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PhD Thesis Abstract

AFFECTIVE PERSONALISED CONTEXT AWARE SYSTEMS

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Keywords: Context Awareness, Affective Computing, Personalisation, Ontologies.

1. Introduction

The **research domain** of this thesis is the intersection area between the domains of Context Awareness and Affective Computing, named here Affective Awareness.

The **objective** of this thesis is to create a framework designed for context aware applications developers. The proposed framework consists of models, methods and algorithms. It allows one to model, represent, acquire and interpret user's affective states and to adapt the behaviour of the context aware applications. The adaptation is made based on the user's affective (emotional) response, in order to comply with the user needs and preferences, which may vary in time.

We **approached** the objective by introducing affective elements to each of the important architectural components of a context aware system. Thus, we add user's affective states detectors to the contextual data acquisition part. The context model is extended with affective information. And the adaptation to the context is optimised by interpreting the user's affective response to the system's decisions.

2. The State of the Art

According to the research literature there are different problems categorized according to where they appear in the structure of a context awareness application: modelling, instant context elements values acquiring and adapting the behaviour to the context. The actual solutions for applications' preferred behaviour are based on action-condition rules that were hard to edit or on high complexity solutions (e.g. Meta-Bayes networks) that increase in complexity as the context elements number increases. Moreover, the representation of these preferences was made without allowing an update of the values of these preferences at runtime and without memorizing them in the context ontology.

In order to discover the preferences we used the affective reactions, quantified by the valance parameter, which measures the subjective level of the user's satisfaction. But there are two important missing issues within the research literature. First, there was no rigorous evaluation method to detect the affective states and consequently the corresponding valence for spontaneous emotions and non-intrusive detection (facial features). Therefore, one could not determine the precision of the measured valence. And the second, the assessment of the affective states, especially the secondary affective states, was difficult and did not take into account the current context elements' values that worked as emotion induction or catalyst factors.

Regarding the affective states modelling, at the moment of our proposal, in the research literature, the following elements where left out from the affective and context models: the parameters of the affective states (valence, activation, and intensity), the relations between different type of states (current, basic, secondary) and the relations between the affective states and the other context elements. Moreover, the affective states modelling lacked the distinct dimension of intensity (supposed to be, without any precise demonstration, present by default and proportional to the distance between the position of the state and the origin of the activation-valence plan) and also a more nuanced relation between the basic and secondary affective states.

3. The Original Contributions of the Thesis

A. The Unified Affective Model named **Fuzzy Logic Activation Valence Intensity** (FLAVI) allows the quantisation of the activation-evaluation space and its personalisation by using fuzzy logic.

The quantisation is based on the statistical definition of two fuzzy sets for the representation of the membership of the secondary state to each of the basic states. After testing the hypothesis that the intensity of the affective states are proportional to the distance between the position of the state and the origin of the activation-valence plan, it was proved that the model should also include the intensity axis. We also proposed a model construction methodology. It contains two algorithms one for the personalised model PersFLAVI and one for the general model GenFLAVI-P/CI with two variants (P-probabilistic, and CI-confidence intervals) [C4][C11] (Chap. 3.1).

Discussion: This model bridges the dimensional affective model (i.e. activation-evaluation) and the discrete ones (enumeration of affective states). In relation to the existing dimensional models it has the advantage of experimentally clarifying the need for the distinct dimension of intensity and a clear, mathematical, yet personalised (fuzzy) relation between the secondary affective states and the basic ones. It allows, to both the engineer and the psychologist, to describe more accurate the affective states and their relations in an application on a computing or telecommunication system.

B. The Extended Context Model with Affective Elements named **SOCAM-FLAVI**. We extended the SOCAM (Service Oriented Context Aware Middleware) ontological context model in order to include the FLAVI affective states model containing detailed affective elements not accurate enough in the ontology for user description GUMO (General User Model Ontology). The new model, SOCAM-FLAVI, allows, in addition, the ontological representation of the relations between the current affective state, secondary and basic affective states on one side and the relations between the affective states and the context, on the other [C7] (Chap.3.2).

Discussion: The utility of this extended model consists of the possibility of adapting the context aware application behaviour to the user context also for which we also detailed especially the current affective state. Consequently, the applications may become mode empathic to the user desires expressed by emotional reactions.

C. The **Context Affective Secondary** (ConAff2) Assessment Method for the assessment of secondary affective states from context in real-time. The first variant of the method is based on the User Profile, and the second, and improved one, is based on a Neural Network that personalises the assessment trained by the user's behaviour patterns [C6] (Chap. 4.1).

Discussion: Nowadays there are a small number of methods for direct measurement of the secondary affective states. This method is innovative because it proposes the use of user's context. It is a deductive method compared to the existing methods that extract the affective data from different user parameters (visual, postural) and that are complex and quite intrusive. Because it is a complimentary method, we may see the advantages of combining it with the methods based on user parameters analysis.

D. The **Affective Valence Empirical Determination** (AVED) three level values Valence Computational Method. It is a time based analysis of the samples corresponding to each of the basic affective states detected by the dedicated software (FaceReader) for the current state and according to threshold values determined empirically [C9] (Chap. 4.2.3).

Discussion: It is a practical solution to the issue of inaccurate determination of the valence intervals for the existing simple linear calculation, especially in the neutral valence domain of values. It has the advantages of a more stable valence values due to the mediation in time of the samples corresponding to the basic affective states provided by the emotional assessment tool and the personalisation of the threshold values for the three levels of valence.

E. The **Facial Assessment for Natural occurring Affective states in Real-time - Evaluation Method** (FANAR-EM) is designed to evaluate the precision for the affective states detectors, working in real-time for spontaneous natural occurring affective states.

We applied this method to FaceReader, the software that automatically assesses the basic emotion values based on facial features, in real-time. We considered the case of facial features expressing spontaneous affective states induced by presenting IAPS (International Affective Picture System) images to the subject in comparison with previously determined valence values and the validation with three human experts [C9] (Chap. 4.2.2).

Discussion: The proposed method is looking forward to establishing some clear landmarks in the evaluation methodology for affective states detectors missing at that moment in the literature. The particular case of determining the current affective state valence is analysed as an example. In order for it to be valid, the method uses from Psychology a consecrated set of pictures for inducing emotions (IAPS) presented randomly to the user. We also compared the resulting valence values obtained after applying the method with the evaluation made by three human experts.

F. The **Personalized Affective Valence Determination** (PAVD) Method increases the percentage of correct valence detections, with 3 and 9 levels, in real time, from facial features. The case of facial features detection corresponding to spontaneous feelings by presenting images to the subject has been taken into consideration. Supervised learning was used for the personalisation. For the basic affective states assessment we used FaceReader software tool [C9] (Chap. 4.2.4).

Discussion: The situation before this proposal was that the detection method was a general one, meaning that it did not take into account the physiognomy particular features and neither the subjective particularities of the way the individual felt these affective states. The method proposed here includes the user (subject) in the tuning loop of the detector for the training phase and has the advantage of increasing consistently the detection precision of the valence of the current state in the real time running phase. The same principle can also be used for increasing the precision for determining the basic affective states.

G. The **Affective Controlled Behaviour Adaptation Mechanism** (ACBAM) is a behaviour regulation mechanism for context aware applications. It is based on the user's affective reaction to system's decisions. In order to prove the concept, we applied it to a smart house application.

The mechanism allows the discovery, storage and usage of preferences in order to meet the user's needs which are constantly changing.

We designed and implemented the multiagent system on the JADEX platform using TAOM4E, we created the Smart House ontology, and we integrated the Phidgets sensors and actuator. The representation of behavioural preferences of a context-sensitive system was made with the weights saved in files, while the context and the actuators were represented in the ontology [C5][C1] (Chap. 5).

Discussion: The situation prior to the proposal was that the context-aware systems had a predefined rules behaviour set at fabrication or with rules that were difficult to be edited by the user. The advantage of the mechanism is that it allows the discovery and adequacy to these preferences. This mechanism is useful for the user that sees in the system a smart companion that learns his preferences. It also eases the system's maintenance work in the sense that it does not have to be periodically reprogrammed by a specialist. Moreover, by using ontologies, this knowledge about the preferences can be reused, which is useful for the user as well as for the developer.

4. Future Work

The research in the thesis has generated some open problems and directions for further research. The main research directions are:

A. The modelling of affective states in the context-aware systems:

- the constant optimization of the FLAVI model by involving the user in the tuning loop,
- the usage of a computational cognitive model of emotions in order to determine through deduction/derivation the affective states by using assessment variables (relevance, desirability, expectancy etc.).

B. The detection of affective states:

- the creation of temporal models for facilitating the detection of secondary affective states from facial features (using, for example, the FaceReader software),
- the increase of the correct classifications percentage of the affective states (basic and secondary) through personalisation, following the method applied for valence (PAVD),
- the exploration of the multimodal detection of the affective states in mobile context.

C. The adaptation of context-aware applications with an affective personalised behaviour:

- the adaptation of a context-aware system can be improved by using an appraisal model of emotions by an emotional conversational agent that offers an interface with emotional features to the user,
- the storage of behavioural personalisation parameters in the ontological representation would allow the reuse of that user’s behavioural preferences in a similar context,
- the comparative study of fast and persistent solutions for learning the behaviour of context-aware systems, based on the user's reaction (feedback).

Author's scientific publications

A. Books

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