Emotion Detection by Event Evaluation using Fuzzy Sets as Appraisal Variables

Michael Kotzyba, Barbara Deml, Hendrik Neumann (michael.kotzyba@ovgu.de)
Otto-von-Guericke University, FMB IAF-Human Factors Engineering, 39106 Magdeburg, Germany

Stefan Gluege, Kim Hartmann, Ingo Siegert, Andreas Wendemuth
Otto-von-Guericke University, FEIT IESK-Cognitive Systems, 39106 Magdeburg, Germany

Harald C. Traue, Steffen Walter
University of Ulm, Medical Psychology, 89075 Ulm, Germany

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Introduction

A very important and challenging task in cognitive science is the detection and modeling of human emotions. On the one hand, computers could benefit from that, because emotions play a significant role in rational decision making, perception, learning, and a variety of other important cognitive functions. On the other hand there is a need for genuinely intelligent computers that adapt and interact with human users in a natural way. To achieve this goal, computers need the ability to recognize and to express emotions (Picard, 1997).

Even for humans it is difficult to recognize the emotions of other persons. But this is not always evident because we use knowledge about the situational circumstances. For example, if a person is getting failure messages for a long time while using a computer program, it will be obvious that the facial expression is anger. Without this situational knowledge it is much more difficult to be empathetic. Therefore, computers should also use knowledge about the situation or the event to detect human emotions.

The appraisal theory is an emotion theory providing a model for evaluating a situation or an event in terms of relevant variables. In this work we present a framework which maps the evaluation process from appraisal theory to a fuzzy model in order to derive the emotions of a user in a specific situation/event.

At first we give a short introduction to appraisal theory. Then we introduce our fuzzy model of appraisal theory. Finally the model is evaluated on recorded data of a human-computer interaction in a Wizard-of-Oz scenario.

Appraisal Theory of Emotion

Almost all emotion theories assume that the specific kind of emotion experienced depends on the result of an evaluation process of relevant events (Scherer, Schorr & Johnstone, 2001). Thereby it is evaluated how these events affect the well-being of the organism. Appraisal theories attempt to specify the nature of criteria used in evaluation in terms of different appraisal variables or dimensions. Examples for these dimensions are "goal significance" representing the goals and needs that are of high priority at the moment (e.g. the goal of survival, maintaining social relationships or win a game), or "urgency" representing the need for an action.

In Ellsworth and Scherer (2003) it is suggested, that the given appraisal variables allow to deduce an emotion as the most probable emotional reaction to a certain event. For example, joy or happiness will occur, if the appraisal values for the variable "goal significance" are high, while the value for "urgency" is low etc.

Implementation of Appraisal Theory

In this section it is described how the model has been developed and how it works using a fuzzy model (Kahlert & Frank, 1993; Michels et al., 2006)

Appraisal Variables as Fuzzy Sets

In this implementation ten different appraisal variables are used (cf. table 29.2 in Ellsworth & Scherer, 2003). To operationalize the appraisal variables and their linguistic values, each appraisal variable is modeled as a fuzzy set. The fuzzy sets consist of several fuzzy variables, depending on the number of postulated values of the appraisal variable. For example, "urgency" can have five different values ("very low", "low", "medium", "high", "very high") and thus it is modeled by five corresponding fuzzy variables. Each appraisal variable is mapped to a uniform number range from 0 to 100. The corresponding fuzzy variables are distributed uniformly in this range. For simplicity we use a triangle function to model a fuzzy variable.

Using all ten fuzzy sets, we are able to model both the emotional state of the user and a possible evaluation of an arising event in terms of appraisal variables. In Figure 1 a systematic overview of the framework is given with an event and the user state with ten appraisal variables (av).

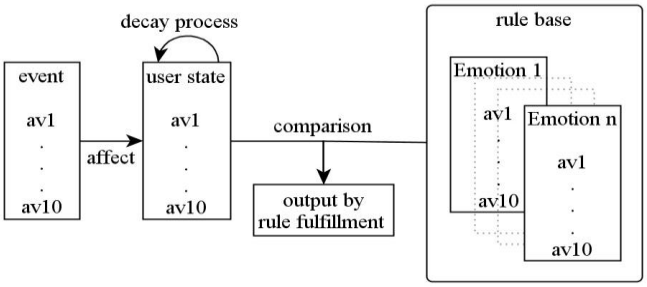

Figure 1: Conceptual view of the framework

Adapting the Emotional State

According to appraisal theory, the emergence of an event triggers an evaluation process. To model this process, the fuzzified appraisal variables of an event can be used to adapt the corresponding variables in the user state. For example, an event with high "goal significance" should affect the user's condition for "goal significance" positively. In which manner the events affect the user's state is not trivial because humans interpret events and their relevance differently. In the simplest way, the appraisal variables of an event can affect the user's emotional state directly by overwriting it (cf. left hand side of Fig. 1).

Derivation of Emotions

As stated above, the appraisal variables can be used to deduce an emotion as the most probable emotional reaction to a certain event. Each emotion is described by appraisal variables with specific values. From this specification one can generate a rule base for each emotion. To derivate an emotion, the postulated emotion profile and the user state can be compared to calculate the fulfillment of the emotion rule base (cf. Fig. 1).

Experimental Evaluation

To test our framework, we use a dataset of 18 test persons playing the popular game "concentration" aka "memory" on a computer. While playing, the test person is supported by a computer assistant, imitated by the investigator (Wizard-of-Oz experiment). Each test person plays six games, also called experimental sequences (abbr.: ES). The ES are designed to provoke different emotional states. We focus on the ES2 and ES5, because they represent emotional extrema: In ES2 a simple card set, low time constraint and positive feedback by the assistant provoke a pleasant or positive feeling i.e. happiness. ES5 includes a difficult card set and the assistant gives negative feedback to provoke negative feelings, i.e. anger. For more details concerning the dataset, see (Walter et al., 2011).

To apply the model, all possible events (like a hit or neg. feedback) were extracted and possible evaluations regarding the corresponding appraisal variables were formulated. For example, it is plausible that turning over a pair of matching cards is considered as goal significant while receiving neg. feedback is considered as unpleasant. For simplicity it is assumed that an event affects the emotional state of the user directly. Since emotions have a short duration, a decay process is implemented (cf. "user state" in Fig. 1). At this point it is assumed that a "neutral" user state will be reached if all appraisal variables receive the value "medium".

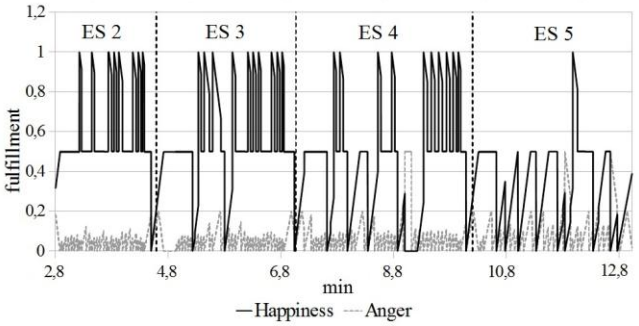

Figure 2: Rule fulfillment over ES2 up to ES5

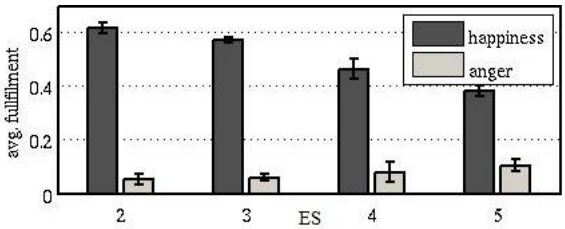

Figure 3: Average rule fulfillment over all test persons

In figure 2 the results for the ES2 up to ES5 of one test person are illustrated. In this experiment we only use the rule base to derive happiness and anger. The values in the diagram represent the fulfillment of the two emotion rules, calculated by the model, based on the events that occurred in the sessions. In comparison to ES5 the values in ES2 for happiness are higher and anger occurs only slightly. In ES5 the values for happiness are reduced and anger is increased. Figure 3 shows the average values of rule fulfillment for each ES over all test persons. Here one can discover the same pattern for emotions as in Fig 2. These results confirm that the appraisal theory is applicable in terms of the presented model.

Outlook

Humans interpret events and their relevance differently. For that reason the focus of future work lies in event evaluations via appraisal variables and whose derivation from available data. Possible sources can be audio, video and psychobiological data. Further the dialog between the user and the application, as well as the environment and the personality or the user's mood should be considered, too.

Other important issues are the decay process of emotions and the occurrence of multiple events.

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