and emotional states, which involves perceptual skills to detect emotions and the ability to model human emotions. A socially intelligent machine could also display emotions (even if it does not actually experience them itself) in order to appear sensitive to the emotional dynamics of human interaction.

The concepts of intention and emotion awareness, central to empathic products, can also be seen as belonging to the wider concept of *context awareness*. The urge to understand more about the user and his/her context started with the ubiquitous computing vision that placed abundant technology in user’s everyday environment (Weiser, 1991). Context awareness was first defined by Shilit and further developed by Dey and others (Schilit, 1994; Dey, 2001). Initial definitions focussed on the situation of an entity, where the user’s context (or the context of the devices carried by the user) was mostly the focus of the attention. Context was understood to include location, identity, activity and time, but more recently the viewpoint has shifted towards a notion of the user being part of a process or ecology, as exemplified by ambient intelligence. Ambient intelligence refers to a vision in which devices interact to support people in carrying out their everyday life activities and tasks in a natural way using information and intelligence that is hidden in this network of interconnected devices. In the context of ambient intelligence and context awareness emotions and intentions of the user can be seen as additional types of context information, that can be used, in conjunction with other context information, to support users in their activities.

Another branch of context awareness research has concentrated on *activity analysis*. Most prominently this has been done for mobile devices and for smart environments. Activities of the mobile user can be derived by combining sensory information from the mobile phone with general knowledge about the user. Thus motion sensors give clues about the type of motion of the user (at rest, walking, running, walking steps, driving a car, etc.) and the situation (indoors, outdoors, noisy or light/dark environment, in a meeting with (known) people, etc.). This research relies on sensor data processing, merging, classification and reasoning. Research in smart environments is often related to ambient assisted living and attempts to derive information about people’s wellbeing (sleeping, awake, daily rhythm, falls, level of general activity) from the various sensors – often including cameras – in a smart environment. The applied technologies are similar, but tend to be computationally more demanding because of the variety of sensors and the computational power available. Knowledge about the activity of a user is a good starting point to detect behavioural patterns and help to assess the stage of the process the user is in. It therefore provides valuable input for intention detection.

## Features and typical usage

As suggested by the discussion in the previous section, empathy in products can come in many forms and be applied in different ways. However, there are certain things that are common to most empathic products. First, as a prerequisite for empathy, the empathic products need to have a capability to *observe* the user. This observation is typically done through *sensing* the user via one or more sensors, of one or more types. For instance, camera-based computer vision systems can provide the basis for observing the user in an empathic system, allowing the system to observe things like facial expressions or body movements. Wearable devices can sense physiological changes (e.g., heart beating faster) as well as movements, microphones can pick up variations in the tone of user’s voice, and so on. The sensing part of an empathic system may consist of a number of different types of sensors and their associated signal processing. In a sub-class of empathic systems, sensorless methods based on observing the user’s interactions with the product or service are used.

In order to achieve an empathic understanding of the user, *the reasoning part* of the empathic system interprets the signals from the sensors through empathic models. These models encapsulate the understanding of how the observations relate to the users’ intentions and emotions, and what is the significance of those observations in the current context, in relation to certain goals for example. In order to properly carry out this reasoning, the reasoning part typically also needs to have a sense of time, and a sense of history, of past experiences and interactions of the user.

The reasoning with the sensor information, making use of models that incorporate assumptions and further information about the user and context, results in refined information concerning the state and context of the user, an improved understanding of the user. This in itself is often valuable information. Typically this improved understanding is used to steer decisions and actions in the system.

Usually an empathic product thus includes an empathic part, which in turn can be seen to be comprised of parts for *sensing*, *reasoning*, and *actuation*. Actuation here refers generally to the means by which the empathic system carries out actions, in response to its understanding of the user’s state and to users actions. This paints a picture of an interactive product or service, with a feedback loop to the user provided by the actuation part, and this is what empathic products often, but not always, are. Taking a wider perspective, in most empathic products some sort of feedback loop can be identified, even if the feedback is not directly from the system to the user. It might involve, as pointed out in section 2.1, other persons to “close the loop”, persons that use the refined information provided by the system for the benefit of the user.

Above we considered the *empathic part* of the empathic product. This highlights the fact that practically always there are other more conventional parts and features in empathic products, apart from the empathic part and the empathic features. An empathic car still has systems for steering and controlling the headlights, for example, which need to be designed. Similarly, the designers and developers of an empathic video conferencing system still need to consider conventional features, such as those related to video coding and transmission.

This suggests that empathic products can have a wide range of uses in different application domains. In the case of interactive services, main motivation for empathic features may be to improve the user’s experience through smoother human-computer interaction, and by providing service that is better tailored to the user’s needs. In other cases the value of empathic features comes from allowing other persons, be they healthcare personnel or entertainment service providers, to better understand the end-users/customers. Generally, empathic features allow the product to better support the user in reaching his goals in the given context. Different application domains of empathic products are further discussed in the following section, and concrete examples are given in chapter 8.

## Classifying empathic products

A number of different criteria can be used in classifying empathic products, such as their application domain, their intended usage, the empathic features that they have, and the technologies they use. In this section we outline different classes of empathic products, and point out some of the implications that the differences between different types of products may have from the product design point of view. These category-specific design aspects are discussed in more detail in later chapters from different perspectives (such as architecture of the product, user experience, and ethical aspects). In this section we focus on establishing the principles and criteria based on which empathic products can be classified into different categories.

Without referring to specific sensing technologies, empathic products can also be classified according to the kinds of user expressions, reactions, or behaviours that they sense in order to detect emotions and intentions. These can be thought of as the modalities that the system uses to detect emotions or intentions:

1. Facial expressions
2. Body expressions (including more coarse-grained approaches like tracking the positions of people in public spaces to more fine-grained detection of things like body postures or hand gestures; in some cases person’s proximity to an object may be a useful indicator of the person’s intentions)
3. Voice, Speech (this refers to *how* the person is speaking, i.e. paralinguistic cues like loudness and pitch of the voice, instead of what is being said)
4. Language (sentiment analysis seeks to detect emotions from spoken or written language)
5. Physiological responses (these can include for example emotion-related changes in the heart rate, perspiration, or electrophysiological signals in the brain)
6. Eye movements (the direction of our gaze is an indicator of our focus of attention, and eye movements as well as pupil size may reveal something about our emotional state)
7. Interaction patterns (this category refers to the instances in which the emotion or intention is detected based on the way in which the person interacts with a product or service; for example, by analysing the dynamics of keystrokes when a person is typing we may infer something about her stress levels – looking at *how* she is writing instead of what is being written)

Empathic systems can also integrate data from multiple modalities. A wide variety of sensor types can be considered for use in empathic products. Camera-based sensing approaches are common, and can provide information on many of the above expression and behaviour modalities, including facial expressions, body expressions, eye movements, and to some extent also physiological responses in some contexts. Proliferation of sensors in public and private spaces, as well as in personal devices, is one of the drivers for empathic products. For example, mobile and wearable devices contain accelometers, heart-rate sensors, and so on, that provide information on the movements and changes in the physiological state of the user. Empathic products can use dedicated sensors, or make use of data from commodity sensors already available in the user’s devices and in his environment. Requirement to invest in expensive sensing technology may be a barrier to the use of an empathic system. Another distinction between different sensing technologies is their different levels of invasiveness. In some cases having to wear a specific device may be considered too invasive and troublesome, while a remote sensing approach can be perceived as less invasive. Sensorless empathic products (relying on the analysis of interaction patterns, for instance, or sentiment analysis of the text written by the user) are a specific category of empathic products.

While discussing ”categories of empathic products” it should be noted that while this Guidelines document looks at products and services from the empathy point of view, in a large portion of cases ”empathic product” itself is not considered to be a product category of its own, especially from the marketing point of view. Rather, as suggested in the previous section, empathic features in a product are just that: features in a product that differentiate it from other non-empathic products in the same category. In this sense empathy in a product is a feature just like color or some technical feature: we may have red cars, cars of other colors, empathic cars, and cars that do not have empathic features, for instance. However, there may well be products where “empathy” *is* a core feature of the product, without which the product would not make much sense. In any case empathy is usually only a part of the product, and there are conventional parts and features included that need to be designed as well using conventional approaches.

In principle almost any interactive product or service, or any product that has a user (as long as the product is not a completely passive component) can be envisioned to be endowed with empathic features. It is useful however, also from the design perspective, to consider empathic products in different application domains. In the Empathic Products project the four following application domains of interest were agreed upon: wellness, marketing, communication, and entertainment. All of the cycle cases of the project, in which different kinds of empathic systems were developed, fit in one of these application domains. All of these domains are quite wide, for example empathic entertainment can be seen to range from home entertainment (such as video games or toys) via mobile entertainenment to amusement parks, for instance. In this project the empathic entertainment cases focused on television. A number of other domains can be thought of where empathic features could be particularly useful: these include education and collaborative working environments. Robotics, in different application areas, is also an interesting domain for empathic features, but it was not included in this project. In chapter 8 concrete examples of empathic products of different categories are given.

# User experience of an empathic product

## Introduction

This chapter gives the necessary background information to understand especially those aspects of user experience that are specific to empathic products. The chapter draws from the existing information in the fields such as psychology and user experience design but emphasizes the practical implications to the design of the empathic products, keeping the theoretical aspects in the background.

It should be noted that in this chapter we approach emotions, intentions, and experiences more generally from the perspective of psychology, looking at things from the user-side. In chapter 6, in contrast, we consider the same things from the computer side, looking at how emotions or other states of the user might be recognised and classified. While in this chapter we are concerned with psychological theories and models of emotions (among other aspects of user experience), in chapter 6 we look at how computational models based on those theories can be used in inferring the emotional state of the user.

Before proceeding with this chapter, let us briefly return to definitions, namely that of user experience. In the recent years, user experience (UX) has received a lot of attention in human-computer interaction, and also in many other fields. A quick look at the literature yields dozens of more or less different definitions for user experience, the perspective varying depending on the application area and the goals that one has for examining user experience. For our purposes here, taking a wide generic perspective, we can first simply define experience as referring to everything a person thinks and feels in a given situation. Actually, everything we *ever* sense, perceive, think, and feel is an experience. User experience is then simply comprised of all the thoughts and feelings that a person has in the context of using a given product. Widening the perspective further, all thoughts and feelings that the person, the user, associates with the product, whether it is when contemplating the idea of buying the product, or when anticipating a product that does not even exist yet, or after having used a product for years, can be considered to be part of user experience. User experience may just as well be thought of in the context of services, users do not need physical products for experiencing. Clearly, user experience is subjective and dynamic: it is different from person to person and varies with time for all users, during one instance of using a product, and over days, months, and possibly years of using a product.

As hinted by the abovementioned multitude of definitions for user experience, multiple efforts have been taken in both technical and user oriented research fields to understand user experience and to take it into account in the design process. These different approaches often share many similarities, while still being completely separate from one another. We refer the interested reader to Geerts et al. for a view that relates user experience to the concept Quality of Experience (QoE) and that includes also the experience before and after using a product or service. They identify some major technical components that can influence the QoE as well as methods that can be used to assess the quality of experience. We return to different approaches to evaluating and designing for user experience in section 3.6.

Conventional usability is an important part of user experience. Usability problems prevent good user experiences. Good usability is about getting the users past the technology and allowing them to focus on what they want to do or accomplish, making the process as transparent as possible. Your word processor freezing, or your pencil breaking, is bad usability because it takes your attention away from what you want to do, organizing your thoughts and finding words and sentences to express them, and into the tools you are using. However, central to the concept of user experience is the idea that there is more to it than usability attributes: in addition to those user experience encompasses value to the user and emotional impact, including things such as joy of using, aesthetics, motivation and the perceived value in using the product. Some practioners also consider social and cultural interactions in the context of user experience.

The aforementioned aspects can be thought of as different dimensions of user experience. In case of empathic products the user experience aspect gets really interesting since by definition empathic products are aware of some dimensions of user experience, essentially allowing the product to observe the user experience, or at least to get an occasional glimpse of it, as it unfolds during the interaction between the product and the user, and possibly to take actions in an effort to adaptively shape the user experience. We return to special aspects of the user experience of empathic products in section 3.4. Before that, in section 3.2 we discuss emotions and related psychological concepts; these are psychological dimensions that can be used in describing the emotional impact side of user experience, what it feels like to use a product or service. Section 3.3 continues with a discussion of the different modalities of expressing emotions, such as facial expressions and body movements or postures. These expressions of emotions, and intentions, allow empathic products to recognize them and reason with them; this is the focus of chapter 6. Not all ways of sensing and observing emotions and intentions are related to psychological dimensions discussed in this chapter, though.

After discussing the special aspects of the user experience of empathic products in section 3.4, we continue with the acceptance of emotion sensing products in section 3.5, considering in the light of our experiences and other information how different features and design choices of empathic product may impact their acceptance among potential users.

Section 3.6 concludes this chapter with discussion on aspects related to analysing the user experience of empathic products and approaches to designing for the user experience. User experience evaluation is a part of validating an empathic product. In the case of empathic products, different psychometric measures associated with user experience measurement have the further relevance in that they offer different ways to assess the reliability and validity of the emotion sensing part of empathic products (specifically convergent validity, which refers to the case of different measures being consistent with one another, increasing the confidence that the sensing part measures the emotion that it is meant to measure).

Returning one more time to the definition of user experience, we note that while user experience is at the core an experience of the user, from the design perspective it is a useful practice to think of the user experience as being evoked by the product. Indeed, we often talk simply about a product’s user experience when referring to the kind of experiences the product evokes in users. The term experience design is also regularly used, referring to the thinking that what ultimately matters in products is the experience they provide and that the desired kind of user experience should be our overall design goal. Some people contest the claim that it is possible to actually design an experience, emphasizing the fact that neither the product itself nor it’s design determines the user experience. Clearly, two persons using the same product in identical contexts may well have totally different experiences (due to their different current desires and moods, as well as their different personalities and skills, for instance), and so will one person using the product at different times, in different context. So, strictly speaking, by having designed a product, we cannot claim to have designed an experience. Here we acknowledge that when speaking about designing *for* the user experience, we seek to understand the desires and experiences of our users and the implications of our design choices for those experiences. We aim at designing our products so as to evoke desired kinds of experiences and to provide value for the user. Sensing and observing the users opens further possibilities for being empathic to the emotions and intentions of the users, better understanding and consequently improving their experiences.

## Psychological dimensions of subjective experience

### Emotions

Emotions are a powerful force influencing the behaviour of humans as well as several other species (Plutchik, 2002), and as such, they are assumed to be strongly involved also in human-technology interaction and in user experiences. Although the concept of emotion appears to be generally understood, it is surprisingly difficult to come up with a simple, solid

definition. In the last 100 years or so, psychologists have offered a variety of definitions,

each focusing on different manifestations or components of the emotion. Although various definitions of emotions have been proposed, most emotion theorists endorse a multi-component view where emotions are constituted by three aspects or components: *subjective feelings* (e.g. feeling amused), *expressive behaviours* (e.g. smiling), and *physiological responses* (e.g. heart pounding); others add *cognitive appraisal* (e.g. “I think that the fact that the train arrives ahead of schedule will help me get home sooner, which is where I very much want to be at the moment.”) and/or *behavioural action tendencies* (e.g. retreating from a fearful situation) as well (e.g., Oatley et al., 2006; Plutchik, 2002).

Dimensional emotion theories hold that subjective emotional experiences can be reduced into a space spanned by a small number of emotional dimensions, such as *valence* and *arousal* (Posner et al., 2005; Russell, 1980). Figure 1 displays such a two-dimensional space schematically. (Helle et al., 2011, Desmet, 2003)

Note that each instrument and method that is claimed to measure emotions in fact

measures one of the above components. As a consequence, both the number of reported

instruments and the diversity in approaches to measure emotions is large, a fact that is of considerable relevance to the development and validation of empathic products.

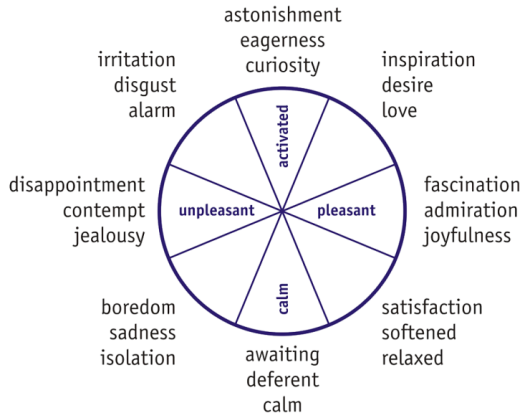


Figure 1. Different emotional responses (adapted from Desmet (2007))

The valence dimension reflects the degree to which an emotional experience is negative (unpleasant) or positive (pleasant), whereas the arousal dimension indicates the level of activation associated with the emotional experience ranging from very calm or sleepy to very excited or energized. It has been suggested that together the valence and arousal dimensions constitute the *core affect*, an ever-present emotional state underlying one’s consciousness (Russell, 2003).

More recent works have suggested that instead of a single continuous dimension, the positive and negative valences should be considered as two independent dimensions (Cacioppo, Gardner, & Berntson, 1999). Additionally, other theorists have suggested that the two main, orthogonal dimensions of emotional experience are negative activation (NA) and positive activation (PA) that represent a 45° rotation of the valence and arousal axes as illustrated in Figure 2 (Watson & Tellegen, 1985; Watson et al., 1999). The NA axis extends from highly arousing negative emotion (e.g., fear, anger) on one end to low-arousal positive emotion (e.g., pleasant relaxation) on the other, while the PA axis extends from highly arousing positive emotion (e.g., joy, enthusiasm) to low-arousal negative emotion (e.g., depressed affect, boredom). The PA and NA dimensions have been paralleled with biological approach and withdrawal motivations, respectively (e.g., Wattson et al., 1999). From the computational perspective, discussed further in chapter 6, the unrotated valence and arousal dimensions likely lend themselves better for use in representing emotions in empathic products.

Sometimes a third dimension is added to represent the core affect. This third dimension allows one to differentiate between emotional states that share the same levels of valence and arousal (for example, anger and fear are both characterized by high arousal and negative valence). This third dimension is typically called *dominance* (sometimes stance), and at the opposite end of the dominance axis one finds submissive emotional states. To continue with the above example, anger is a high dominance emotional state, while fear is characterized by submissiveness (low dominance). The three-dimensional space spanned by the valence, arousal, and dominance dimensions is often referred to as the PAD space, for the initial letter of each dimension label (pleasure being used as a synonym for valence here). (Mehrabian, 1995, Lisetti & Hudlicka, 2015)

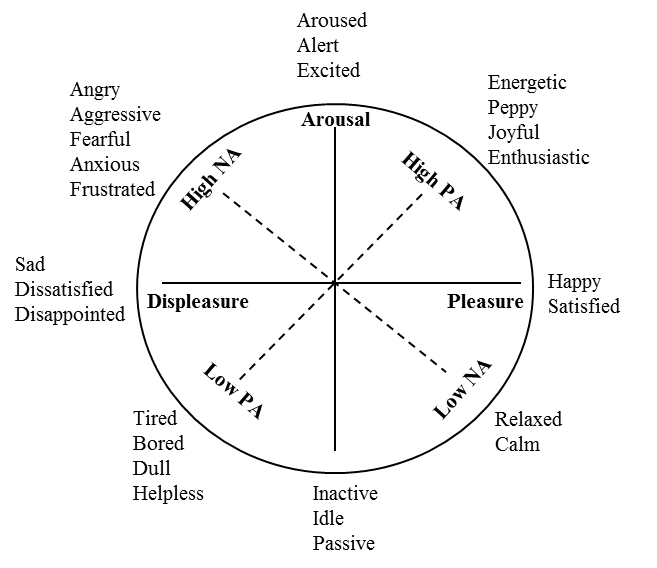


Figure 2. : Positive and Negative Activation abbreviated as PA and NA, respectively, are mapped on a Valence-Arousal two-dimensional map of affect (adapted from Larsen & Diener (1992) and Watson, Wiese, Vaidya, & Tellegen (1999))

Figure 3 shows a number of distinct *emotion categories* overlaid on a diagram that can be taken to depict a two-dimensional space of emotions. Since Darwin’s evolutionary views on emotions there have been theories of certain basic emotions and corresponding brain regions that have been thought to be specialized in producing the given emotion and calling into readiness certain evolutionary successful action plans – action tendencies that have better promoted the surviva and well-being of an individual than some alternative kinds of reactions. While modern neuroscience does not support the idea of localized emotion modules in the brain as such. For example, amygdala has traditionally been called the “fear center” of brain, but has later been found to be involved in other emotions and mental processes as well. It seems that certain networks of neurons, comprised of regions from different parts of the brain working in synchrony may well represent “neural blueprints” of different emotions, different activation patterns forming neural correlates of distinct emotional states and associated subjective feelings. The idea of distinct emotion categories fits well with our intuitive understanding of emotions resulting from introspection of our own feelings; there are distinct subjective feelings associated with different emotions: it feels certain way to be excited, which is a distinctly different feeling from being sad, frustrated, or satisfied, for example.



Figure 3. An Emotions Color Wheel (adapted from Do2Learn (2011))

As described in section 3.3 below, the notion of basic emotion categories arose from the observation that there seemed to be rather universal unique facial expressions associated with distinct basic emotions. A well-known categorical theory of emotions was proposed by Ekman (1999), who identified seven characteristics that distinguish basic emotions from one another and other affective phenomena: (1) automatic appraisal, (2) distinctive universals in the antecedent events, (3) presence in other primates, (4) quick onset, (5) brief duration (minutes, seconds), (6) unbidden occurrence (involuntary), and (7) distinctive physiology (e.g., autonomic nervous system, facial expressions). He proposed that these characteristics are found in the following 17 basic emotions: amusement, anger, awe, contempt, contentment, disgust, embarrassment, excitement, fear, guilt, interest, pride in achievement, relief, sadness, satisfaction, sensory pleasure, and shame. According to Ekman there are at least six or seven basic emotions with distinctive universal facial expressions: anger, fear, disgust, sadness, happiness, surprise, and contempt (added later). (Lisetti & Hudlicka, 2015)

While the notion of basic emotions is still controversial among psychologists, the idea of emotion categories is certainly useful from the perspective of modelling emotions and related processes in empathic products, as discussed in more detail in chapter 6. It should also be noted that the notion of emotion categories is not necessarily contradictory, and indeed can be complementary to dimensional emotion theories, as also suggested by the above diagrams. As mentioned earlier, the core affect is an ever-present emotional state underlying one’s consciousness and can be understood to refer to the most elementary feelings – the feeling one has about whether one is in a positive or negative state, aroused or relaxed, or in a neutral state. It is useful to make a distinction between this elementary feeling and higher-level emotions. Russell and Barrett (1999) use the term *prototypical emotional episode* for these higher-level, full-blown emotions, to distinguish them from the elementary feelings of core affect. Core affect is always there, can be as free-floating and possibly unconscious as a mood and not directed at anything, but it can also be directed and in the focus of one’s conscious attention when it becomes part of a full-blown emotion, when an emotional episode occurs (these higher level emotions, emotional episodes are *not* always present). (Lisetti & Hudlicka, 2015)

As described in chapter 6, a variety of sensing and analysis methods can be used in an effort to detect either dimensional elementary feelings or higher-level categorical emotions. Depending on the type of the empathic product and the available sensing technology, either one, or both, could be relevant and feasible. For example, heart rate or skin conductance measurements can be used as a basis for detecting variations in arousal level, while analysis of facial expressions by machine vision methods can be used to detect basic emotions such as anger or surprise. Section 3.3 specifically discusses expressions of emotions.

### Cognitive appraisal dimensions

Cognitive appraisal theories describe a mental process where an emotional experience evoked by a situation is based on the person’s (conscious and unconscious) appraisal of an object or event in terms of variables such as how relevant it is to oneself, how it relates to one’s current beliefs (how expected or unexpected the event is) and goals (how desirable or undesirable the event is), how likely the event is to take place, and also the degree to which the person thinks she can avoid an undesirable event or make a desirable event come about, and how she might cope with the consequences of the event. In other words, in appraisal theories emotion arises from patterns of one’s judgements concerning the relationship between events and objects and one’s beliefs, desires, and intentions. These judgments are thought to characterize personally significant events in terms of what are referred to as *appraisal dimensions*, or *appraisal variables*. Appraisal dimensions can include the kinds of variables as mentioned above, including goal relevance, goal congruence, novelty, intrinsic pleasantness, and coping ability.

The relevance of appraisal theories to empathic products comes from the fact that they can provide a psychological basis for understanding and reasoning with emotions and other variables in the specific context of the application, which can be useful in the recognition of emotions, as well as when predicting, or possibly simulating, emotional responses of a given person (or virtual character) to certain stimuli or events. In some cases the empathic product may seek to actively mold the emotional state of the user. Some kind of model is then needed to figure out what kinds of actions would shift the user’s emotional state in the desired manner. Empathic products can also be envisioned that themselves respond emotionally to the user during interaction, although it is very challenging to do this convincingly.

Psychological appraisal theories, though far from comprehensively describing all aspects of emotions, do provide an intuitive framework that explains the fact that the same situation may evoke different emotions (subjective feelings and associated expressions and physiological responses and behaviors) in different persons, and also in the same person at different times. Indeed, emotional response resulting from cognitive appraisal is typically understood to cause the person to adjust her goals, beliefs, and/or desires, resulting in a continuous cognitive appraisal loop in which the both emotional and appraisal dimensions evolve. It is further useful to note that awareness about the intentions of the user, which appears to be a central feature of empathic products along with emotion awareness, can also be considered as being related to the appraisal dimensions.

The most elaborated and systematic, and thus lending itself to use as a basis for computational models, of the modern appraisal theories is perhaps the so-called OCC theory. The acronym comes from the initials of the theorists that proposed it, Ortony, Clore, and Collins (1988). They specify cognitions underlying 11 positive and 11 negative emotions and propose that other emotions are subspecies of these 22 emotions. The common assumption of this and similar process models of appraisal is that appraisal processes can occur in several different modes, particularly as non-automatic and as automatic processes. Non-automatic appraisals can be seen as sort of conscious inferences. Automatic appraisals are assumed to be unconscious and to be triggered fairly directly by the perception of events or objects that elicit them. Automatic appraisals can explain why emotions often rapidly follow their eliciting events. Like other cognitive processes, initially non-automatic conscious appraisals can become automatized as a result of their repeated execution. (Reisenzein, 2015)

**Psychological theories form the basis for computational models and representation of emotions and inform the sensing of and reasoning with emotions and intentions in empathic products.** While the various psychological theories of emotion (and related cognition and behavior) continue to be strongly debated, contested, and modified in the light of new findings from psychology and neuroscience, this does not need to take away from their practical usefulness in informing the development of computational models for empathic products. In fact, It is not necessary for the models to exactly reflect the psychological and biological processes in order for them to be implemented as computational models that can be used in sensing emotions and reasoning with them in empathic products. The specific context of the empathic application determines the perspective to emotions and intentions that is most relevant in that particular case and helps to decide which psychological theories, if any, provide the most useful framework in practice. Some psychological theories provide a relatively straightforward computational implementation and have therefore become quite popular choices. One should be aware, however, that sticking to a given popular model may unnecessarily limit the design of the product.

## Expressions of emotions and intentions

### Facial expressions

There is some evidence that six or seven facial expressions of emotions are universally recognized. While some researchers have challenged this view, the presumed existence of universal expressions for some emotions has been interpreted as an indication that these six emotions are innate to human beings across cultural boundaries. Indeed, Darwin (1872) was the first to scientifically study the emotions: noticing that some facial and body expressions of humans were similar to those of other animals, he concluded that behavioral correlates of emotional experience were the result of evolutionary processes (rather than cultural conventions).

As mentioned above, according to Ekman (1972, 1992) there are at least six *basic emotions* with distinct associated facial expression: joy, sadness, anger, disgust, fear, and surprise. When activated by suitable perceptions or appraisals, these inherited “affect programs” are said to generate emotion-specific feelings, physiological reaction patterns, and an involuntary tendency to show a particular facial expression (e.g. smiling in the case of joy). However, this “instinctive” tendency need not result in a facial expression because it can be, and often is, voluntarily controlled in an attempt to comply with social norms that regulate emotional expression (so-called *display rules*).

It is interesting to note here that psychophysiological emotion measures based on measuring the activations of certain facial muscles, typically carried out in laboratory conditions with rather invasive sensing methods (and thus not applicable to practical empathic applications but possibly useful in the validation of the reliability and accuracy of their emotion sensing parts), rely on the assumption that emotional states are reflected in the facial muscles, even if facial expressions are not perceptible by visual observation.

Of the different modalities of expressing emotions, facial expressions have received by far the most attention from researchers. Ekman and Friesen (1978) developed the *Facial Action*

*Coding System* (FACS), in which distinct components of “facial actions” (such as raising the inner brows, or pulling lip corners wider) are observed in order to identify emotions. They identified a set of *action units* (AUs) that identify independent motions of the face. Trained human coders decompose an expression into a set of AUs, and this coding technique has become the leading method for objectively classifying facial expressions in the behavioral sciences. The classified expressions are then linked to the six basic emotions. The Facial Action Coding System and action units are also typically used in automatic recognition of facial expressions of emotions, as discussed in chapter 6. (Calvo, R. A., D'Mello, S., 2010).

Very high correct emotion classification rates have been found in experiments in which human observers have classified photographs of prototypical (acted) facial expressions of basic emotions, typically Ekman’s six basic emotions, into the given emotion categories. It has been argued, however, that the simplified experimental setup in these kinds of experiments makes the observer agreement on expressed emotions artificially high. Observer agreement has been found to decrease with increased cultural distance (Nelson & Russell, 2013). Recent reviews of spontaneous facial expressions of emotions in laboratory experiments (Reisenzein et al., 2013) and naturalistic field studies (Fernández-Dols & Crivelli, 2013) suggest that with the exception of amusement, experiences of basic emotions are accompanied by their presumably characteristic facial expressions only in a minority of cases, and that low emotion intensity and attempts to control facial expressions are not by themselves sufficient to explain the dissociations between the experienced emotions and facial expressions. (Reisenzein, 2015)

**Facial expressions are a natural part of empathic communication between humans and provide useful information on the emotional state of the user.** Psychology supports the everyday observation that facial expressions tell us a lot about the emotional state of the person. However, the assumption of earlier theories that there is an almost direct one-to-one relationship between some of the experienced emotions and accompanying facial expressions is not fully supported by more recent findings. Thus, facial expressions can be considered a potentially useful source of emotion-related information for empathic products in many kinds of contexts but cannot be expected to completely indicate the emotional state of the user in real-world conditions.

### Body expressions

While the number of studies on whole-body expressions of emotions is very small compared to those focusing on facial expressions (likely because the connection appears to be less clear and more context-dependent), body expressions have recently started to receive more attention. Both static (postures) and dynamic (movements) body expressions have been considered as sources of information when humans recognize the emotional states of other persons. Both have been found to provide cues that aid in discriminating between emotions. While there are many factors that determine how emotion is expressed and perceived from body expressions, most of the work in this area has examined cross-cultural differences. For example, in a study of perceiving emotions from whole-body postures of a 3D faceless, cultureless, genderless human-like avatar, similarities were found in the perception of sad/depressed postures among the three cultures (Americans, Japanese, and Sri Lankans) included in the study. (Bianchi-Berthouze & Kleinsmith, 2015)

As an example of body movement cues for emotions, in a study focusing on body expressions of emotions in musicians, the ratings of naïve observers for different emotion categories suggested that anger is indicated by large, fairly fast and jerky movements, while sadness is exhibited by fluid, slow movements (Dahl & Friberg, 2007).

Besides such high-level descriptions of body expressions, low-level descriptions of body configurations have been used to examine which cues allow humans to distinguish between specific emotions. Dael et al. (2012) proposed a body action and posture coding system (BAP) for the description of body expressions at an anatomical, form, and functional level with the aim to increase intercoder reliability for collecting human observations of body expressions.

The perception of emotions based on gait has also been investigated, showing that there are certain primitives in the walking patterns that drive perception of emotions (Roether et al., 2009). Postures have been examined as indicators of active and nonactive emotional and cognitive states, in the context of playing whole-body video games for instance (Kleinsmith et al., 2011). An extended review of body expression features that have been explored and their relation to emotion is provided by Kleinsmith abd Bianchi-Berthouze (2013).

As of yet a system comparable to the Facial Action Coding System does not exist for body expressions, but the research efforts such as those discussed above are building a foundation for such a model and give a basis for automatic recognition of body expressions of emotions and intentions. The research also suggests that even more than in the case of facial expressions, body expressions and their interpretation vary with individual and cultural differences, as well as the context. Indeed, body expressions can provide very useful context-specific information in empathic applications, without requiring complex theories to explain them. For example, hand gestures such as pointing may be very indicative of the current focus of user’s interest and his intentions in the context of a given empathic application. Body movements and postures may also replace speech during dialogue, or when speech is not used at all. They may regulate the flow and rhythm of interaction, maintain attention, and add emphasis or clarity to speech.

### Voice (Paralinguistic features of speech)

Speech is a rich communication medium that is very natural for humans to use in communicating with one another. Speech contains both the explicit linguistic message (*what* is said) and implicit paralinguistic information (emotion, as well as age, and gender of the speaker, for instance) encoded in *how* it is said. While the understanding of the production mechanisms of emotional speech is still evolving, research has shown that emotion information can be expressed and perceived through speech. While there is still ambiguity with respect to how different acoustic features communicate the different emotions, the listeners seem to be able, to some degree, to recognize the basic emotions based on prosody (rhythm, intonation, stress, and related attributes in speech) and nonlinguistic vocalizations (laughs, cries, grunts, sighs, and such). Typical examples of acoustic features of speech include variations in the pitch and intensity of the voice. The most reliable finding is that pitch appears to correlate with arousal. The accuracy of recognizing basic emotions from speech is generally somewhat lower than from facial expressions. Sadness, anger, and fear are the emotions that are best recognized through voice; disgust is the most difficult one to recognize. Beyond basic emotions, speech attributes can also signal emotional states such as stress, depression, boredom, and excitement. (Calvo & D'Mello, 2010; Lee et al., 2015)

### Other modalities of expressing emotions

In addition to the aforementioned modalities for expressing emotions (facial expressions, body movements and postures, and voice), there are other channels of communication in which our emotions may be (implicitly or explicitly, consciouscly or unconsciously) expressed or reflected. Spoken and written language may contain both explicit and implicit messages about our emotional state. In chapter 6 approaches for analysing emotional content of language are briefly discussed along with other ways of sensing emotions and intentions in empathic products. As mentioned earlier, physiological response is also a component of emotion, although not considered an expression in the same way as smiling for instance. Sensing of physiological responses thus provides a possible way for sensing emotions, as also discussed in chapter 6. Rather than as expressions of emotions, psychological responses are considered later in this chapter as measures of user experience (section 3.6.2). When considering human-computer interaction or communication between humans that is mediated by technology, there are aspects of interaction that may signal the user’s emotional state. For instance, dynamics of keystrokes when writing on a computer, or other interaction patterns, may reflect our mental state to some extent.

## Special aspects of the user experience of empathic products

From the perspective of user experience, introducing sensing-based empathy into systems and products represents a fundamental conceptual change. In the conventional, non-empathic products the user experience arises from the interaction of the user with the product or service. It should be stressed that also in the design of conventional products we try to be empathic to the needs and desires of the users. In the spirit of modern user-centric design we try to understand our users and their contexts when using the product, and to design the properties of the product so as to provide the best possible user experiences; this includes being sensitive to the what actually creates the value for the user. The process of designing for the user experience is further discussed in section 3.6. From user’s point of view an empathic product is generally, with some exceptions, an interactive product of one kind or another. Good interaction design calls for careful analysis of users and their respective goals. This understanding is then used to design solutions that satisfy and inspire users, and that also address technical constraints and business goals. Such design practices are recommended for empathic products as well, and indeed there are non-empathic parts in empathic products that need to be designed as well. However, empathy in design does not mean that the product is empathic in the sense that we discussed in chapter 2.

In the case of conventional products user experience is a *goal* of the design (when we choose to design for the user experience). In the case of empathic products user experience is still a goal of the design, but it is also a design parameter. Empathic products are effectively sensing some aspects (some dimensions) of user experience, and taking actions based on what they know of the user experience, sometimes aiming to shift the experience in a certain way. This means that in order to design the empathic part of the product we need to identify the dimensions of the user experience that are relevant in the context of the product usage and that can be sensed and reasoned with in a manner that is conducive to good user experience.

This gives an interesting metalevel to the user experience of empathic products. When considering the overall user experience of an empathic product, that likely involves in some way the user’s perception of interacting with a product that is aware of her experience and is adapting its actions based on that awareness. In other words, the user experience of an empathic product depends partly on the user’s attitude towards having his subjective experience made a variable in the interaction with the product or service (although the user may not consciously think of it in these terms). Next section continues by discussing factors relevant to the acceptance of emotion sensing products among potential users. Analysis of user experiences and designing for them are further discussed in section 3.6.

## Acceptance of emotion sensing products

Empathic features in products and services is something that the users are not used to, although empathic products can in some ways be seen as the next step in a continuum of increasingly context-aware products. Therefor acceptance of empathic products can be expected in some ways to follow common trends of technology acceptance in case of new technologies, but with some special aspects.

A central issue in the acceptance of empathic products concerns how privacy (discussed also in the next chapter) is handled in the design of the product and how it is perceived by the users. On one hand the large masses are silently accepting the fact that more and more information is collected of them. If they see a benefit, an apparently “free” access to a digital service or benefits of a loyalty program for example, many people are quite willing to give access to their private information, without necessarily contemplating or fully understanding the extent to which this information may be used. On the other hand, growing concerns have been expressed about this incremental loss of privacy, and more extensive regulations have been called for. The general sentiment in many regions has appeared to be against public surveillance, safety being on the other side of the argument.

Many empathic products, with their sensing systems, can be perceived as surveillance systems that collect information on people. And indeed this information can be the true value of the system for the actual customer investing in the system, be it a retailer or television broadcaster interested in the experiences and behaviours of the shopgoers or audiences, respectively. This raises the important question of who actually is the user that the system is designed for. The short answer is that both, the user sensed by the system and the user benefiting from empathic analysis, are stakeholders that should be taken into account in the design process. However, it is good to have a clear vision of who the system is ultimately being designed for. This does not imply that other stakeholders should be neglected: if the end-user does not see value in the system for himself he is unlikely to be willing to use it or be engaged by it.

Beyond the basic privacy concerns, what makes empathic products special from the acceptance perspective is the fact that they do not deal with just any kind of private information. They deal with emotions. What could be more personal, more closer to the core of a human being, than her emotions? While there are large differences between individuals, many of us are somewhat reserved about showing our emotions, or at least want to control where, when, and how we display them. A system that shares emotion-related information publicly, or is perceived to do so in a manner that the user perceives to be out of his control, is likely to do face serious acceptance issues.

An important distinction here is between the products that are in public space and those that are in the private space. In private spaces, in contexts such as home entertainment, the user has typically made the voluntary choice of using the empathic product, by buying a video game with advertised empathic features for example. However, the whole context for the experience is very different if a passerby is engaged by an empathic system in a public space: think of an interactive display in a shopping center that uses computer vision methods to recognize the emotional state of the user, for example. In that context, the person may be very reluctant to deal with a system that seems to observe him in ways that he does not completely understand and that might publicly share information of him in unexpected and possibly embarrassing ways.

The perceptions of private space and public space differ between cultures. There are also cultural differences in norms governing acceptability of showing emotions in different kinds of spaces, for example. Developers of empathic applications should be sensitive to how these cultural differences might affect attitudes towards emotion-sensing or other empathic products. There are also considerable individual difference on the attitudes towards empathic interactions that are likely to be reflected in attitudes towards empathic products.

It is important in empathic communication in public spaces to make sure that the contact and possible feedback is not unwanted, to make sure a person is not engaged in interaction against his will. If the contact is not wanted, it should be easy to decline from further interaction. This can be likened to human personnel in a shop politely asking if they can help a customer. Similarly, an empathic system can ask a person “Can I help you?”. If there is an easy way to say “no”, then there should not be a problem of the system appearing to impose itself on the people.

The above example emphasizes the importance of designing the interaction with the user so that it becomes easy for the users to understand what is going on when they interact with the system. User collaboration is also a key requirement for most of non-intrusive sensing technologies. The system should also be sufficiently simple in appearance so as to be easy to understand.

It should also be made clear to persons that any personal information or their interactions with the systems will not be stored or shared publicly. Building trust that the data will not be abused is central in the acceptance of empathic products in all application areas.

Another important point concerning the acceptance of empathic products is that they should be very well tested before bringing them to market. Depending on the application domain and specific use cases, sufficient accuracy and robust handling of incorrect recognitions is often critical for the acceptance of the product. For example, wrong advertisement shown to the user as a result of imperfect recognition is not likely to be a major issue, but wrong directions given to the user as a result of faulty sensing and reasoning, or wrong classification (e.g. sex and age) of the user, are probably not acceptable. However, less than 100% accuracy of recognizing user states or attributes is a fact practically all empathic products have to deal with. This can typically be done through well thought out interaction. Again referring to human to human communication, which is also typically ridden with smaller and larger misunderstandings, an important part of empathic interaction is the chance to smoothly and politely correct the misperceptions of the other side. Empathic products should optimally also provide a channel for corrections, possibly even learning through the interaction. There are practical examples where the user has tried to change her appearance in order to correct, without success, the misclassification of her gender by the system. While funny in this case, incorrectly working empathic products do risk creating negative viral marketing for themselves. It is not too difficult to envision a situation in which emotion recognition and reasoning gone drastically wrong provides juicy material of dysfunctional technology, to be widely shared in social media: imagine an empathic application celebrating the death of the user’s close relative with bright balloons and fireworks. Failure to recognize finer details of the context, such as irony or sarcasm in the sentiment analysis of written text, can easily lead to such mistakes.

In order to avoid and recover from awkward situations resulting from possible incorrect recognition and reasoning, it is useful if the empathic systems have capabilities for self-analysis, allowing the system to detect if it is not working properly and to react accordingly. If suspecting, based on the user’s reactions for example, that it’s current reasoning and subsequent actions are wrong, the system could directly ask the user for more information and/or fall back to a neutral state, possibly informing the user about problems.

A further point that deserves to be mentioned in the context of designing empathic products: users of most kinds of products like to feel that they are in control over what is going on. Thus one should be careful with having empathic products take direct actions based on their interpretation of the user’s state and goals, without asking the user for confirmation. For instance, having an empathic television service automatically changing channels or adjusting volume controls by default is not likely sit well with most users. However, providing useful and tailored options for the user based on refined understanding of his needs may be welcome, as long as the decision is not taken away from the user.

**Think of how to deal with the inaccuracy of detection.** In most practical environments the emotions, intentions, or other attributes of the user can never be expected to be recognized with 100% accuracy. Good design takes this into account: it provides ways for the incorrect interpretations of the user state to be smoothly corrected and it avoids putting the user into uncomfortable situations as a result of incorrect interpretations.

**Clearly specify who is the user that an empathic product is being designed for.** Often in the expected value chain of empathic products the end-user interacting with the product (for example, a television viewer receiving empathic recommendations or a shopper interacting with an empathic billboard) is not the customer who pays for and/or operates the system, who uses the system in a different sense and for different purposes than the end-user. The requirements and other design implications may be quite different when considered from the perspectives of the end-user or the customer that actually pays for the system. There does not need to be (and usually should not be!) an extremely black-and-white decision to cater only, for instance, to the needs of the paying customer and neglect the perspective of the end-user, but one should be clear in specifying the different stakeholders and how their perspectives will be taken into account in the design process (if at all). It can be a source of considerable confusion during a design process if it is not known to whose needs a specific aspect of the product is being designed and optimized for.

**Provide added value to the end-user.** While the paying customer and the main beneficiary of empathic systems is in some cases a service provider, not the end-user interacting with the empathic product, the end-user experience should not be neglected. It is very important, from the perspective of user acceptance of the product, that the end-users also perceive added value in the empathic product or new empathic features introduced into existing services. If the end-users do not perceive such added value, they have no motivation to use the service or at least they will not be delighted with the product or service, robbing the service provider of their clients or audience, or harming the brand experience they provide.

## Designing for and evaluating the user experience of an empathic product

### Introduction

Designers and developers of empathic products or services can draw inspiration and understanding of users from the fields of psychology and user experience studies, and apply suitable methods for understanding and evaluating the user experience of the empathic products they develop. However, it should be noted that reliable and meaningful user experience evaluation can be a challenging task, and in many cases requires considerable expertise. Here we present a selection of approaches and methods suitable for analysing and designing for the user experience of empathic products, and comment on how they may be applied to the design of empathic products. Many of these approaches can also be used in an agile manner by small teams.

In the previous section on acceptance we already touched on many points that are specific to user experience of empathic products. In the following sub-section we provide an overview of user experience can be taken into account if different phases of the design. These approaches are rather generic, with some additional points added that are specific to empathic products.

In the remaining sub-sections we concentrates on measures of different user experience dimensions. Psychophysiological measures of section 3.6.2 are also relevant from the perspective of sensing emotions (and related states), as discussed in chapter 6. They can also be used in user experience evaluation in controlled conditions. This just highlights the fact that in essence empathic products are evaluating user experience (some aspects of it) on the fly.

### Overview of user experience methods applicable in different design phases

While comprehensive description or even exhaustive listing of various UX methods is beyond the scope of this text, as a generic basis for thinking of how to approach user experience when designing empathic products, we provide here a glimpse of methods that can be used in various design phases in order to improve the UX of various kinds of products and services (adapted from Roto et al. (2014)). Hartson & Pyla (2012), among others, provide detailed and practical descriptions of this kind of approach and applicable methods. Examples of applicable methods are listed in various design phases as pointers for the readers interested in finding additional information. The methods are also discussed later in this section.

1. Gain insight

Start with background studies. Gain insights into what kind of user experience is appreciated by your target audience.

Examples of applicable methods:

* Field visits
  + Experiential Contextual Inquiry
  + Behaviour observation
* Interviews
* User experience literature

1. Set UX goals

Based on the background studies, set 1 to 4 high-level UX goals. UX goals help in communicating the experiential aims between the design team and other stakeholders. In order to design for a specific kind of user experience, you need concrete and focused UX goals. High-level UX goals are elaborated to design implications and further to functional requirements and measureable UX targets.

1. Design implications

Use the UX goals in ideation of a new product or service concept. Consider their implications for the design.

Examples of applicable methods:

* Role playing
* Design probes
* Co-design workshops

1. UX targets

Once you have a better idea of the design, more specific targets can be defined. UX targets are measureable and are used in evaluations throughout the development process.

1. Concept design

In the concept design phase, you design the interaction, product features, and the appearance based on UX goals.

1. Evaluation

In order to get the design right, an iterative design + evaluation cycle is needed. UX targets can be used to see whether the UX design is going in the right direction.

Examples of applicable methods:

* UX expert evaluations
* AXE
* UX questionnaires
  + AttrakDiff
  + PreMo
  + PANAS

1. Implementation

Implementation and UX testing is an iterative process as well. Sometimes you need to reject concepts at the implementation stage and go back to fix the design.

1. Go to market
2. After sales support

Also after the product is out, communication at all points should be in line with the original UX goals.

1. Collect feedback

By studying the current products in use (through UX surveys, for example), you learn about the long-term UX, a factor that has a strong influence on customer loyalty.

While not directly envisioned with empathic products (the kind of emotion/intention aware products that we understand them as here) in mind, the *empathic design* approach contains aspects that seem well suited for making sure that we properly take users into account when designing empathic products, in the initial stages of the process. Empathic design is a design research approach that is directed towards building creative understanding of users and their everyday lives for new product development. The concept of creative understanding involves a rich and empathic “feel” for the user, and the ability to translate this understanding of users’ everyday lives into user-centered products and services (Wright & McCarthy, 2005; Postma et al, 2009. The empathic design approach is considered most valuable in the early stages of new product development (Koskinen & Battarbee, 2003), corresponding to phases 1 to 4 of our UX design phases above, with emphasis being on phase 1. (Postma et al, 2012)

Several authors describe a variety of tools and techniques that are regarded as particularly helpful for promoting understanding of users in design. Kouprie & Sleeswijk Visser (2009) divide these techniques into three main classes: techniques for direct contact between designers and users (research), techniques for communicating findings of user studies to design teams (communication) and techniques for evoking the designer’s own experiences in a domain relevant to the user (ideation).

Direct contact with users is emphasised by many practitioners. Most authors recommend having designers conduct observation studies, e.g. to follow the user in his context (Leonard & Rayport, 1997). Co-creation workshops with researchers and users, preferably with designers present, can assist users to explore and express their contexts of product use. Different types of communication techniques have been proposed when direct contact is not possible, which in practice is often the case for limited resources (e.g. budget and timing). One option is for external researchers to conduct the user study, and interpret and communicate the user data and findings to the design team.

For enhancing empathic communication, raw data (photos of users in their home environment, original quotes in their handwriting, etc.) has been advocated as a way to let designers make personal connections to the users’ experiences (McDonagh-Philp & Bruseberg, 2000; Fulton Suri, 2003a;, Sleeswijk Visser et al., 2005; Sleeswijk Visser & Stappers, 2007.) A growing range of storytelling techniques, including personas, scenarios, storyboards and role-playing, has been developed and applied to help designers appreciate the user experience (Buchenau & Fulton Suri, 2000; Go & Carroll, 2004; van der Lelie, 2005; van der Lugt & Sleeswijk Visser, 2007). (Kouprie & Sleeswijk Visser, 2009.)

Designers can also examine the user’s experience by simulating the user’s

condition. A variety of role-playing techniques has been described under names such as product handling, experience prototyping, bodystorming and informance (Buchenau & Fulton Suri, 2000).With role-playing techniques (Laurel, 2003), the designer takes the perspective of the user, and acts out situations in user’s role. Buchenau and Fulton Suri (2000) refer to exploring new product concepts or interactions with such simulations as experience prototyping. An experience prototype is any kind of representation, in any medium, that is designed to understand, explore or communicate what it might be like to engage with the product, space or system that is being designed. This can be seen as one way of setting the UX goals and exploring their design implications (phase 2 – 3 on the list above). Focusing on situations can bring the designer new ideas, e.g. by wearing a blindfold and going for a walk a designer learns which obstacles you face as a blind person. Then the focus of understanding the user is on behavioural and experiential aspects instead of user characteristics. (Kouprie & Sleeswijk Visser, 2009.)

As apparent by discussion on above paragraphs, there are multiple possible approaches for gaining insights about the users and their contexts, and to build conceptual models describing those. However, often there is big hurdle in creating a link between the insights gained from user research and the actual product design. Storytelling technique based on *scenarios* involving *personas* (prototypical descriptions of users constructed from aggregated data gathered from real and potential users), widely used in interaction design, aims to bridge this gap (Cooper, 2014).

The behaviour patterns that are captured using personas ideally come from actual user research data, from user interviews and firsthand observations for example. Persona goals are constructed from inferences and deductions made by the designer when interpreting this data. Sometimes it is suggested that real users, with their real photos and real behaviors, should be brought deeper into the design process, in the manner of *participatory design*, instead of relying on personas. However, analysing and clustering the behaviors of many people and describing the clusters as personas serves an essential purpose: it allows the designers to separate critical behaviors and needs that are common to a large segment of (potential) users from the idiosyncratic behaviors and needs of individual users (Cooper, 2014). This highlights the wider significance, even if personas and scenarios are not used as such, of being able to identify and describe relevant *user segments*, different groups of users that have needs, attitudes, and values that are different from those of other segments. This allows them to be taken into account more systematically when designing for user experience, instead of struggling with anecdotal, idiosyncratic, and contradictory evidence from individual users.

Persona-based scenarios are concise narrative descriptions of one or more personas using a product or service to achieve specific goals. This allows the design to start from a story describing an ideal experience from the persona’s perspective, focusing on people and how they think and behave, rather than on technology, or business goals. The scenarios are used to extract design requirements (referring here to the personas’ needs, not to features or specifications of the product), which are in turn used to define the product’s fundamental interaction framework (including things such as the layout of the user interface, and functional elements of the product). (Cooper, 2014)

The interaction design concept of personas and scenarios is useful also in the context of empathic products, with empathic features bringing an additional element to the scenarios and interaction frameworks. Interesting and potentially useful adaptations of the scenario approach to the design of empathic products can be thought of. As an example of such modified approach, the empathic product itself can be treated as a persona, allowing the interaction design to be considered from an alternative perspective.

It should be noted, however, that the scenario approach as such does not fully encompass all aspects of user experience, in the wider sense in which we understand it here. In user interface design the term user experience is often used in a narrower sense, to describe the user’s “journey” while interacting with the product, concentrating on her behaviour, not so much on her subjective experience (what it feels like). This can be seen to correspond to what Hassenzahl (2010) describes as the user’s do-goals and motor-goals: do-goals are outcomes that the user wants to or needs to attain (e.g., making a phone call, watching a movie), and motor-goals are the sub-goals, the individual actions the user needs to carry out in order to do so (e.g., pressing the dial button on the phone). Those kinds of do-goals and motor-goals are part of the user experience, but they are not all there is to it. On top of do-goals we can set another level, so-called be-goals. Be-goals (such as “being competent”, “being close to others”, “being autonomous”, and “being stimulated”) motivate action and provide it with meaning, and value from the user’s perspective. Considering also the be-goals, and how the empathic and other features of the product are related to them, allows us to more fully design for the user experience. It can also be argued that the be-goals are more closely connected with emotions than do-goals (this can be considered from the perspective of appraisal theories).

As a practical example of another approach that can be used as a basis for evaluating design concepts, we mention AXE (Anticipated eXperience Evaluation) (Gegner & Runonen, 2012) . AXE is a qualitative method that can be used an initial perspective on the user experience for a product or a service already in the early stages of design. It is a method that involves singular users in an interview setting. The method uses visual stimuli to make evaluation participants imagine a use situation and to reveal their attitudes, use practices and valuations. AXE is both an evaluative method and a method for collecting suggestions for improvement. The results connect perceived product attributes with different dimensions of user experience. There are three major steps in the approach: concept briefing, concept evaluation, and data analysis.

Prior to the evaluation the design team has to define the design targets against which the results should be compared. The establishment of design targets gives the design team a shared understanding of the goals throughout the design stages and the ability to assess whether user’s perception of the concept matches the goals. Typically the concept is conveyed through description and use scenarios. Also mock-ups should be used to clarify and illustrate the concept.

Empathic products are novel and complex. This means that users do not have preconceptions of such products (or such features; as previously discussed, empathic part is typically added to conventional products, giving new features to familiar products, instead of creating a completely new category of products). Still, the challenge remains, that one cannot easily investigate user’s experiences with existing empathic products – they are not likely to have any. It is also a challenge to discuss products with empathic features with users if they do not have a concrete idea of what they may be. Early mockups can be helpful here, but they also face the challenge of giving the user a realistic feel and concrete idea of what the product is about, how empathic interaction could work in practice.

Many kinds of products and services benefit from iterative design and development, allowing their design and user experience to be improved through multiple cycles of testing and improvement. As is the case with other novel and complex products and services, use of iterative design loops is recommended for empathic products as much as feasible, with the feedback from user studies and user experience evaluations used to refine the design. This must be balanced against the fact that reasonably polished implementation is likely required in the case of empathic products in order to get useful feedback. This challenge can be somewhat mitigated by concentrating on testing prototypes that focus on limited aspects of the final product. The main role of prototypes and user experience evaluations in the middle stages of the design process is not to be technology demonstrations showing off as many of the envisioned features of the final product as possible. Instead their intention is to provide information and knowledge to further improve the design, to answer questions that are relevant for the next steps of design.

**Answer design questions with your empathic product protypes and pilots.** In order to get the maximal benefit from the prototypes you build and the piloting you conduct, spend some time to clearly state the questions you want answers for. The answers to these questions allow you to efficiently improve your empathic product and its user experience in the next loop of iterative design. For example, can the system detect the relevant emotions or intentions in real-world environment with sufficient accuracy? Is the empathic interaction approach that you have planned intuitive and fun to the users? Do the new empathic features that you plan to add to the prototype bring added value over existing features (in the current prototype or existing product)? The questions may vary with the design phase and the type of the product, and you may well gain unexpected usefull information, but the risk is that if you don’t know why you are building a specific prototype or running a pilot trial that you may end up wasting your time – instead of getting useful answers to improve your design.

Due to the novelty of methods and technologies involved in empathic products, there is also room and need for technology-push kind of approaches in research and development projects, technological experimentations done in order to get an idea of what kinds of things can be done in practice. These kinds of prototypes can be used as a means for probing the user responses to different aspects of technologies. However, it is likely that one needs to go back to the drawing board to rethink many aspects of the design if one aims for market-ready products.

When carrying out the iterative design-evaluation loops, a number of different kinds of user experience evaluation methods can be used. While useful feedback can be obtained with very small-scale, free-form user tests (e.g. simply asking a couple of persons from outside of the design team to take a moment to sit down and test some aspect of a prototype can give sufficient insights for the design to move forward in an agile manner), one should be aware that the methods one uses to collect and analyse information about user experiences influences reliability and validity of the information.

*Reliability* is related to reproducibility of the measurement and consistency of the data. *Validity* refers to whether the measure actually measures what it is supposed to measure. Validity of measurements can be considered from different perspectives. For example, *convergent validity* refers to the case where the same dimension of user experience (arousal for instance) is measured with a number of different methods (a questionnaire, psychophysiological measurement, and observation of facial expressions, for instance): if all measures agree with one another the convergent validity is high, suggesting that we are indeed measuring arousal. *Environmental validity* is related to the consideration of whether the measurement corresponds sufficiently well with the situation in the relevant environment. Low environmental validity is often a source of concern for laboratory measurements, which may not correspond to the actual experience in the real world, or be relevant in the real use contexts. These concepts are relevant to the validation of sensing methods in empathic products as well.

In the following section we discuss questionnaires as tools for collecting self-reported data from the users concerning emotional impact and other aspects of user experience.

### Questionnaires

In order to properly measure certain emotion-related aspects of user experience, validated questionnaires should be considered. For instance, *Positive Affect Negative Affect Schedule (PANAS)* (Watson et al., 1988) is a validated and well accepted questionnaire for assessing the valence (pleasantness) and the quality of emotion. It consists of 20 emotion adjectives (such as proud, excited, scared, and hostile), ten for positive affect and ten for negative affect. Such self-ratings are the most commonly used measures for emotion-related dimensions of user experience (emotional impact, or hedonic quality, as it is sometimes called). For example, valence and arousal dimensions are routinely measured via graphical or textual Likert scales. Positive and negative activation (PA and NA) are often measured as sum variables of self-rated items such as joyful, enthusiastic and peppy (high PA) or distressed, anxious and fearful (high NA) (e.g., Ravaja 2004b; Watson et al., 1999).

*Self-Assessment Manikin (SAM)* (Bradley & Lang, 1994) is a commonly used graphical instrument for measuring emotional impact. The valence scale consists of nine graphical depictions of human faces ranging from sad to happy expression, whereas arousal scale contains nine graphical characters varying from a calm state to a state of high visceral agitation. SAM is administered during or immediately after user interaction. *PrEmo* (Desmet, 2003) is another example of a graphical instrument that can be used in questionnaires to measure emotions. It uses seven pictorial representations of pleasant emotions and seven of unpleasant emotions.

A common challenge with all emotion measurements collected after usage is that emotions are often fleeting, and it is often difficult to accurately recall the dynamics of an experience afterwards. Somewhat similar challenges are faced in annotating affective states in time-varying data to be used in training image recognition algorithms. Indeed, the dynamic nature of emotions and experiences poses wide-ranging challenges for empathic products.

In cases where no detailed knowledge about the exact emotions is needed, even simpler methods can be used. Latulipe et al. (2011) used the love-hate scale (a single rating on a scale of -50 to +50) and found that this scale provided information about both valence (love versus hate) and arousal (absolute value) during their experiment that let students assess art performance on video. The one-dimensional nature and single question allowed its use while the students were watching video content.

AttrakDiff (Hassenzahl et al., 2003, 2008) is a questionnaire developed for measuring different aspects of user experience. It uses semantic differential scale items anchored at opposite ends by pairs of adjectives such as supporting/obstructing, trustworthy/shady, exciting/dull for evaluationg the so-called pragmatic quality (comprised of perceived usability and usefulness of the product or system) and the hedonic quality (emotional impact). Variations of the AttrakDiff scheme, with the number and content of items adapted to fit different contexts, have been reported (Schrepp et al., 2006; Chorianoipoulos & Spinellis, 2004). When applying AttrakDiff, choices should be made among the different versions of the questionnaire and concerning which items to use, and one should consider if the questionnaire items should be adapted so as to be relevant and easily understood in the particular case.

Indeed, identification of the user experience dimensions that are relevant to the system we are developing is a central question in the concept design, and is something that one should aim to answer in the early stages of the design process. These are related to the higher-level UX goals and the more specific UX targets (indeed, subjective measures of these dimensions might be included within the UX targets, along with objective measures such as number of user errors). Questionnaires in the vein of AttrakDiff can be used to measure these dimensions when evaluating the user experience. This also has a potentially direct and significant bearing on the design of the empathic part of the product, knowledge of the relevant user experience dimensions also informing the decision of what should be sensed: if we can sense information that is related to the relevant user experience dimensions, we are likely many steps closer to being able to use that information for improving the user experience.

It should also be noted that regardless of whether an empathic product deals with emotions as such or not, the emotional impact is a central aspect of user experience in many cases. Therefore measures of emotional impact are still likely to be relevant in the user experience evaluation of such products.

### Psychophysiological measures of emotional impact

#### Introduction

Psychophysiology is a branch of psychology that studies the changes in the activity of the physiological systems caused by the psychological input (Turner 1994). The psychological input can be represented by different cognitive, emotional and behavioural phenomena. These are then studied as to their effects and relationships to physiological systems by observing/measuring, for example, heart rate, electrodermal activity and electroencephalographic activity. Provided that specialized equipment and expertise are available, these types of psychophysiological measurements have been found to yield useful information for assessing user experience in terms of attention and emotion of users. (Helle et al., 2011)

Physiological measures can be used in evaluation of user experience, typically in controlled laboratory conditions. Similar approaches can also be used for sensing the physiological component of emotions in empathic products.

In contrast to users’ self-reports or annotations of emotions, psychophysiological measures may also reveal subtle emotional responses that are not available to conscious awareness. A potential problem with psychophysiological measures is that they may be related also to other psychological constructs than the one that is of interest in the given instance. For example, heart rate can explain both changes in attention and emotion, thus making this measurement difficult to interpret: heart rate accelerates with increasing emotional arousal but is decelerated by attentional engagement. (Helle et al., 2011)

#### Facial electromyography (EMG)

In facial EMG the facial muscle activation level is measured by attaching electrodes on specific facial locations, and which is used frequently as a psychophysiological index of positive and negative valences (P. Lang et al., 1993). There are three muscles whose responses are usually recorded using electromyography: zygomaticus major (lip corner raiser muscle), corrugator supercilii (brow furrower muscle), and the outer region of the orbicularis oculi (cheek raiser muscle).

#### Electroencephalography (EEG)

EEG is based on the recording of the electrical activity of the brain with electrodes placed in a special cap (2-256 electrodes). The EEG data are typically analyzed using spectral analysis. One of the most important indices derived from EEG data is brain prefrontal asymmetry that has been used to index emotional valence and motivational direction. Accumulated research suggests that relatively greater left frontal cortical activation is associated with positive activation (PA) and approach motivation, whereas relatively greater right frontal activation is associated with negative activation (NA) and withdrawal motivation. In addition, alpha activity has been found to correlate with attention, emotional arousal, interest and recall (Simons et al. 2003). Alpha wave power is defined as the amplitude of brainwaves in the 8-13 Hz frequency band.

#### Electrodermal activity (EDA)

EDA measurement is commonly known as *skin conductance* and it measures changes in the electrical conductance of the skin caused by the level of sweat in the eccrine sweat glands. EDA is frequently monitored to measure the activation of the sympathetic nervous system (Ravaja, 2004). Consequently, EDA is an excellent index for the physiological component of arousal, and it has been shown to correlate with subjective ratings of arousal (P. Lang et al., 1993).

#### Heart rate (HR) and related measures

Heart rate refers to the number of heart beats in a minute (Ravaja, 2004). HR is influenced by both sympathetic and parasympathetic arousal. In order to measure the heartbeats, one can measure the electrical potentials generated by the heart during each cardiac cycle using electrocardiography (ECG). In psychophysiological studies, only the reliable identification of the R peaks on the ECG is usually required which indicates the time when the left ventricle contracts and pump the blood out to the body. The time between R peaks represents the interbeat interval.

Another measure is given by the *heart rate variability* (HRV). Heart rate variability refers to the fluctuations of HR occurring in response to mental or physical demands. Related to stress and mental effort, it is known that if stress and mental effort (e.g., caused by searching information from Internet) increases, then HRV decreases (Tullis and Albert, 2008).

### Behaviour observation in analysing emotional impact

In addition to questionnaires and psychophysiological measures, the emotional impact can be evaluated through observing the behaviour of the users. This can be done in different ways, such as by having experts observe users in natural interaction settings (either live or through recordings) and code the user behaviour according to an appropriate observation scheme. This coding by human observers can include information on expressive behaviour related to the emotional state, such as facial expressions and body postures.

Alternatively or additionally, sensing technologies such as computer vision based systems for automatic analysis of facial expressions can be used when evaluating the emotional impact as a part of user experience study. Similar technologies are used in sensing the state of the user in empathic products. These technologies are described in section 6.2.

**Interdisciplinary teams and generalists with holistics views are valuable in the design of empathic products.** Due to the complexity and novelty of empathic systems, relying only on limited specialists in the design and requirement specification of empathic products is likely to cause difficulties along the way. Generalists with holistic perspective to the system being designed are especially valuable in the case of empathic products. Interdisciplinary design teams are useful, but face the risk that the design process fragments into separate diverging parts that do not properly understand one another and that do not start coming together as a whole – generalists viewing the product and the design process as a whole can ensure that the work done in different phases of the design process serves the common purpose (and that there is a common shared purpose in the first place!) and converges towards the finished product. For example, psychologists and psychological experiments can provide expertise and potentially useful information and insights, but that knowledge will only help the design process if it can be expressed in a manner that can be related to the relevant technical and creative design choices.

# Privacy and Ethical Considerations

## Introduction

In the previous chapter on user experience of empathic products we already examined certain aspects of empathic products that we consider to be relevant to their acceptance among possible users, many of which are related to privacy. In section 4.2 of this chapter we continue and summarize the discussion on privacy, with brief notes concerning the diversity of regulations and legislation and how to approach that. In section 4.3 we briefly consider ethical issues related to empathic products that go beyond privacy.

Detailed philosophical discussion on ethical issues related to sensing emotions is beyond the scope of this text. However, we feel that in a treatise on the design and development of empathic products, one cannot completely bypass ethical issues and privacy. The purpose of this chapter is thus to raise some questions, rather than to provide conclusive answers. We also wish to inspire designers of empathic products to consider privacy and ethical issues during the design process. Indeed, some design choices can have a direct connection to the privacy. Also, there are some rather concrete ethical issues that one can come across when designing, developing, and testing empathic products.

## Privacy

While concerns related to the incremental loss of privacy in the increasingly digital and connected world have recently received growing attention also in the mainstream media, people at large still seem mostly unaware of or indifferent to the development trends that may lead to more blatant exploitation of the users and their private information. The privacy and wider ethical issues are likely to receive growing attention in the future, although it is difficult to predict how the public opinion, as well as regulations and legislation in this area will evolve in different regions. In any case, empathic products in general have certain intrinsic properties that make them prone to be used in ways that can raise concerns for privacy. It is good to be aware of this, and to think of how these concerns might be mitigated through appropriate design choices.

Many empathic products can be seen as surveillance systems. There are rules and regulations in place that govern the use of surveillance systems, concerning for instance whether and how persons should be informed about being observed by surveillance systems, what kind of data can be collected, and how it can be stored, shared, and used. Especially when considering global markets, the diversity of applicable legislation in different regions poses challenges for developers of empathic systems. An approach that works for developers and providers of certain kinds of empathic products and components (e.g. sensing technologies, research tools) is to transfer the responsibility for ensuring that the way in which the technology is used complies with local rules and regulations to the application developer or to the party that applies the system. Also in these cases, it is in the technology provider’s interest to develop technologies that lend themselves to be used in a legal manner as widely as possible, allowing the privacy of the users to be respected while providing useful information. In the case of application and service providers operating at global markets, one simply needs to ensure that the product offered to a given market complies with applicable legislation in that region. This may make it necessary to provide different product versions with different feature sets to different markets.

A significant aspect of empathic products that further emphasizes the concerns about privacy is that they often deal with very sensitive and personal information, such as emotions. Empathic systems also have the means to acquire this information even if the users do not volunteer it.

An important distinction from the perspective of privacy is whether the system is used in public or private space, and whether the user volunteered to use the system or not (think of a person using an empathic learning application or playing a game with empathic features at home, compared to a passerby being observed and engaged by an empathic system at a shopping center or airport). Profiling users can be useful in many ways in each of these cases, in ways that can be considered beneficial to the user, but care is needed in how the information is used. If the user volunteers to use the system and the information (even if sensitive) stays in the user’s own control, there are no obvious problems with privacy (e.g., a profile based on user’s emotional responses, shown to him in the learning application and used to give guidance and adapt the learning environment). Data security can still be an issue in these cases, though, if third parties can gain unauthorized access to the personal data. Further, in networked applications one should make sure that the information is not shared against the user’s wishes or his knowledge, to the other users for instance. This relates to how the observed empathic information is used to portray the user to the other people. One also encounters this portrayal issue in empathic interactions in public spaces: it can be problematic if an interactive display, for instance, observes some sensitive information of the user, and displays it in a way that makes it visible to other persons.

One needs to balance between avoiding collecting sensitive data and obtaining useful data. There are certain general design principles that help in mitigating privacy concerns. The first is to avoid unnecessarily storing personal information, or information from which the user might be identified. For example, in camera-based real-time recognition systems it is not necessary to store the raw data or other information from the which the user might be identified. In the context of a given empathic application, it may be sufficient for smooth empathic interaction that the system knows, based on observations it has done, that it is currently (with some degree of certainty) dealing with a young and confused female, for example. Aggregate statistics of this kind of data can be collected, and can provide added value to different stakeholders, but it is likely not necessary to represent the data so that individual users can be identified. Naturally, on the other side of this consideration is the fact that certain stakeholders would likely benefit from very detailed profiling data of users. Ultimately it is up to persons responsible for legislation to control what can be done. However, we suggest that it is good sense to design empathic products so that the privacy of personal information can be guaranteed as well as possible.

We also note that empathic systems can often be used for collecting other information and used for other funtions than those for which they were primarily designed for. For example, the same system that analyses (and maybe responds) to the length of queues in shops, pharmacies, and such, can rather easily be used to collect statistics on the performance of the shop personnel. Such multipurpose systems can be seen to provide added value to the one who employs them. However, from the perspective of privacy one should ensure that all persons observed by the system are aware of the fact, and have a choice in what kind of information is collected of them.

Another design principle that is meant to ensure the privacy of personal information is to make a strong distinction between data streams, and to have a clear idea of purpose for which they are used. For example, in a mobile application there may be data streams between a server and the mobile client, some of which may not need to leave the mobile device, or the local environment in which it is used, in order for certain empathic functionalities to be implemented. More personal the data is, the more carefully it should be controlled that the data does not travel farther than it needs to.

The system should ensure that the user understands its capabilities for observation. It should also make it clear to the users that their personal information or interactions with the system will not be stored or shared publically.

## Ethical considerations

The proliferation of technological systems able to sense and analyse the emotions of persons with increased accuracy in different contexts, a possible future trend which the concept of empathic products entails, raises ethical concerns that cannot be neglected when thinking about the design, use and marketing of empathic products. Indeed, design choices can be seen to have a rather direct connection to some ethical questions: how the product is designed, what features it has, affects how it is used and how it is perceived.

Already during the design, development, and testing phases, one can come across certain ethical issues. As discussed in chapter 6, data collection is an essential part of developing and tuning the models and classification algorithms, a phase that is usually needed in the design of empathic products and one whose success can be critical from the perspective of the performance and user experience of the product or service. While there can be considerable case-by-case differences in what kind of data is needed, often it is useful to have data from situations in which people express different kinds of emotions – and usually it is beneficial or even necessary that people actually experience emotions, not just fake different types of emotional states. Although use of actors to portray emotions may be useful in some cases, and relatively easy, this kind of acted data may not correspond sufficiently well with natural expressions of emotions, resulting in problems with the ecological validity of the data.

Naturalistic data is ecologically valid, assuming it has been collected in a context relevant to the application being developed, but it is often very laborious to collect. A compromise between the two is the elicitation of specific emotions for the purposes of data collection: for example, putting participants of a laboratory experiment or some other kind of trial in situations in which they are likely to experience and express joy, sadness, anger, or other specific emotions. There are privacy issues involved in how this data is presented (is it made available as a part of public database for other developers, for instance). Beyond the privacy issues, such data collection trials may unwittingly put participants in situations that cause distress. The main advice to conducting data collection from the ethical perspective is to ensure *informed consent* of participants: this involves making sure that the participants understand what they are taking part in, how the obtained information will be used, and that they are doing it of their own choice and that they can interrupt and quit the trial at any point.

Informed consent is a useful concept to keep in mind also when considering the actual users of the system. This implies that the users understand the system’s capabilities and how they are used, are fully aware of the consequences of using the system and accept them. Further ethical issues related to informed consent (or lack of it) and the user’s autonomy arise when one considers how empathic products may influence their users. Due to the fact that emotions are known to have a strong influence on human behaviour, it can be speculated that knowledge of a person’s emotional states gives the system considerable leverage over the behaviour and also thinking of the person. Ideally, the system would use this influence for the benefit of the user, e.g. an empathic wellness application motivating a healthy behaviour change. Even in such cases it can be argued that the user should be fully aware of the kind of control that the system can exert on her.

However, in some cases the benefit for the user may not be so clear, and the value may be for some other stakeholder than the end-user interacting with the system. Examples in the marketing domain come to mind in which the system can be envisioned to aim to influence the user, mainly to serve the purposes of someone else (e.g., the brand owner). After all, this is the purpose of advertising, to influence the product and brand appraisals and purchase decisions of consumers, often through aiming to associate certain positive emotions with the given product or brand. This is a rather well accepted way of marketing products, as long as done according to rules and regulations. However, with improving technologies and new kinds of empathic systems, with access to information on a person’s mental states the power of advertising to influence the person’s perceptions can be seen to increase considerably. For example, assume a highly accurate system that can predict the user’s emotional state for the next two minutes while watching television. How far should this information about the emotional state be exploited (e.g. in advertising)? By adapting the content of advertisements to the emotional state, discreetly teaching the user to associate a certain brand or product with a positive feeling, the system can likely leverage the emotions in a considerably more influential way than conventional advertising. This example leads to the question: Where are the boundaries for systems manipulating people? Current technological level still restricts in practice the degree of influence that such systems can have on people, but this can change in the future with advances in technologies and methods.

While we refrain from taking strict ethical stances on possible future uses of empathic systems, it is hoped that such systems will aim to have a positive influence on the subjective experience of the user, ensure that the system’s capabilities are understood, avoid deceiving the user, and respect his autonomy. The concept of *positive computing* is also worth mentioning here, as a framework that advocates the design and development of technology to support psychological wellbeing and human potential (Calco and Peters, 2014).

*With great power comes great responsibility.* (Voltaire)

# Architecture of an empathic product

## Introduction

In chapter 2 we introduced the concept of empathic products and briefly discussed the common functional parts normally found in them. In this chapter we build on that introduction, and outline a conceptual generic architecture of empathic products. The intent of the conceptual architecture is to direct attention at an appropriate decomposition of the system without delving into the details of interface specification. By focusing on key constructs and abstractions rather than on implementation-specific technical details, conceptual architecture provides a useful vehicle for communicating the architecture and understanding what type of modules are required for creating an emphatic product.

The purpose of this chapter is thus to provide a high-level system view as a reference for thinking of what goes on in an empathic product generally. In this chapter we do not provide design guidelines as such, but it may be useful to refer back to this chapter when related design aspects arise in other chapters. Specifically, section 6.5 looks into design aspects related to the interplay between the different parts of an empathic system. Despite the abstract perspective of this chapter, we do provide some concrete examples to try and link the discussed abstract concepts to practice.

The conceptual architecture diagram presented later in this chapter, in section 5.3, identifies the main system components and interconnections between them as well as different actions related to them. Before looking at this architecture diagram, let us recap and add to the discussion of chapter 2 by taking a high-level abstracted view on what a generic empathic application does, and what are the main functional parts involved.

## High-level abstracted view of empathic products and their main functional parts

Let us first be reminded that, as discussed in chapter 2, empathic features are only a part of the empathic application. Here we concentrate solely on the empathic part, the sub-system in the empathic product that facilitates the empathic features of the product.

The diagrams in Figure 4 provide a high-level abstraction of what goes on in most empathic products. The empathic system in the product observes the state and behaviour of the user or audience. The system is in many cases also aware of and has a degree of influence over the physical stimuli that the user or audience is currently perceiving through their senses. For instance, an empathic television application likely has access to information about, and may even have control over the content shown to the viewer or audience. The system might determine that a middle-aged man is watching financial news in a low-arousal state of mind, possibly bored. Similarly, an empathic billboard in a shopping center knows and is in control over what information is shown to the person and can observe the state and behaviour of the person in relation to what is being shown. For example, the empathic system may have observed that a woman has approached the billboard and has turned her head toward the pictures of hair conditioners shown on the right-hand side of the display, appearing to be both interested in what she is seeing there and confused about what to do. The empathic system often has information of a target state and behaviour of the user or audience as well, and has means to take actions that aim to shift the current observer state and behaviour towards the target. Empathic interaction may involve updating the information on both the observed and target states and behaviours based on the history of interaction over different timeframes. A change of channel might be recommended to the man watching television, more information on hair conditioner selection and directions to the cosmetics department shown to the lady at the billboard.

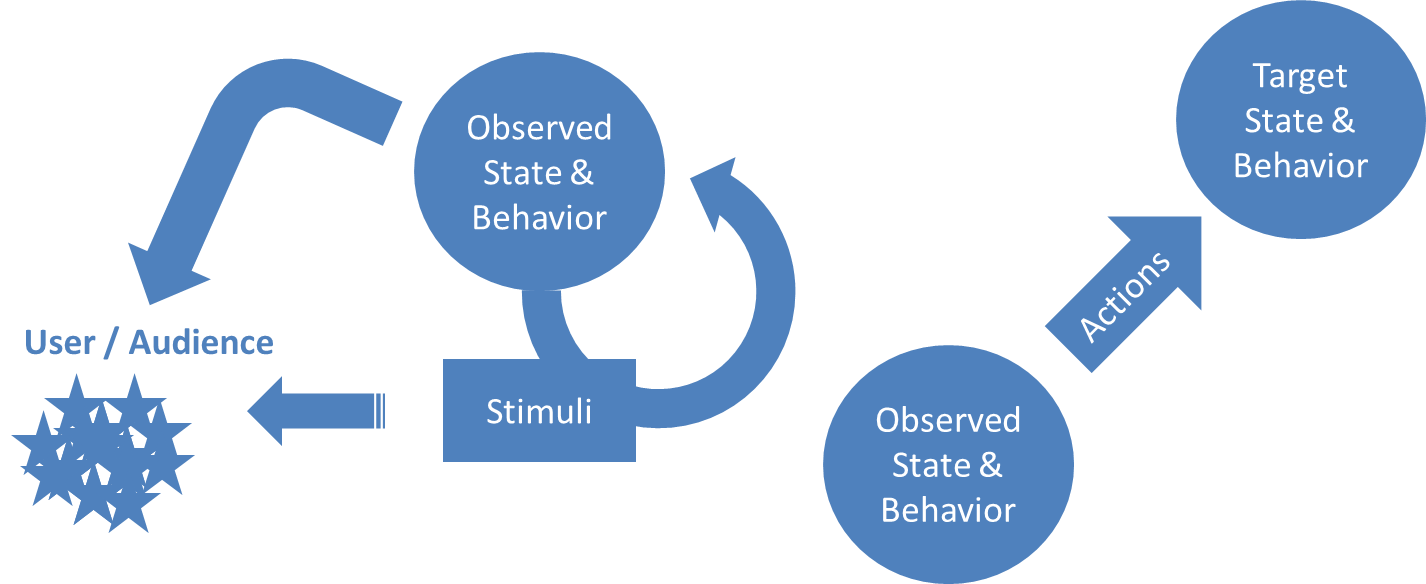


Figure 4. An abstraction of states and actions common to most empathic products

As discussed in chapter 2, observation of the user is typically done through *sensing* the user via one or more sensors, of one or more types. In order to achieve an empathic understanding of the user, *the reasoning part* of the empathic system interprets the signals from the sensors through empathic models. Camera-based computer vision systems can provide the basis for observing the user in an empathic system, allowing the system to observe things like facial expressions or body movements, for instance. Wearable devices can sense physiological changes (e.g., heart beating faster) as well as movements, microphones can pick up variations in the tone of user’s voice, and so on. The reasoning with the sensor information, making use of models that incorporate assumptions and further information about the user and context, results in refined information concerning the state and context of the user, an improved understanding of the user. This in itself is often valuable information. Typically this improved understanding is used to steer decisions and actions in the system, carried out through *the actuation part* of the empathic system. The sensing–reasoning–actuation loop common to most empathic products is depicted in figure 5.

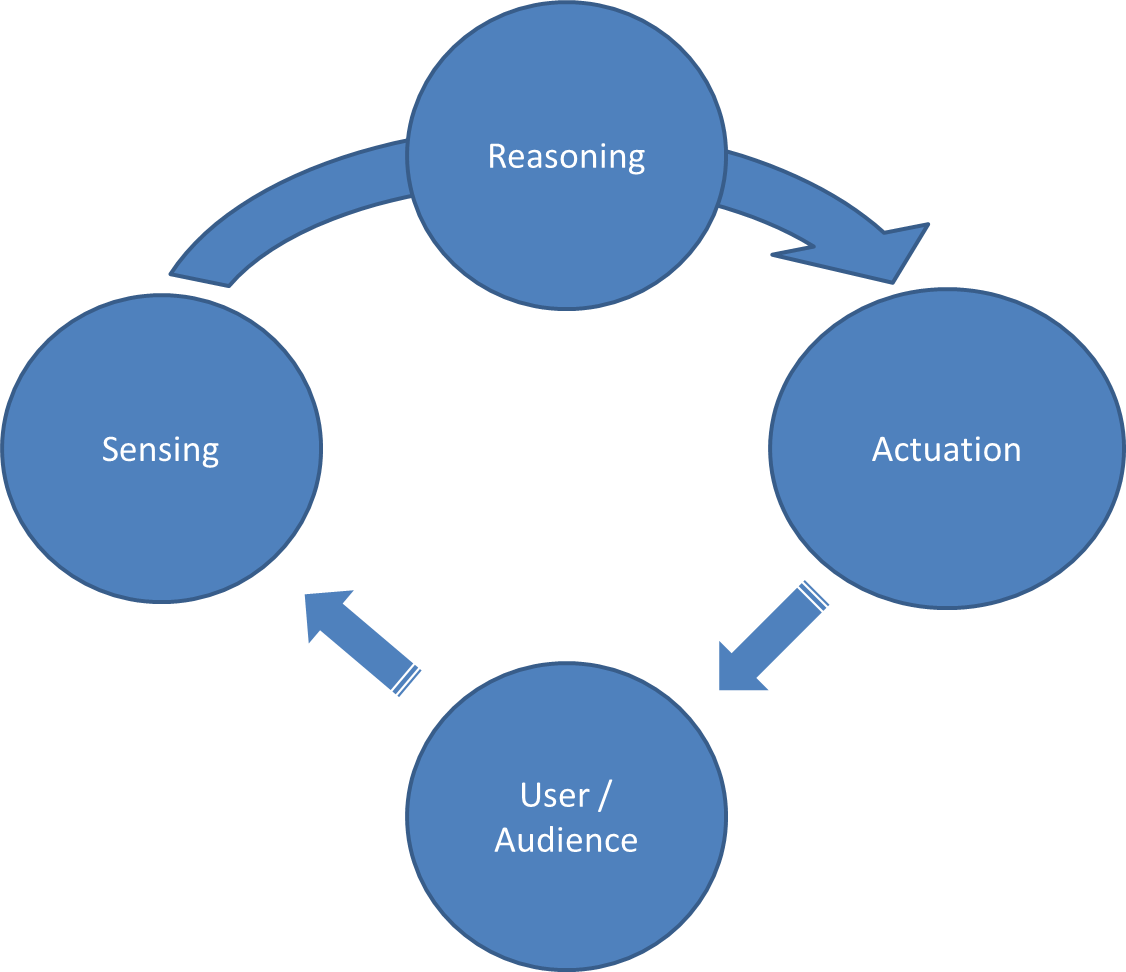


Figure 5. The sensing–reasoning–actuation loop common to most empathic products.

## Conceptual high-level architecture of empathic products

In the previous section we hinted at the components required to implement the high-level functional parts of an empathic product. The conceptual architecture diagram in figure 6 more precisely identifies the main system components and interconnections between them, as well as different actions related to them.

There are three main modules that have been identified to be common to all empathic applications:

* The Empathic State Projection module,
* The Empathic Profiling, and
* The Empathic Modeling.

*The Empathic State Projection module* takes as its input the signals from one or more sensors measuring the subject, and processes this low level information in order to determine higher level information such as facial expression, text valence or head orientation. From the processed data, this module calculates the empathic state such as emotion (e.g happy) or type of movement (e.g. head turn left). Different machine learning algorithms or mathematical models can be used to accomplish this. The module yields an observation of the subject for each given point in time, for example detect a smile on a face and determine that the subject state is happy. This module corresponds to an abstracted sensing module.

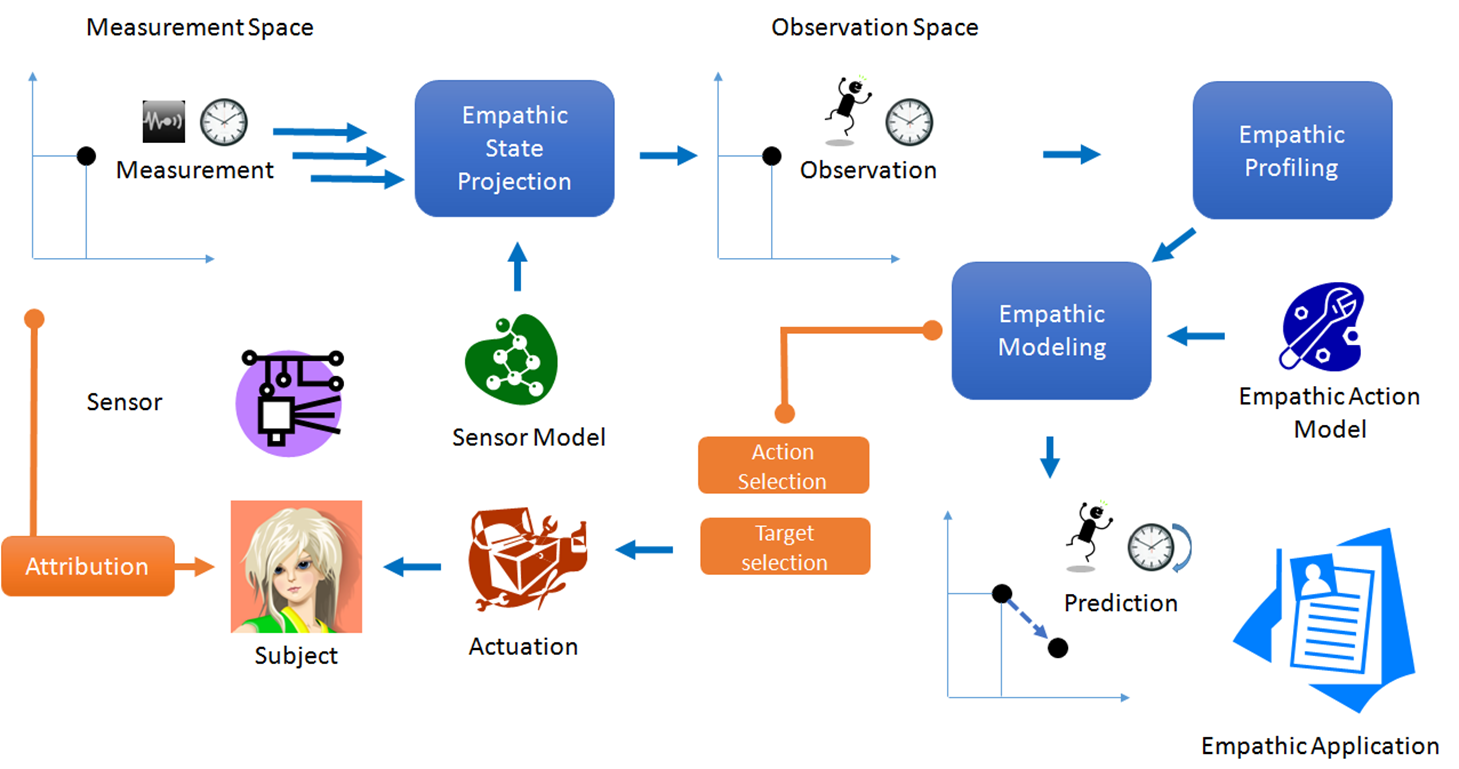


Figure 6. Conceptual generic high-level architecture of empathic products

*The Empathic Profiling module* takes as its input the empathic state projection, expressed as a set of observations, to determine empathic information of higher level. This module often takes inputs from several sources and uses also other than empathic observations, such as user profiles and the context of use. The information is fused by using different modeling methods to understand and determine the relation of the observed state of the user and other information related to the user. Based on observed emotion and context the user behaviour can be interpreted, e.g. if the user is smiling, approaching and looking at the interactive screen when a flowered dress is shown on the screen, the module determines that user likes the shown item and is interested in it.

*The Empathic Modeling module* takes as its input the data coming from the Empathic Profiling module and data coming from Empathic Action model. Based on this information the Empathic Modeling module determines the most appropriate action for the system to take. For instance, when the person seems to like the dress advertisement, the interactive screen can offer directions to where the item can be bought or show more similar products.

This abstraction of the emphatic architecture is a higly simplified view, and can lead to very complex decision making modules when a real system is defined. Currently the real-life systems are limited by the fact that viable empathic products have to be able to cost-effectively measure and process the data: it is practically impossible to take into account all the different behavioural aspects and actions in order to provide deeply empathic interaction. The abstraction helps the product designer to understand the different processes to be included in empathic architecture.

# Classifying, modelling, representing, and expressing empathic information

## Introduction

This chapter focuses on the principles of methods and models involved in sensing and classifying the emotional states and intentions of the users, reasoning with the empathic information, representing it, and using it to steer decisions and actions. In chapter 3 on user experience, we discussed emotions and intentions from the perspective of psychology. Here our emphasis is on the sensing and classification of different emotional and intentional states, with the technological implementation in mind. However, we will not go into details of the models, algorithms, and technologies involved, instead focusing on the principles that are relevant from the perspective of higher-level design. It should be noted that classification schemes, different vocabularies for representing and reasoning with emotions and other user states, as well as other emotion-related models, are based on the psychological theories discussed in chapter 3. They are computational implementations of the psychological models and related phenomena and processes.

In section 6.2 we discuss approaches for modelling and classifying the user states based on different modalities of expression and perception. These sections can be compared to corresponding sections in chapter 3, where we discussed from the psychological and behavioural perspective how humans express and recognize emotions. In section 6.3 we present different computational classification schemes (or vocabularies) for emotions and related user states. Section 6.4 introduces the EmotionML format for representing emotion data, and gives recommendation concerning its use. In section 6.5 the feedback loop from sensing and reasoning to actuation, and related design aspects, are considered.

## Sensing and classifying emotions and intentions

### General

In this section we briefly describe different approaches that empathic products can use to automatically recognize emotions, intentions, and related attributes of users. Common to most methods is that they use a sensor (or multiple sensors) to observe certain features of the user, then use a classifying algorithm that (based on the features obtained from the sensor) classifies the state of the user into certain categories, or represents the state with continuous values in a dimensional space.

Typically supervised learning is used to train the classifier to recognize certain relevant user states. This requires a training data set in which the user states have been annotated. The user states in this training data set are used as a ground truth, and the parameters of the classifier are tuned so that these user states are optimally recognized based on the features present in the training data (or that can be calculated from it). Data collection is therefore a significant step in training the classifier. It is also often very time-consuming to collect data that is of sufficient quality and representative of the actual context of the application. In some cases existing corpuses containing collections of expressed emotions can be used (such as photographs of different facial expressions).

### Facial expressions

As discussed in chapter 3, facial expressions communicate emotions and intentions. The face also conveys information on a person’s sex, age, and other background variables. Automated face analysis seeks to recognize one or more of these attributes.

Automated emotion recognition approachces in computer vision often use the Facial Action Coding System (FACS), originally developed for helping trained human onbservers to analyse facial expressions, as discussed in chapter 3. As a basis for recognizing emotions, first it characteizes the expression in terms of action units (AUs) that describe independent motions of the face (such as lowering brows, raising cheeks, depressing lip corners, or dropping the jaw), and then classifies the facial emotion of the face. The six basic emotion classes (anger, happiness, sadness, surprise, fear and disgust) and a neutral state are widely used.

Regardless of the details of the specific facial expression recognition algorithm, the algorithms generally contain the following steps: face detection and tracking (in a video image), alignment and normalization of the face to canonical orientation and size (to remove the effects of differences in face position, rotation, and facial proportions), extraction of facial expression features, often followed by feature selection step (data reduction to deal with high dimensionality of initial features,) and then the classification steps to describe the face in terms of the emotion expressed or in terms facial action units (to be further mapped into appropriate emotion labels). These steps, along with steps needed in training the algorithm, are depicted in figure 4.



Figure 4. Generalized facial expression recognition framework.

Geometric techniques provide corrections such as those for roll, yaw, and pitch, as depicted in figure 5. Distance metrics (e.g. eye distance, eye to mouth distance) are used to normalize the face to a canonical size. Photometric techniques (such as histogram equalization) aim to eliminate illumination related defects from the facial area.

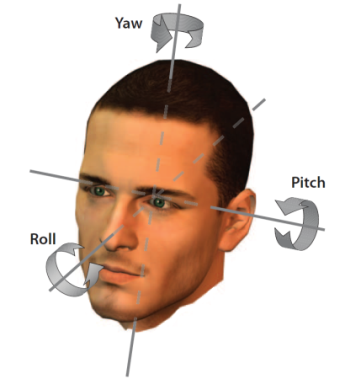


Figure 5 Three egocentric rotation angles (Murphy-Chutorian, 2009)

Figure 6 shows an example of the abovementioned pre-processing steps in practice.

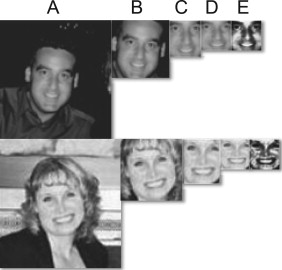


Figure 6. Preprocessing steps for two sample images from GENKI dataset. (A) Original image. (B) Face detection output. (C) Rotating and reshaping the face dimensions. (D) Normalizing face size. (E) Histogram equalization. (Danisman et al., 2013)

After the preprocessing steps, facial expression features of various kinds can be extracted by using

* Geometric feature extraction methods (e.g. Deformable models, Active Shape Models (ASM)) to extract geometric features
* Texture extraction methods (e.g. Gabor wavelet transforms, Local binary patterns LBP) to extract texture features
* Motion flow algorithms (e.g. optical flow) to extract motion features
* Pixel intensities (e.g. gray level pixel values)

In addition, vertical and horizontal projection functions and second order derivatives are widely used for the facial feature extraction process.

In the feature selection step the dimensionality of the original features is reduced by selecting a subset of relevant information from the original data (by eliminating redundant information). Principal component analysis (PCA), Nonnegative Matrix Factorization (NMF) and AdaBoost are used for dimensionality reduction. Feature subset selection method is also used by for facial expression recognition.

Bayesian networks, neural networks, and support vector machines (SVMs), among other methods, are widely used classifiers in facial expression recognition domain.



Figure 7. AU4 (brow lowerer) samples from Bosphorus database (http://bosphorus.ee.boun.edu.tr/)

### Body expressions (postures and movements)

While facial expressions have received the most attention as a nonverbal modality of expressing emotions also in automated analysis, a growing interest is taken on analysis of body movements and postures. There is no agreement on how much emotion such body expressions truly convey, how much of body postures and movements is consciously controlled behaviour and how much truly reflects the emotional state, but recent evidence suggests that the body expressions are more important factor in emotional expressions than previously thought (Van den Stock, 2007). The human emotions and intentions are reflected in the body posture and movement and they can be used consciously to emphasize the verbal message (especially hands). There is an extensive survey on affective body expressions (Kleinsmith & Bianchi-Berthouze, 2013) that covers different aspects from human perception to automatically recognised body expressions and emotions that they convey.

There have been studies to understand how the body expressions map either to discrete emotions or continuous space. Kleinsmith & Bianchi-Berthouze (2005) studied human postures and the affective dimensions that human observers have when evaluating the emotion. They also mapped the emotion dimensions and postural expressions via low level features to affective space for creating a framework for interpreting emotion of postures. Paterson et al. (2001) mapped the upper body movement (head, shoulders and arms) to a psychological space to model experienced affect. In automatic emotion recognition based on body expressions it has been more common to map the emotions to discrete emotions rather than to a dimensional space.

While it has been shown by neuroscience and psychology that body movements are an important modality of emotional communication, notably head and hands movements, only a few theories on gesture-based emotion recognition have emerged. The reason is certainly that in the past most emotion recognition systems were based on classification into “universally” shared emotional categories. Such a classification is seldom feasible when it comes to gestures, where the context is often crucial to the interpretation. As we noted in chapter 3, while research efforts such as the body action and posture coding system (BAP, Dael et al., 2012) are building the foundations for observing body expressions of emotions and interntions, as of yet a system comparable to the established Facial Action Coding System does not exist for body expressions.

Works have been done on analysing coarse-grained posture. For example, Mota and Picard (2003) use posture sequences and hidden Markov models (HMM) to predict the interest of children during a learning task on a computer. Other studies relate to body kinematics, following psychology showing that the dynamics play an important role in motion interpretation. Kapur et al. (2005) use the velocities and acceleration of body joints shaping a skeleton to recognize 4 emotions (sadness, joy, anger, fear). The movement features are given as input of SVM or decision trees for the machine learning. Balomenos et al. (2004) combine facial features and particular hand movements and use them with HMM to classify image into 6 emotions. Gunes and Piccardi (2007) use the variations of centroid, rotation, width, height and area for the hands, head and shoulders' regions as inputs of SVM to classify the images into 12 emotional categories.

Glowinski et al. (2011) created a framework of affective behaviour of upper body movements based on visual information on acted emotions (GEMEP corpus). They used gestures accompanying utterances and in the three level analysis of the gestures. They started from measuring low-level motion features (position, speed, etc.) and created a set of expressive features out of them including energy, spatial extent, smoothness/jerkiness, symmetry and leaning of the head. These features were further refined to dynamic features to consider temporal aspects of affective gestures and they achieved 25 features vector. They used Principal Component Analysis (PCA) to reduce the dimensionality of feature vectors and they retained four components, which were motion activity, temporal and spatial excursion, spatial extent and postural symmetry and motion discontinuity and jerkiness. They determined the optimal number of clusters (four) and compared it to ground truth of GEMEP corpus’ valence/arousal space. The one of the main result of their work is that ”bodily expressions of different emotions may be dynamic rather that categorical in nature – concerning movement quality rather that specific type of gestures”.

Tan et al. (2013) were able to derive association rules between body postures, detected by Kinect, and emotions as measured through physiological sensors during a natural conversation between two people while standing. The emotions derived from the body postures through the association rules showed high correlation with the measured emotions.

*Hand gestures* are a particularly interesting sub-category of body movements, since they are increasingly involved in human-computer interaction. First attempts to integrate hand gestures in human-computer interaction resulted in sensors and some special mechanical devices that must be worn by user to measure specific data of the hand (Quam, 1990). This group of devices consists of the likes of acoustic or inertial trackers, magnetic sensors, and special gloves.

Although such invasive interaction techniques provide very accurate results and are useful especially for cooperative users, such cumbersome and expensive tools tend to impose a burden and a high barrier to use in our everyday life. Computer vision techniques are less intrusive and provide a more natural way of interacting, since the require no additional devices to be worn or held by the users.

A complete hand gesture recognition system is composed of three layers: hand detection, hand tracking and gesture recognition. The detection layer consists on the extraction of hand region and position. The tracking layer performs temporal data association between successive frames in the video sequence. Finally, the gesture recognition layer uses the previous spatio-temporal information to categorize gestures into the appropriate classes.

The most important differences in the vision based hand gesture recognition approaches arise depending on whether a 3D hand model or an image appearance of the hand is used. The first solution tends to create a three-dimensional model of the user hand which will be used for the recognition task. The second one tries to calculate hand features directly from the 2D image.

### Group behaviour and people tracking

In what can be seen as a coarse-grained level of analysing body movements, we come to people tracking: tracking the *location* of persons (and features that can be derived from location, such as speed and direction, as well as features related to the path the persons take through a space of interest).

Different public screens and digital signage systems in retail and advertising as well as digital installations are getting very common these days. Some of these systems are passive but some of them hold already different interaction methods. The user can either interact by gestures of her body with the content or the systems can become interactive via personal devices. As the future systems will contain more and more interaction, different methods to understand behaviour of the people are required. Depth sensing technologies can provide valuable tools for natural interaction and for making systems more intention-aware.

With the computer vision and depth sensing technologies we can also provide intuitive interactions methods via gesture recognition and automatically understanding more of the people behaviour or emotions as well as use this information in user interface design of public displays (Müller et al., 2010). The multiuser public displays will face the challenge of managing interactions from multiple users. The interaction can be provided by using a “hot spot” to select the main user, or the system can divide to multiple applications that each user can control (Deshpande et al., 2009). Also, interactive public displays have to be aware of the user’s state of mind towards the interaction.

The audience funnel models describe the audience behaviour in front of public displays (Müller et al., 2010). At the first stage the user is only passing the display, but in second stage they start to react to it by glancing, smiling or approaching towards it. Detecting this implicit behaviour of the user will enable developing more empathic interactive screens. In this stage the interactive system should engage the user by encouraging further interaction. This will require understanding the actions and movements of users in space as well as users’ emotional state.

In intelligent spaces we can track the position of persons and know if they are approaching an interactive screen. Also from the tracking abilities we can derive intelligent conclusions of people intentions, depending on application context. For example detecting if a person is entering or leaving the building or store or actions taken by the users may distinguish between employees or visitor. This information can provide tools to create personal and profiled information systems.

When we understand better the people behaviour and movement (flow) in space we can tailor the content in digital displays. Computer vision and depth sensing technologies can provide valuable information that can be utilised in smart spaces including tracking people, understanding their actions and (emotional) behaviour and gestures for natural interaction.

The depth sensors are a good tool for tracking people as they are more robust for changing illumination and lack of contrast as well as improve the performance of people tracking in some difficult cases. Depth sensors do have their problems as they generate artefacts and other reflection errors in some cases. In [Han08] they noted that bad configuration of the sensors caused errors or the sensors interfered with each other. (Jungong et al., 2012) noticed that when using plain depth data from height map the segmentation and tracking will fail in situations where occluded people have similar depths. If the identification or labelling of the tracked people is required it would be convenient to use the RGB data as well. The depth sensor based people trackers are rarely evaluated in heavily populated environments (e.g. in entrance of malls) which is understandable due to the considerable effort required for creating the ground truth data and verifying the results. Albiol et al. (2012) did test their system in a supermarket, but the main emphasis was in re-identification of people.

**Think beyond the basic emotions to determine the application-relevant emotion or intention categories.** While used in many systems, basic emotions are not always that useful in real-life scenarios, so be prepared to consider with an open mind and a wider perspective what emotional or cognitive states, or intentions of the user are the most relevant ones to the specific empathic product concept.The consideration from the user perspective should be done in parallel with considering the limitations and possibilieties of technologies – it may turn out that the existing technologies for identifying basic emotions can be extended to classifying other kinds of application-relevant user states as well.

**Consider the temporal duration of the emotions and intentions when deciding on the relevant user states to measure in a given application.** Emotions and their expressions are often transient, a quick smile or an expression of sadness, for example, in response to something that is gone in a fleeting moment. Tracking of these transient emotions can be in central role in various kinds of applications, but often it is useful to consider also more persistent and continuous states of the user. For instance, in a shopping context a relevant emotional or cognitive state, one that may persist for many minutes, may be confusion or hesitation (indicating that the person may need some kind of advice or assistance), and in a TV viewing context the relevant emotional dimension may be overall interest/boredom towards the content being shown. This is another perspective to thinking beyond the basic emotions when defining the application-relevant emotion or intention categories.

**Obtain and maintain a working understanding of the current level of empathic technologies, and a realistic vision of the advances in the foreseeable future.** Designers’ should have a technological level in mind when thinking of empathic product concepts and use scenarios, and an understanding of how feasible different kinds of concepts are and what it takes in practice to implement them. What kind of performance can be expected from such a system in real-world environments? Do not confuse future visions of mind-reading with what is possible today in practice. Although technology will improve, at the moment low data quality heavily constrains what can be done in an empathic application with the data, especially when using inexpensive commodity sensors. Still, being able to sufficiently reliably observe even a relatively simple, limited aspect of the user’s state of mind, relevant in that application-specific context, may allow us to significantly improve the user experience and provide added value. In this regard, it is good to form a realistic idea of the timeframe at which one aims for market-ready empathic products or systems, and to take that into account in the design process.

**Be prepared to do real-world testing and tuning to get a hands-on feeling for the sensing performance that you can expect to achieve.** Technical specifications and laboratory measurements cannot give you a full idea of how the sensing system will perform and behave in real-world contexts. In order to get that understanding you need to do experimentation in real-world conditions. Also, be prepared to spend some time tuning sensors and the associated signal processing algorithms in order to ensure that you get optimal information out of them for the needs of your application.

### Data collection for training of recognition algorithms

As mentioned above, most of the classifiers used for recognizing emotions or intentions rely on some form of supervised learning, meaning that they need an annotated learning data set containing a representative set of relevant expressions or behaviors, with annotations describing which category (or intensity) of emotion or intention (or other category of interest) each expression or behaviour corresponds to, in order to “learn” to recognize the appropriate emotional states or intentions. The parameters of the classifier algorithm are tuned based on this ground truth of the annotated learning data set, allowing the classifier to learn to estimate the relevant emotion or intention categories or intensities based on the automatically observed features of the person.

In the case of more mature automated analysis techniques, such as recognition of facial expressions through machine vision, when used in simple contexts, one might achieve a reasonable recognition performance without an extensive training phase. However, in most cases one needs to plan for the training phase and data collection, which can be rather demanding and time-consuming. In any case, one also needs annotated data to analyse reliability and validity of the recognition methods used in the empathic product.

The quality of the training data set can have a considerable effect on the recognition performance, with further consequences for reasoning with this information and steering actions based on it.

A range of different approaches can be used for data collection and annotation, each with different advantages and disadvantages. It is less time-consuming to collect *acted* *data*, in which certain expressions are posed or recorded in pre-scripted situations according to premade scripts, than to collect *naturalistic data* containing spontaneous expressions and behaviors. Somewhere in between completely acted and completely naturalistic data is the data where expressions and behaviors have been *elicited* by suitable stimuli (such as showing evocative photographs in laboratory conditions)

The methods used for obtaining the annotations for naturalistic learning data can be broadly divided into two categories: observational methods and self-report methods. Observations can be carried out live by field observers or they can be conducted retrospectively using a video recording, for instance. There are different kinds of observation protocols, with specific instructions for coding expressions or behaviors. One needs to consider, for instance, whether to look for a range of physical and verbal evidence of the person’s emotional state or intentions in a holistic manner, or to focus on a more limited set of factors, and categorizing based on a predetermined list of potential expressions and behavors. In various self-reporting methods, the users are asked to indicate their own emotions: the users can volunteer their emotions at any time during an interaction using a list of emotions, for instance, or they can answer questionnaires at predetermined intervals. Self-reporting methods avoid the problems of outside interpretation, but the persons still need to have a consistent understanding of the labels used. Self-reporting methods are also prone to bias from self-presentation effect. Further, when done in real-time rather than retrospectively, self-reporting can interrupt the flow of interaction and potentially influence the user’s emotions (the user can get bored of frustrated with carrying out the annotations).

In some cases existing corpuses containing collections of expressed emotions can be useful. These conventionally contain acted data (such as photographs of different facial expressions portrayed by actors), but can also contain other types of data. In recognition of the central role of data in building these kinds of empathic and other affective systems, more and more emotion and behaviour data collections are becoming available, including also multimodal databases.

## Classification and representation schemes for emotions and intentions (empathic information)

### Introduction

The emotions are modelled as either discrete emotions or in continuous space (or both). The psychological theories behind different kinds of representations were described in chapter 3. Here we present in compact form a selection of schemes that can be used in practice as a basis for classifying and representing emotions and related mental states.

### Dimensional representations

The dimensional representations describe emotions as points in a vector space. When using continuous dimensions the emotional space often contains 2 or 3 dimensions. In two-dimensional modelling valence (positive/negative, pleasing/displeasing) and arousal (excited/calm) characterises the emotion, as in Glowinski (2011) for gestures. Dimensional representations are also used for other modalities. The three dimensional model is often called PAD model (pleasure, arousal and dominance). In this case dominance describes the how controlling and powerful the emotion is compared to submissive state. These representations are discussed in more detail in section 3.2.1.

Below are some examples of dimensional spaces.

The Feeltrace tool of Schöeder (2003) is used for the annotation of videos and allows the coder to move a marker towards 2 directions in the plan corresponding to 2 dimensions :

* positive/negative
* aroused/calm

The emotional state can be described through the video as a vector of 2 values, as shown in figure 8.

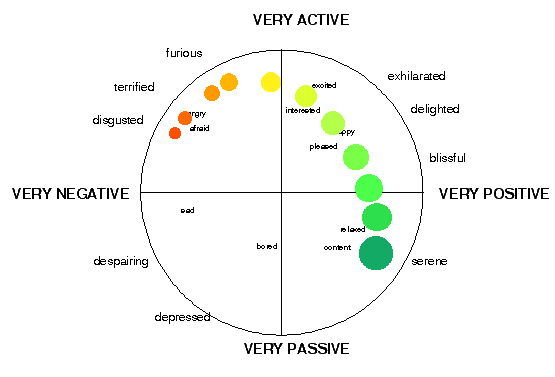


Figure 8. Example of a FEELTRACE (Cowie et al. 2003) display during a tracking session for recording how perceived emotion develops over time

The Wundt's space comprises 3 dimensions:

* positive/negative
* aroused/calm
* tension/release

The affective lexical space of Fitrianie (2006) resembles the one of Schröder :

* positive/negative
* active/passive

The Genève wheel of Scherer (2005) comprises 4 dimensions :

* valence
* control
* arousal
* conductive/obstructive

The 3-dimensional PAD (pleasure, arousal, dominance) space is sometimes appended with 2 additional dimensions :

* valence
* arousal
* dominance/submission
* (intensity)
* (anticipation)

### Categorical representations

Although the definition of basic emotions or the corresponding discrete categories are not universally agreed upon, Ekman’s six “basic emotions” fear, anger, sadness, happiness, disgust and surprise, with a neutral state, are rather widely used in automated recognition of emotions, especially when facial expressions are concerned (Ekman’s theory links the basic emotions to facial expressions). While talking about categorical representations might suggest otherwise, often an intensity or probability value is also given for emotions in categorical representations. Also, different levels of multiple categorical emotions (or other states) may be detected either simultaneously or during a given time interval, instead of exclusive assigning one category to describe the state of the user at the given time.

## Representing empathic information: EmotionML

### Introduction

There is a need of representation agreement when two emotion systems, an emotion producer and an emotion consumer are required to interoperate. EmotionML is both a powerful and flexible representation language for emotions but it may not suit everybody. Its strengths and weaknesses are presented, followed by practical ways to circumvent the problems. Whether to adopt the EmotionML standard for this representation depends on several factors that we detail in this section.

### When not to use EmotionML

While we are advocating the use of EmotionML for emotion systems, there are cases in which it would not truly be needed. The most challenging aspect when designing a representation format is to evaluate the trade off between adapting the system to the format and the gain of using that particular format. We detail here some considerations about situations in which not using EmotionML may be a good option.

#### When the emotions and environments are simple

At first glance, EmotionML seems not needed when the emotion systems are very simple and do not need complex representation, for instance when representing only one emotional category ("*joy*") or a simple floating value for valence (e.g. "*0.7*"). However this assumption only holds if the systems at hand are so stable that their developers are sure their inputs/outputs will remain as simple. Should the representation be made more complex, for instance by weighting each emotion, a whole new format would need to be developed and shared with other systems. Hence, developers need to ensure that the other emotion systems that work with the producer or the consumer will not change either, thus systems that work with *ad hoc* formats are required to have a limited scope of use. Not using EmotionML then requires both that the emotions are simple and that the environments of emotion systems are simple as well.

#### Problems of value range normalisation

Even if the emotion producer and consumer work with simple, atomic representations and work in simple environments, it is required that they both agree on a value range for representing emotions. Indeed, one system may coin an emotion as "*joy*" while the same emotion may be referred to as "*happiness*" by the other system. The problem is the same for dimensions such as valence, one system may take its values in [0,1], while the other may use the [-1,1] range. Therefore, both producer and consumer must provide an accessible specification of the value range they accept. Ideally this specification is online and machine-readable.

#### When the bandwidth use is very critical

The main disadvantage of EmotionML may be its verbosity: it is not a lightweight format mainly because it relies on XML but also because each emotion has to refer to a vocabulary URI (see *value range specification* section).

The following emotion in EmotionML represents "*joy*" (domain specific metadata has been omitted):

<emotion xmlns="http://www.w3.org/2009/10/emotionml"

category-set="http://talc2.loria.fr/empathic?query=vocabularies#metaverse">

<category name="joy"/>

</emotion>

It contains 168 bytes, that is 56 times more than the 3 bytes of the atomic representation "*joy*". Even without the (yet mandatory) vocabulary URI, the emotion contains 89 bytes. The EmotionML namespace alone comprises 36 bytes.

EmotionML has a lot of qualities but the developers need to make sure that the overhead caused by the representation is tolerable within the system environment, especially if the system is meant to run on mobile devices with a limited bandwidth (as an alternative see *EmotionML light producer* section).

#### Conclusion

EmotionML may be avoided in small setups but in any case, it cannot be avoided that the producer and the consumer agree on a particular emotion vocabulary that is meant to be fixed, well defined and accessible for both parties. If all these assumptions are met (simplicity, stability, limited use scope, vocabulary access) EmotionML would not be truly needed. This is for instance typically the case in small and limited experiments when the modules are not meant to be shared with others.

### When to use EmotionML

EmotionML is actually meant to address these two main problems that are complex emotions and value range normalization, and we detail here these two aspects.

#### Complex emotions and environments

We use the term complex emotions to refer to all emotions that are not atomic values. The simplest cases are combined emotions that gather several categories (fear + anger for instance) or several dimensions (valence + appraisal for instance). With regards to combined emotions, one may want to weigh each emotion (fear=0.2, anger=0.5 for instance). As soon as the representation needs to go beyond atomic values, EmotionML is truly a must. It is particularly true if the emotion needs to be precisely anchored in time as EmotionML provides a time-anchoring mechanism. It is also true if the emotion needs to refer to the source it was inferred from, for instance a text fragment, or a particular gesture.

Moreover, the use of a well defined standard is also recommended when the use scope of modules is not fixed beforehand, that is if modules are meant to be reused or evolve in time in complex and unpredictable environments.

#### Value range specification

One of the biggest strength of EmotionML is its convention regarding the value range specification. First, it normalizes the floating value range (in [0,1], 1 being positive, 0.5 neutral and 0 negative). More importantly, it requires that any categorical emotion refers to a vocabulary specifying the values range for the categories names (and dimension names as well for dimensional emotions). In a sense, it is like the emotion embeds its own documentation.

The given example shows an emotion referring to an *ad hoc* vocabulary named *hate\_and\_love* composed of two categories *love* and *hate* which is hosted online.

*Example of vocabulary (hosted for instance at http://my\_server\_url.org/empathic\_vocabulary.xml)*

<emotionml xmlns="http://www.w3.org/2009/10/emotionml" version="1.0">

<vocabulary id="hate\_and\_love" type="category">

<item name="love"/>

<item name="hate"/>

</vocabulary>

</emotion>

*Example of emotion referring to the vocabulary*

<emotion xmlns="http://www.w3.org/2009/10/emotionml"

category-set="http://my\_server\_url.org/empathic\_vocabulary.xml#hate\_and\_love">

<category name="love"/>

*</emotion>*

The main benefit of such approach is a strengthened interoperability link between the emotion producer and consumer since the consumer can query in real time that are the values it is expected to consume.

#### Automatic vocabulary generation

We recommend that the vocabularies be produced automatically from the source code. For instance, many programming languages offer an enum facility that constrains the range for a variable. It is then possible to directly generate the vocabulary from the enum, hence making sure that the values specified in the vocabulary are the ones that are used internally by the producer.

### EmotionML in practice

EmotionML has a flexible plugin mechanism to include emotions in external formats: it is possible to directly embed an emotion encoded in EmotionML anywhere allowed in the external format. This mechanism is very handy, typically for annotation purposes, but makes the verbosity problem more prominent as illustrated in the following example.

*Example of embedded emotions*

<sentences>

<sentence>

<content>Just apply for a job at Apple</content>

<tagged-content>

<tagged-word id="0" pos="RB" lemma="just" morph="Just"/>

<tagged-word id="1" pos="VB" lemma="apply" morph="apply"/>

<tagged-word id="2" pos="IN" lemma="for" morph="for"/>

...

</tagged-content>

**<emo:emotion dimension-set="http://www.w3.org/TR/emotion-voc/xml#fsre-dimensions">**

**<emo:info>**

**<origin source="manual" xml:lang="en" xmlns="empathic"/>**

**</emo:info>**

**<emo:dimension name="valence" value="0.5"/>**

**</emo:emotion>**

</sentence>

<sentence>

<content>I like that</content>

<tagged-content>...</tagged-content>

**<emo:emotion dimension-set="http://www.w3.org/TR/emotion-voc/xml#fsre-dimensions">**

**<emo:info>**

**<origin source="manual" xml:lang="en" xmlns="empathic"/>**

**</emo:info>**

**<emo:dimension name="valence" value="1.0"/>**

**</emo:emotion>**

</sentence>

...

</sentences>

In this example, there are two sentences. Each sentence carries a tagged content, but also an emotion (in namespace emo). To respect the EmotionML standard, it is required that each emotion refers to the dimension-set that defines the valence dimension. Moreover, the info element that holds metadata information is specified each time. All this information is redundant and uses space and processing time. For instance, given our example, if there would be 100k annotated sentences, the emotion annotation alone would take around 24Mo amongst which only 300ko would be relevant content.

The solution to circumvent the redundancy problem is to gather the emotions in an EmotionML document and *refer* to them rather than *embed* them. Indeed, the EmotionML standard enables to specify the dimension-set URI and the info metadata only once in the emotionml element.

*Example of EmotionML document*

<emotionml xmlns="http://www.w3.org/2009/10/emotionml"

dimension-set="http://www.w3.org/TR/emotion-voc/xml#fsre-dimensions">

<info><origin source="manual" xml:lang="en" xmlns="empathic"/></info>

<emotion id="neutral"><dimension name="valence" value="0.5"/></emotion>

<emotion id="positive"><dimension name="valence" value="1.0"/></emotion>

</emotionml>

Note that this example pushes even further the emotion reference by considering that these emotions are *emotions kinds*. In this example, there are only two emotion kinds, so it is even possible to label them with meaningful identifiers, here "positive" and "neutral". This mechanism is in some sense very similar to the vocabulary mechanism. However, the meaningful labeling is only possible when the emotions are really emotion kinds, and thus such labeling would not work with non-discrete dimensions, emotions with time anchors, source annotation, weights, etc. In all these cases, a non-nominal labeling is necessary, for instance "e127".

#### Proposal to standardise external reference to EmotionML

Nevertheless, EmotionML does not specify how EmotionML document and emotions needs to be referred to from external formats. We thus propose here the following conventions:

**emodoc** : this feature of type **xsd:anyURI** is an URI reference that refers to the EmotionML document which contains the emotions. The **emodoc** feature must be set for the XML element that refers to an emotion or one of its ancestors. In case several ancestors define an **emodoc** feature, the closest one needs to be considered. For instance, if all emotions are to be found in the same document, the **emodoc** feature can be set at the root XML element.

**emoid** : this feature of type **xsd:id** is an identifier that uniquely identifies the emotion within the document referred to with the **emodoc** feature, as described above. The actual URI to the emotion can be retrieved by combining **emodoc** and **emoid** : <**emodoc**>#<**emoid**>

*Example of an external format referring to the previous document*

<sentences **emodoc="docs/my\_emo\_doc.xml"**>

<sentence **emoid="neutral"**>

<content>Just apply for a job at Apple</content>

<tagged-content>

<tagged-word id="0" pos="RB" lemma="just" morph="Just"/>

<tagged-word id="1" pos="VB" lemma="apply" morph="apply"/>

<tagged-word id="2" pos="IN" lemma="for" morph="for"/>

...

</tagged-content>

</sentence>

<sentence **emoid="positive"**>

<content>I like that</content>

<tagged-content>

...

</tagged-content>

</sentence>

</sentences>

Assuming that our EmotionML document is stored relatively to the current document at "docs/my\_emo\_doc.xml", each sentence can carry the **emoid** feature that refers inside the EmotionML document. Note that the document can also be stored online and referred to by an URL.

There are several benefits of using this technique:

- It is not required to mix the external format and EmotionML beyond the **emodoc** and **emoid** features

- The **emodoc** feature can be set only once in the root element

- It limits the size of the emotion annotation by sharing the vocabulary URIs, and potentially the info metadata

- When it is possible to use emotion kinds, the emotion annotation is even more limited in size.

#### EmotionML light producer

In order to increase practical interoperability, and in the case an emotion consumer would *not* be able to process EmotionML, we suggest that the emotion producer should be able to produce both **full** EmotionML representations and **atomic** representations if possible. The idea is to limit the verbosity of the output of a producer while retaining the ability to retrieve more complete outputs.

Such EmotionML light producer would obey to given conventions:

- The light producer needs to work in two modes: a ***full*** mode and an ***atomic*** mode

- The mode can be specified when performing the analysis query or it could have a mode by default, the selection of the mode must be well documented

- In the **full** mode, the producer outputs regular EmotionML emotions

- In the **atomic** mode, the output is simplified following given rules:

- For any weighted categories (e.g. anger=0.1, sadness=0.3), return the most intense emotion category; if two categories have the same weight, return one or the other following a well defined and accessible precedence convention. In the example it would return "*sadness*". It would be the same for appraisal or action tendencies.

- For any dimensions (e.g. valence=0.4, arousal=0.2), return one or the other dimension by default whatever its intensity. Assuming valence is the default dimension, it would return "*0.4*" in the example

Therefore, the emotion consumer can still access some functionality of the producer, but is limited to a simpler functionality. If the consumer desires to access the vocabulary reference URIs or if it desires to retrieve more complex emotions, it would have to support EmotionML and use the full mode. If it only cares about the most dominant emotion or the single default dimension, it can use the atomic mode. This dual behaviour is interesting since it keeps all the quality of EmotionML without making them explicitely required in the output. But note that the gain comes at the price of better documentation. An EmotionML light producer is required to clearly specify:

- How to select the operating mode

- What is the categories/appraisal/action tendencies precedence (if present)

- What is the default dimension (if present)

**In short, EmotionML light producer:**

- Works in two *modes*: a full mode and an atomic mode

- Enables to keep the bandwidth use low in atomic mode

- Enables to interact with consumers unable to process EmotionML

- Is restricted to simple emotions in atomic mode

- Benefits from EmotionML functionality in full mode

### Summary of EmotionML guidelines

**Summary of EmotionML guidelines.**

***One should use EmotionML when one of these conditions is met:***

* *the emotion systems are meant to evolve*
* *their scope of use is not fixed*
* *their emotions could be complex, for instance:*
  + *they may have several categories (sadness + anger, etc.)*
  + *they may have several dimensions (valence + arousal, etc.)*
  + *their categories may be weighted (anger=0.1, sadness=0.3)*
  + *the emotions can contain time anchors, reference to source, etc.*

*→ Typically, for reusable emotion systems in complex architectures.*

***One may avoid using EmotionML when all these conditions are met:***

* *the emotion systems are simple and stable*
* *their scope of use is limited and well known*
* *their emotions are atomic and will not evolve, for instance:*
  + *a single string representing an emotion name ("joy")*
  + *a single floating value for valence or arousal ("0.7")*
* *the specification for the range of values is easily accessible*

*→ Typically, for small modules in experiments.*

***One should be careful using EmotionML when this condition is met:***

* *the bandwidth use is critical*

*→ Typically, on mobile devices for real time emotion sensing.*

***When using EmotionML we recommend:***

* *generating automatically the vocabularies in producers if possible*
* *a conventional mechanism to refer to EmotionML from external documents*
* *an EmotionML light producer convention to ease connexion to non-EmotionML capable consumers*

## The sensing–reasoning–actuation feedback loop and related design aspects

In the earlier sections of this chapter various approaches for recognizing emotions and intentions have been briefly described, followed by considerations about how to represent emotions and related information in empathic systems. Chapter 5 focused on the overall architecture of empathic products. In this section we close this chapter by considering generic design aspects involved in planning and developing different parts of an empathic system and making them work together as a whole.

An important variable that cannot be ignored when designing empathic systems that are aware of their users, is *time*. Considering the states of the user and interactions between the user and the system, there are variable time scales at which different things play out. Regarding emotions and related mental states, there are fleeting emotions (e.g., a sudden feeling of surprised delight accompanied by a quick smile), somewhat longer-term states (e.g., a feeling of joy and pride after a personally significant achievement), and very long-term states (e.g., feeling stressed or depressed for days, weeks, or months; or certain traits of the user, which change only gradually or can be thought of as almost permanent states). A designer of empathic systems needs to be aware of the relevant time scales, and an empathic system needs to be aware of them when making decisions about actions in relation to observations. If the system is to respond to intense momentary happiness of user, expressed by laughter in reaction to a surprising event, an emotion that is very fleeting, the system needs to be capable of making the complete loop from sensing and observation to reasoning and actuation in a very short timeframe. The time scales involved in the general activity level of the user, which the system might also monitor, change in considerably longer time scales.

Consideration of various time scales also pertains to the fact that an empathic system is a multistep process, in which the signal from the sensor is first translated into an observation at a certain point in time, and the observation is further interpreted as and observation of the user’s state (as it was at the certain point in time). There may be various signals in the system, and these steps should always be considered for each of them. In some cases the signals and processing can be almost real-time and continuous, but in a networked application, for instance, there may be an interval of minutes between the instants when the application can have the data collected from sensors available. Further, in some cases it only makes sense to interpret the user’s state based on sensor data from a longer interval of time.

The system needs to take these time scales into account when reasoning with the sensor data and the observations derived from it, and further when considering what possible actions to take on the actuation side, when (and if) providing feedback to the user. If the action aims to influence the state of the user, then the system should also have the temporal dynamics involved in taking the action at the given moment and seeing the results of the action pan out in time somehow modelled.

While not many empathic systems are such closed loop systems that actively monitor and influence the emotion and experience of the user, in the design of most empathic systems it is necessary to consider the time scales of feedback in relation to observations, and how different design choices regarding the timing of feedback affect the overall user experience. For instance, in a stress monitoring application the moment when the system detects exceptionally high stress levels may not be the optimal time to provide feedback to the user, as this would likely just add to the stressfulness of a demanding or busy situation. A better option would be to provide summary feedback at a later time, accompanied by guidance for managing stress levels. One example of a more realtime feedback loop would be the idea about a game for practising meditation, in which the empathic system shows the user its observation of her current emotional state (in terms of calmness/arousal, for instance) and the user aims to control her emotions (by calming down with help from the guidance provided by the application, for instance).

Another time-related challenge is the synchronization of different data streams. In a home environment an application relying on data from multiple networked commodity sensors faces the challenge of varying kinds of connections, delays, and transfer speeds. Sometimes access to data is almost immediate, but sometimes it’s a matter of minutes or more. This creates challenges for putting everything on the same timeline and for designing the dynamics of the feedback loop. In future the smartphone may serve as the local data hub that takes care of the synchronization.

The capability of empathic products to observe the user, and also to observe influence of different actions on the user, gives them potential to learn over time. While not feasible in every case and not required, learning does give the systems a means for improving over time. When possible, fine-tuning the system by self-learning (accumulating data from observing the users, and using that data to tune the models that govern its reasoning) is considered a useful approach: a big part of being empathic is learning users’ habits, and in some cases also learning how to surprise the users, and one way to achieve this goal is to keep building the models in the system by self-learning, perhaps quietly observing in the beginning, then starting to interact with the user and learning from the interaction.

**Consider the possibility of designing an empathic system that learns from interaction with the user.** In some cases it may be very useful to have a system that can learn from the interaction with the users and tune its models accordingly. Central to the self-learning aspect in empathic products is the closed feedback loop from sensing the user to taking actions that affect the state of the user, on the actuation side of the system. By observing the influence of different actions on the user it is possible to collect data that can be used to tune the system. In some cases it may be useful to start with a learning period during which the system mainly quietly observes the users, then starts to interact with the users and learns from the interaction, building it’s models. A big part of being empathic is learning user habits, and in some cases also learning how to surprise users, and self-learning can be a useful part of that. (However, self-learning is not a required attribute of empathic products, as it is possible to be aware of the user and to be empathic without learning, and in some cases learning may pose specific challenges.)

# Empathic product design guidelines

The guidelines provided here after use generic high level product development phases as a structure. These phases are planning, definition, design & development and verification & validation (V&V). These phases are always present in product development, but the detailed activities and ordering of them depend on the product type, development mode and the chosen lifecycle model, for example. These aspects are not addressed in these guidelines, but instead the description focuses on the special characteristics of the design of empathic products or features development, i.e., what specific matters need to be taken into account and what actions need to be carried out in different phases when designing empathic products. This approach is chosen in order to enable empathic features development as part of other product development. This is because, in addition to the empathic features, the products usually have also the classical features of a product (empathy is only a part of it). For these parts, usual way of working still applies.

First, planning the approach related to the design process of empathic products or features are discussed, and then each generic phase is briefly introduced, and specific aspects of empathic products are discussed from each phase’s viewpoint.

## Planning

*Planning in general sets up the required conditions and commitments to establish a product, including the needed resources, costs, scheduling, quality goals etc.*

**With respect to empathic products or features, the specific aspects in planning include dealing with the interdisciplinary nature, undefined requirements and uncertain technological capabilities.**

Build coherent design team.

Ensure availability of both technological and human behaviour competences in teams, and consider including generalists in the team. Generalists with holistic perspective to the system being designed are especially valuable in the case of empathic products as due to the complexity and novelty of empathic systems, relying only on limited specialists in the design and requirement specification of empathic products is likely to cause difficulties along the way.

Furthermore, interdisciplinary design teams are useful, but face the risk that the design process fragments into separate diverging parts that do not properly understand one another and that do not start coming together as a whole – generalists viewing the product and the design process as a whole can ensure that the work done in different phases of the design process serves the common purpose (and that there is a common shared purpose in the first place!) and converges towards the finished product. For example, psychologists and psychological experiments can provide expertise and potentially useful information and insights, but that knowledge will only help the design process if it can be expressed in a manner that can be related to the relevant technical and creative design choices.

Prepare and plan for technology evaluation and follow-up tasks

Technology is often new, and immature and thus needs to be trialled to find out in practice what can be done with it, e.g., potential problems are difficult to predict. Also, the promise of the technology provider is often from optimal circumstances, so it is good to evaluate the technology both in lab and real life settings.

Also new and improved technology brakes out continously, so follow the development of your chosen technologiy, but also look around for similar things, as you should be aware of what others have done.

Plan several iterations

Empathic products design process should include multiple small iterationswhere individual components are tested/protoyped instead of sequential process. Each iteration should include definition, design and Validation & Verification, but the maturity of the resulting increment may vary. The results of validation should be incorporated into the next iteration.

Plan how to involve users / users viewpoint in the process

The iterations should involve users, when possible, all the time in order to get feedback as early as possible. Sometimes the user needs and feedback are difficult to collect, e.g,, if the value chain is long, like in media broadcasting (content creation – broadcasting –cable company), or the users are somehow unable to present their opinions. In these cases try to include user viewpoint in some other way.

Be prepared to throw away prototypes, and start over

Some aspects are likely to have been missed in the design, for example due to the unknown technology issues. So it is useful to make fast mock-ups and prototypes, evaluate them, and if the evaluation proves the approach not successful, then the approach should be changed. This should be taken into account in planning of costs, schedules etc.

Consider regulations and plan required actions

The empathic product makers should make sure that laws are followed, and that this fact is clear to the users. Building trust that the data will not be abused is central in the acceptance of empathic products. However, diversity of legislation in different countries and regions is a challenge, so decide which regions are relevant for your product

Plan development so that marketing efforts are supported in early stages

An important element for empathic products is marketing, so the design process should include support for answering the question “How can I market my empathic product?” For example, consider developing and prototyping features that are interesting to customers or “exiting” earlier in the process.

## Definition

*Work in the definition phase in general builds a representation of a future system that will meet stakeholder requirements and that, as far as constraints permit, does not imply any specific implementation. It results in measurable system requirements that specify, what characteristics the system has to possess and with what magnitude in order to satisfy stakeholder requirements.*

**With respect to empathic products or features, specific aspects in the definition phase involve dealing with new possibilities that technology enables and are not known beforehand, and lack of clear stakeholder needs.**

Define the goal / purpose of the empathic feature

The idea is often initiated in the company, and it is technology driven, i.e., thinking what can be done with the technology. Also, as the technology used is often new, the users and customers may not be able to give relevant needs, thus the developers are often the source for the ideas in practice. Thus, it is useful to implement some thoughts fast, and then measure the effectiveness of the resulting prototype in practice. Furthermore, there are also so-called obvious requirements that are essential to the system, but not likely to be mentioned by users or customers.

Identify potential customer and the users

Often in the expected value chain of empathic products the end-user interacting with the product is not the customer who pays for and/or operates the system, who uses the system in a different sense and for different purposes than the end-user. The requirements and other design implications may be quite different when considered from the perspectives of the end-user or the customer that actually pays for the system.

When defining the product, both viewpoints should be considered. User viewpoint is important also for the customer, as in order for the product to be accepted and appreciated, user needs should be considered.

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Analyse and define how to achieve acceptance among users

Acceptance depends on whether the user chooses to use the product, or if a person is targeted by the product in public spaces. Also, the user should get some benefit from the product / feature. It is also important that the system is reactive, and understands if it is not working well. Also, be aware of cultural differences and how they might affect the attitudes towards empathic products. For example, perception of public space vs. personal space and emotion-sensing in general differs in different cultures.

Define high level user experience goals

Set 1 to 4 high-level UX goals. UX goals help in communicating the experiental aims between the design team and other stakeholders. In order to design for a specific kind of user experience, you need concrete and focused UX goals. High-level UX goals are elaborated to design implications and further to functional requirements and measureable UX targets.

Determine the relevant emotions for the application

Based on the goals of the application define what emotions are relevant for the application. Consider whether the basic emotions are enough or more are needed. While used in many systems, basic emotions are not always that useful in real-life scenarios, so be prepared to consider with an open mind and a wider perspective what emotional or cognitive states, or intentions of the user are the most relevant ones to the specific empathic product concept. The consideration from the user perspective should be done in parallel with considering the limitations and possibilieties of technologies – it may turn out that the existing technologies for identifying basic emotions can be extended to classifying other kinds of application-relevant user states as well.

Determine what should be sensed from the users

Based on the relevant emotions for the application, define what should be sensed to identify them (gestures, facial expressions etc). Also, considering how the emotions are generated, i.e., what causes the emotions help in accurate sensing. E.g., according to the appraisal theory, agents appraise their environment and that causes the emotions. Personality affects this. Thus, there is a need for a personality model to be able to predict the emotions as for example, different people can have different expressions for emotions, and one expression can mean different things in different situations.

Furthermore, consider time aspect in this, as time is important aspect when sensing user emotions. There are short term empathic states, long term, and very long term states. System has to be aware of this to base its reactions on correct time frame (sensing - observation - actuation chain). I.e., there is physical signal to sensor, sensor is transferring it to observation, then the system is translating this into observation of empathic state and then acts as has been defined.

Design response

Expressing empathic response is application dependent. Designing the response has to be done carefully. This is critical as the applications are meant to deal with the user in very personal way, and may also generate emotions, thus if there is a mistake, it has much more impact. The response has also implications on what should be sensed, i.e., one may constrain the other.

An event can generate many emotions so which one to consider in priority is difficult to decide. One possibility is to use the intensity of emotion and to show the most important or the most expected considering the context. Another way would be to show mixture of the emotions.

Note that, there is a difference in response desing for system that serves the (main) user or system that serves another (secondary) user, thus the goals of the application should be considered when designing the response.

Analyse and define models for interacting with the user

Based on definition of relevant emotions and the designed response, one should define models for interacting with users in different situations. A possibility to do this is to design several possible profilesfor a given user. The system shall analyse the needs for every profile and then estimate to which profile current user belongs. These profiles can be used by developers for interaction design. The interaction can be passive/active, or implicit/explicit. Passive interaction is more challenging to design and implement.

Consider combining statistical analysis (finding correlations from the data) and the sum of knowledge from consumer analysis (not from observing, but reasoning about how people tend to react) viewpoints.

Consider designing an empathic system that learns from interaction with the user.

In some cases it may be very useful to have a system that can learn from the interaction with the users and tune its models accordingly. Central to the self-learning aspect in empathic products, the closed feedback loop from sensing the user to taking actions that affect the state of the user corresponds to the actuation side of the system. By observing the influence of different actions on the user, it is possible to collect data that can be used to tune the system.

In some cases it may be useful to start with a learning period during which the system mainly quietly observes the users, then starts to interact with the users and learns from the interaction, building its models. This period can be associated with a calibration session, the main difference being that the calibration is not drive by a protocol imposed to the user, but, driven by the natural behaviour of the user itself. A big part of being empathic is learning user habits, and in some cases, also learning how to surprise users, and self-learning can be a useful part of that.

Define architecture

Architecture is important also for empathic products. There should be simple feedback loop (analysing the sensed data , e.g., the order and so on).

If the product involves multiple technologies, it is useful to agree on a protocol (one that partners or one of them is used to) as this helps in integration.

Take care that the product does not become too complex, e.g., due to integration of different technologies. Keep the integration process as light as possible.

Make mock-ups and simple prototypes

As it’s often not so clear what the product should be like, and the work starts from company’s own idea, it is usually not worth to make extensive models to specify it in the early phases. Instead, making early mock-ups and simple prototypes is useful. Utilising available existing techniques enables making fast mock-ups and prototypes.

Collect data

Data is important in designing and validating empathic products. First, environment where data can be collected needs to be set up, then data is collected, and then it needs to be annotated. Data collected from laboratory setting is different than from real environment.

Collection of the data needs to be planned well, including what data needs to be collected, and define a protocol and deploy solutions that record the capturing setting in order to be able to check and validate the annotation. Consider to use samples of the data (patterns) to validate other data captured.

## Design and development

*Design and development in general is done to establish and maintain detailed design solution and implementation for the requirements of the customer and other stakeholders. The process designs, creates, or fabricates a system element conforming to that element’s detailed description. The element is constructed employing appropriate technology and industry practices.*

**With respect to empathic products or features, the specific aspects include early prototyping, data collection and analysis, ethical aspects, and dealing with emotions and intentions.**

Develop prototypes

Develop protoypes to help to discover the essence of the empathic product and make sure it works. When prototyping, focusing on testing a simple component first is useful.

Keep the design simple

Product must be simple enough so that people understand what is going on when they are using / getting engaged by the system.

Consider ethical issues in design choices

Design choices have a direct connection to some ethical questions: how the product is designed, what features it has, affects how it is used and how it is perceived.

Ethical issues involve more than privacy, specifically for empathic products, as the products are often trying also to affect the people’s behaviour and emotions. People are bad in evaluating short term and long term reward, so the designer of empathic products have to be careful with these issues.

Prevent misuse of the system

The misuse of the system should be prevented as far as possible. Although, any system can be misused, design choices can decrease the chance of misuse, e.g., personal data should not be stored, and there should be strict access control.

Collect data and tune models and classification algorithms

Data collection and developing and tuning the models and classification algorithms is usually needed and even critical in the design of empathic products

While there can be considerable case-by-case differences in what kind of data is needed, often it is useful have data from situations in which people express different kinds of emotions – and usually it is beneficial of even necessary that people actually experience emotions, not just fake different types of emotional states.

E*licitation of specific emotions* for the purposes of data collection can also be done: for example, putting participants of a laboratory experiment or some other kind of trial in situations in which they are likely to experience and express joy, sadness, anger, or other specific emotions.

Think of how to deal with the inaccuracy of detection.

In most practical environments the emotions, intentions, or other attrubutes of the user can never be expected to be recognized with 100% accuracy. Good design takes this into account, by providing ways for the incorrect interpretations of the user state to be smoothly corrected and by avoiding putting the user into uncomfortable situations as a result of incorrect interpretations.

Consider the temporal duration of the emotions and intentions when deciding on the relevant user states to measure in a given application.

Emotions and their expressions are often transient, a quick smile or an expression of sadness, for example, in response to something that is gone in a fleeting moment. Tracking of these transient emotions can be in central role in various kinds of applications, but often it is useful to consider also more persistent and continuous states of the user..

Separate data streams and the data use

There should be strong distinction between data streams and the purpose for which they will be used (e.g., location information and it’s usage). This has to be well in control and to ensure, that the data does not travel any more than it has to. The more personal the data is, the more carefully must be ensured, that only necessary data is collected. For example, one should take care of that the data does not leave some environment (i.e. home network) / device (i.e. TV set-top box) etc.

Consider using standard representation for output

EmotionML is recommended to be used for output outside the module, but not necessary to use internally in the module. EmotionML yields however high data overhead, and thus is most useful for external communication and data annotation

## Verification and validation

*Verification and validation in general is done to provide confidence that developed and acquired products and services satisfy specified requirements and operational needs. Verification confirms that the specified design requirements are fulfilled by the system and validation provides objective evidence that the services provided by a system when in use comply with stakeholders’ requirements, achieving its intended use in its intended operational environment.*

**With respect to empathic products or features, the specific aspects are mainly related to validation, as there are no clear stakeholder requirements to validate against, and the intended use is also being defined during development.**

Plan validation and verification

The verification can be done similarly as for other product features (testing, inspections etc.) The methods for validation can range from a light user questionnaires that can be applied in-house by developers to more extensive experimental setups carried out by external consultants or research groups. Observing and using questionnaires are complementary ways to validation.

Validation needs to include both, technical and user viewpoints. The users are not necessarily easy to find, and how to elicit them to participate requires a lot of thinking. The developers and people who understand the technology are good to use as users in the early stages, but later on, the real users, that are not familiar with the technology, and not used to behave in a certain way, e.g., to make the gestures so, that the system can interpret it correctly, should be used.

Define goals for validation (incl. piloting)

The goals of piloting, i.e., what is wanted to be learned should be defined in the beginning. For example, can the system detect the relevant emotions or intentions in real-world environment with sufficient accuracy? Is the empathic interaction approach that you have planned intuitive and fun to the users? The questions may vary with the design phase and the type of the product, However, allow also for accidental discovery, i.e., learning also other things than the goals for the piloting are about.

Carry out piloting

Piloting should be done in both controlled and real environments. In early stages it’s good to pilot in controlled environment to learn to understand the technology. Controlled environment makes it easier to analyse anomalies and errors. Real environment is needed to test the impact of elements such as lighting, noise, etc. Also, the product needs to be fairly ready with respect to the conditions experienced in real environment in order not to give bad impression to future users and customers

When doing real environment piloting, if the product is doing something visual, the content should be good looking and polished as the impression can impact people’s opinion about the product more than the technology in itself (if technology works, but the visual look is bad, people may consider the product bad).

Observing the users during piloting is useful, e.g, by taking a video of the pilot situation, or being present there.

Analyse piloting results

Piloting results should be analysed, e.g.., sensor data should be objectively validated by a person. The analysis should response to the piloting goals, e.g., to analyse whether the system has understood the user correctly.

During analysis, consider if some other issues have affected the results, for example the completeness of the product during piloting can have an effect, as before a new kind of empathic product is completely finished, test users may reject an unusual idea. They may need to see it completed before they can truly understand and appreciate it

Products should be very well tested before bringing them to market

Depending on domain and application robustness / correctness is often critical for empathic products. For example, wrong advertisement shown to the user could be acceptable, however, wrong directions to the user or wrong classification (e.g. sex and age) of the user are probably not acceptable.

# Examples of empathic products of different categories

## Introduction

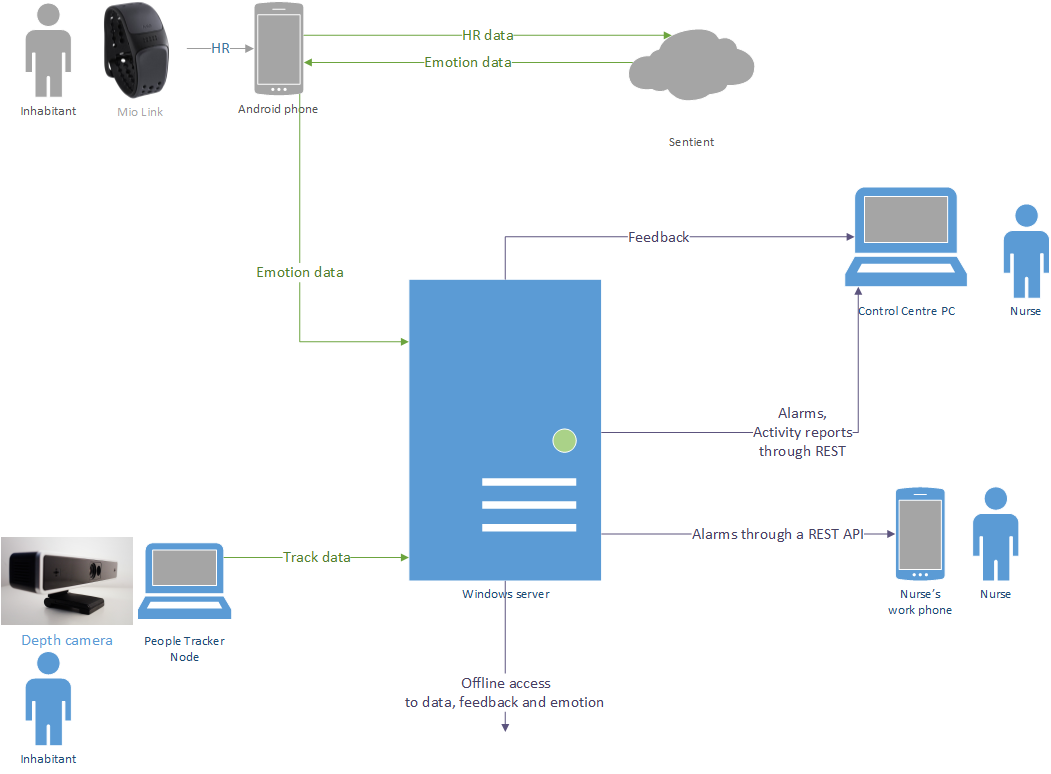
This chapter provides concrete examples of empathic products, showing how empathy can work in practice, and what kinds of technologies and design choices are involved.

## Examples of empathic systems developed in the cycle cases of the Empathic Products project

### Intention-aware Elderly Care

In the Intention-aware Elderly Care cycle case we built a system that provides information about the activity level and emotional status of elderly people to elderly home personnel. It also enables elderly people to live at home longer and provides security for them and their relatives.

The system tracks the activity of elderly people and analyses their movement patterns inside their apartment. The goal is to determine the overall activity level of the inhabitant and to evaluate whether he/ she behaves normally or something alarming is going on. In order to do it, the system leans patterns of normal everyday behaviour, e.g., typical wakeup times, and typical distribution of motion trajectories over time and space. Then the system compares current day with the learned patterns of normal behaviour and calculates its activity score, i.e., an estimate whether current day’s deviation from the learned patterns is relatively small or alarming. These activity scores are visualised and presented to nurses, relatives or other caretakers, showing them changes in activity over last month or a longer period of time. If an activity score of some day is too low or too high, it may indicate that the monitored person is feeling unwell. If the amount of daily activity has a downward trend, the elderly person might have physical or mental issues that need scrutiny. Similarly, if the nightly activity is on the rise, it indicates sleeping problems, which can be a sign of other wellbeing issues. The system also enables us to detect repeating movement patterns typical to some mental health or dementia related seizures, giving an immediate alert to caretakers. We are also analysing the emotional valence using heart rate and analysis software developed by Tecnalia.



The elderly inhabitants do not have to “use” the system in the traditional sense. All they have to do is live their lives as usual, and the system provides them better security and care indirectly by reporting to the nurses and relatives when the inhabitants might need more attention. The purpose of the Intention-aware Elderly Care system is to facilitate communication between the elderly and their caretakers by informing the caretaker if the elderly inhabitant might be in a need of special attention.

Offline storage and later access to the sensor data has been very valuable. The data transfers from the pilot site do not always work reliably, but the People Tracker system stores its measurements locally on each node. If the data does not transfer reliably to the server providing the results to the nurses the results are of course partly flawed and need to be marked such. However, getting access to the data later allows us to analyse it and tune the algorithms to cope with incomplete data.

Another significant issue in these kinds of applications is access to the “ground truth”, i.e. what really has been happening in the apartments. Providing feedback about this - in effect labelling our data - is just extra work for the nurses taking care of the inhabitants, so it has to be designed in such a way that the nurses will see that they get benefit from providing the feedback. In this pilot our feedback collection has been on a simple “normal” / “bad” day scale as we have been initially interested in generating warnings about “bad” things happening, and that does not require too much extra effort from the nurses. We have been promised some access to more accurate data from the pilot site’s daily records to a) get information about what kinds of things are recorded and b) update the reasoning engine with this knowledge.

Using an “activity level” score has seemed to be a bit too abstract concept for the nurses to take into use in their daily work, even though it shows easily understandable trends: the inhabitant has been more or less active than normally. It is possible that tying the activity to real-world values such as number of metres walked per hour during night-time could be more useful.

### EmoShop

The main idea behind EmoShop is the fact that shops and shop like environments should provide individual services to act on customer needs to offer added value compared to online shopping. The system built observes customer behaviour to detect specific situations in shop like environments, such that appropriate personal service can be provided. As this is a very general concept, we limit the detected behavior to hesitation behavior.

The EmoShop system detects people, tracks their positions over time and from the movement pattern and head orientation estimates, it detects whether the people are hesitating or not. Considering the complexity of the system, the cycle case is setup in such a way that for the critical components, two partners offer a solution. For the people tracking technology, both Noldus and VTT have a tracking system available. Noldus uses a monitoring system consisting of multiple video cameras that capture the scene from different angles. The reason to use multiple video cameras is to capture 3D information of the people detected in multiple views and to limit occlusions as much as possible. The people tracking technology of VTT consists of non-overlapping depth sensors to capture people in the 3D world. For the head orientation feature, both VicarVision and Lille University developed a head detection and head orientation estimation module based on different methods. Only the final module, which is the hesitation detection module, is a completely new module, designed specifically for EmoShop by VTT.

As data collection is always troublesome in case of recognizing natural behaviour, we used actors to perform (non-)hesitation behaviour in a controlled environment, which is completely annotated by a human observer, and use this data to train the hesitation detection module. If this training data suffices for the hesitation detection in a natural environment, follows from the pilot, where again part of the data is manually annotated.

To be an empathic system, ideally the Emoshop should provide some interaction with the subjects captured by the system. We investigated three possible feedback loops: (1) by a screen providing personalized feedback by means of an avatar, (2) by feedback on the subject’s smart phone, and (3) by instructing the personnel of the shop to help the customer. Option 1 is developed in another cycle case within the Empathic Marketing domain called Empathic Billboard, where an avatar addresses a customer in person. Therefore, this option is not considered in EmoShop. The technology to provide feedback by a smart phone is available from Noldus and the smart phone can be linked to the tracker by using the iBeacon module implemented by Comland, but due to privacy legislation, the subjects must give their consent for installing a dedicated application. Therefore, it is useless in the hesitation detection context as the subjects will mostly be new customers and hence will not have the app installed. The last option is to trigger the personnel to help the subjects. This is the most viable solution in the EmoShop cycle case and is supported by the developed analysis module.

In the design of the EmoShop cycle case, we included several potential pilot partners from the beginning, including a shopping mall, a supermarket and a service-based shop. This involvement taught us several things. First of all, the actual paying customer is really interested in the analysis of their customers. It gives them insight in how to design the shopping space and where to place the advertisements or the new products. However, they also desire to use the monitoring system for analysis besides its intended behaviour, such as observing the behaviour of their personnel, or as an alternative security system. Hence, in the exploitation of the EmoShop system, we need to address and guarantee the privacy of the observed subjects.

### EmoTuner

EmoTuner is an application for people with Autism Spectrum Disorder to help them train their social skills. Unlike typically developing children who start smiling and responding to smile between 6 to 8 weeks of age, children with autism often do not engage in this “social smile”. Actually the lack of social smile is one of early signs for autism. People with autism have to learn the social skills that come much more naturally to their peers. This includes learning to choose socially acceptable responses and emotional expressions in various social situations.

EmoTuner combines known teaching methods for ASD and emotion recognition into a game. The application presents a social situation to the user in the form of images and accompanying text. The description of the situation is given along with relevant social cues and others’ perspectives. The application then asks the user to choose an acceptable response to the situation and model the appropriate emotion. The emotion recognition engine analyses the user’s facial expression and decides whether the user successfully modelled the emotion. The user is given points/awards for correct answers and appropriate facial expressions.



The application is designed having the specific needs of the target audience in mind. The interface is simple to help user focus on the current task, but uses various visual cues to help the user better understand the task (e.g. emoticons for simplified representation of emotions) or the mechanics of the application (hover effects to help with navigation, stacked token images to show how many rewards have been collected, etc.) The reward system is customizable, with different dificulty levels and possibility to choose token images that are meaningful to the user. The user is always addressed with positive messages, encouraged to try again and never “punished” for not following the instructions or choosing the wrong answer.



# Conclusions

In this document we have discussed the concept of empathic products from different perspectives, aiming to combine relevant background information with practical experiences and insights from the Empathic Products project into a text that can hopefully provide guidance and references when planning and conducting the research and development for the next wave of empathic products. Due to the multidisciplinary approach needed for successfully designing and developing empathic products, we feel that very compact design guidelines without a somewhat wider perspective to provide context would not have adequately served their purpose. While this document barely manages to scratch the surface on some of the topics related to design of empathic products, we like to think that it has captured the most significant lessons learnt so far in designing empathic systems, and provides a starting point to inform and inspire future work.

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