Adding Real Data to Detect Emotions by Means of Smart Resource Artifacts in MAS

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ABSTRACT

This article proposes an application of a social emotional model, which allows to extract, analyse, represent and manage the social emotion of a group of entities. Specifically, the application is based on how music can influence in a positive or negative way over emotional states. The proposed approach employs the JaCalIVE framework, which facilitates the development of this kind of environments. A physical device called smart resource offers to agents processed sensor data as a service. So that, agents obtain real data from a smart resource. MAS uses the smart resource as an artifact by means of a specific communications protocol. The framework includes a design method and a physical simulator. In this way, the social emotional model allows the creation of simulations over JaCalIVE, in which the emotional states are used in the decision-making of the agents.

1. Introduction

In the last years, there have been different approaches for using MAS as a paradigm for modelling and engineering emotional recognition for human beings. Human beings perceive and manage a wide range of stimuli in different environments. Each one of these human beings live and interact within many different environments, generating a variety of stimuli that affect in different ways every human and modify the emotional states of them. These stimuli interfere in our commodity levels modifying our emotional states. Before each one of these stimuli, humans generate responses varying our face gestures, body or bio-electrical ones. These variations in our emotional states could be used as information useful for machines. To do this, it is needed that machines will have the capability of interpreting in a correct way such variations. This is the reason for the design of emotional models that interpret and represent the different emotions. In this case, emotional models such as *Ortony, Clore & Collins* model (Colby et al., 1989) and the *PAD (Pleasure-Arousal-Dominance)* model (Mehrabian, 1997) are the most used ones to detect or simulate emotional states. Nevertheless, these models do not take into account the possibility of having multiple emotions inside an heterogeneous group of entities, where each one of such entities have the capability of detecting and/or emulating a specific emotion. According to this, in (Rincon et al., 2015b) a social emotional model which includes multiple emotions between humans and software agents was defined. This model was based on the *PAD* model to represent the social emotion of a group.

The need for detecting the emotion of an heterogeneous group of entities can be reflected in the different applications that could be obtained. With the appearance of the different smart devices, ubiquitous computation and ambient intelligent, emotional states turn into valuable information, allowing to develop applications that help to improve the human being life quality.

In this work we propose to employ the social emotion of a group of agents (humans or not) in an AmI application. Concretely, we propose in this paper a system for controlling automatically the music which is playing in a bar. The main goal of the DJ is to play music making that all individuals within the bar are mostly as happy as possible. Each of the individuals is represented by an agent, which has an emotional response according to his musical taste. That is, depending on the musical genre of the song, agents will respond varying their emotional state. Moreover, by varying emotions of the agents will modify the social emotion of the group.

The rest of the paper is structured as follows: Section 2 introduces the problem description; Section 3 describes the different components of the proposed system; and finally, section 4 shows some conclusions and future work.

2. Problem description

The proposed application example is an extension of the developed application presented in (Rincon et al., 2015a). This application is based on how music can influence in a positive or negative way over emotional states (Whitman and Smaragdis, 2002). The application example is developed in a bar, where there is a DJ agent in charge of playing music and a specific number of individuals listening to the music. The main goal of the DJ is to play music making that all individuals within the bar are mostly as happy as possible. Each of the individuals will be represented by an agent, which has an emotional response according to its musical taste. That is, depending on the musical genre of the song, agents will respond varying their emotional state. Moreover, varying emotions of each agent will modify the social emotion of the group. The DJ agent plays a song. Once the song has ended, the DJ evaluates the social emotion of the group of listeners that are within the bar. In this way, the DJ agent can evaluate the effect that the song has had the song over the audience. This will help the DJ to decide whether to continue with the same musical genre or not in order to improve the emotional state of the group.

The solution presented has some lacks regarding the right identification of the people's emotions. It has been detected that problems arise due to pub light conditioning and high number of pub clients. Camera identification increases errors when light conditioning is very dark and the number of people increases. So, a novel more customized approach has been integrated as a new kind of artifact, that in a band form is used to perceive the emotion dynamics of each person in the pub. This new information will be correlated with the one obtained by the cameras improving the emotion detection of each individual.

Next section details how this new artifact has been integrated in the previous system, its internal components and how it interacts with the rest of the system.

3. System Proposal

This section explains the different components that constitute the system which describes a way to connect the human beings to an *Intelligent Virtual Environment* (*IVE*). Concretely, the proposed system is structured as shown in Figure 1. Following this figure the different elements of the system are: (i) the *Smart Resource Artifact (SRA)*: this element allows to capture the information of the real world. It has the capability of perceiving and/or acting in the real world; (ii) the *Environment Manager*: this agent has the task to control all the *IVE*, to register each SRA and to know where is each one of the elements composing the *IVE*; (iii) the *Human-immersed agent*: this agent is the virtual representation of the human living in the real word. This agent has the competence of communicating with each human through the *SRA*; and (iv) the *SEtA*: this agent is responsible of calculating the social emotion. This social emotion is obtained from each emotion that was sent by each human-immersed agent. Next subsection details each one of these elements.

The proposed systems employs the $JaCalIVE$ framework (Rincon et al., 2014), specially designed for the execution and adaptation of Intelligent Virtual Environments, allowing an easy integration of human beings in the MAS. This framework can be downloaded from this url: *http://jacalive.gti-ia.dsic.upv.es*. The *JaCalIVE* framework is based on the MAM5 meta-model (Barella et al., 2012). MAM5 allows to design an IVE as a set of entities that can be virtually situated or not. These entities are grouped inside Workspaces (*IVE Workspaces* in the case of virtually situated). Entities that are divided into Artifacts (*IVE Artifacts* if situated) and Agents (*Inhabitant Agents* if situated). The *Inhabitant Agents* include *Human-Inmersed Agents* that allows to model the human inside the system.

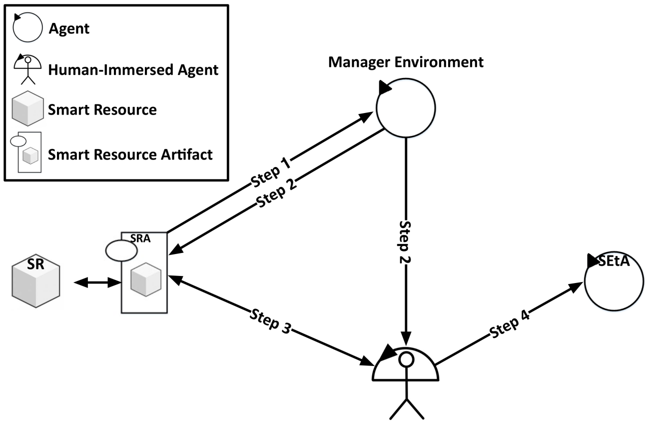


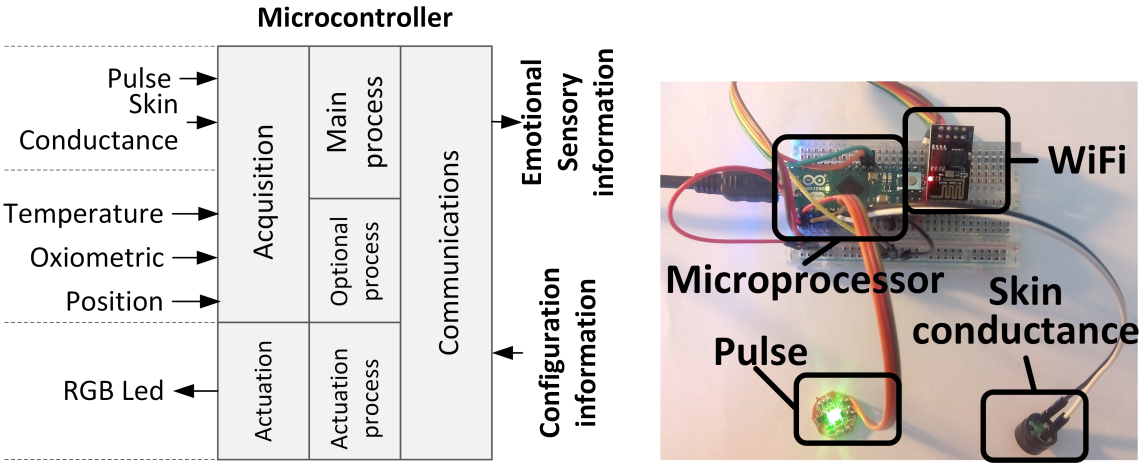
Figure 1: System's Model Design.

3.1 Smart Resources

Recognizing emotions is easy for a human looking at the face or listening the nuance in the voice of a person. Many different methods to recognize emotions automatically have been studied. One of the more extended approach is based on images and video (Sun et al., 2004). Significant improvements have been made using Electroencephalography *(EEG)* (Liu et al., 2011), due to the brain being measured directly. However, both these methods have their associated problems: video image requires high processing load, and a good environment light conditions and *EEG* is an invasive method. Consequently, it is convenient to use other human parameters, like body posture (Coulson, 2004) or body biosignals (Canento et al., 2011).

Body biosignals is a very interesting research field in automatic emotion recognitions because there are a great amount of signals that can be measured. These signals may range from well known signals like heart pulse rate or skin conductance, also known as Galvanic skin response *(GSR)*, to complex signals like Electromyography (EMG); Electrocardiography (ECG); Electrodermal Activity (EDA); Blood Volume Pulse *(BVP)*; Peripheral Temperature *(SKT)*; or Respiration *(RESP)*. Due to the large amount of biosignals it is convenient to select some of them and use a method to classify signals into emotions (Kim and André, 2009).

To measure biosignals it is necessary to use sensors. Sensors transform physical magnitudes in electrical signals. Usually, a simple process can transform the electrical signal, measured by the sensor, in a measure based in a physical unit. Nevertheless, to deduce emotions from units is a hard task (Haag et al., 2004). Therefore the sensor hardware and software measurement has an important role to play in the emotion recognition process. Sensors are placed on devices that can measure from different sensor types and different sensors sources, in this case the devices are called smart devices or smart sensors (Meijer et al., 2008). If there are a lot of smart devices, communications between them, and between smart devices and network servers (for example to store historical measures) is an important challenge. In this latter case, the smart device must increase his connectivity functionality offering services to the rest of the system. Devices are perceived by others as a resource that offers services, so that smart devices change into smart resources, defined in (Munera et al., 2015). Figure 2. a) overalls a Smart Resource specifically to bio-signals. Among all the sensors of the Smart Resource, some sensors can be mandatory and others are optionals. Required sensors are those without which clients connected to the Smart Resource, can not detect the emotions, for example, pulse range. Optional sensors, allow clients to increase the reliability of the emotion detected, for example a temperature sensor. Actuators, in smaller quantity that the sensors, are in general optional. Both, sensors and actuators, have a process step to pre-process sensor signals and adapt them to the agents requirements or to convert actuator orders to signals comprehensible for actuators. Finally, a Smart Resource has a communication step that join the real smart resource with its corresponding *SRA*.



(a) (b)

Figure 2: Biosignal Smart Resource: a) designed and b)implemented.

There are many reasons to use a Smart Resource in the context of biosignals treatment. Some of them can be highlighted. The main advantage is the possibility to select different biosignals and, consequently, adapt the measurements to the user experience. Additionally, a Smart Resource can select the most appropriate biosignal in each moment. For example in a cold environment, temperature sensor can not offer an accuracy value. In this case the Smart Resource does not measure, but estimates the temperature values. Other benefits are the ability to adapt communications characteristics (for example the messages frequency) to the Quality of Service (QoS) parameters or change the processes characteristics (for example processor load or battery consumption) according to Quality of Context (*QoC*) parameters. To test system with real biosignals, a prototype of the Smart Resource has been developed (Figure (2. b)). The Smart Resource consists of an open-hardware pulse rate sensor[1] and an skin conductance (two wires sensor) connected with an Arduino Micro[2] that uses an ESP8266[3] as IEEE 802.11 interface. The main reason to use these components is the integration capacity for a future small bracelet.

Communication between SRAs and smart resources is based on access to services. The smart resource offers an interface to the services as used by its SRA wrapper by following the proposed protocol shown in Fig. 3.

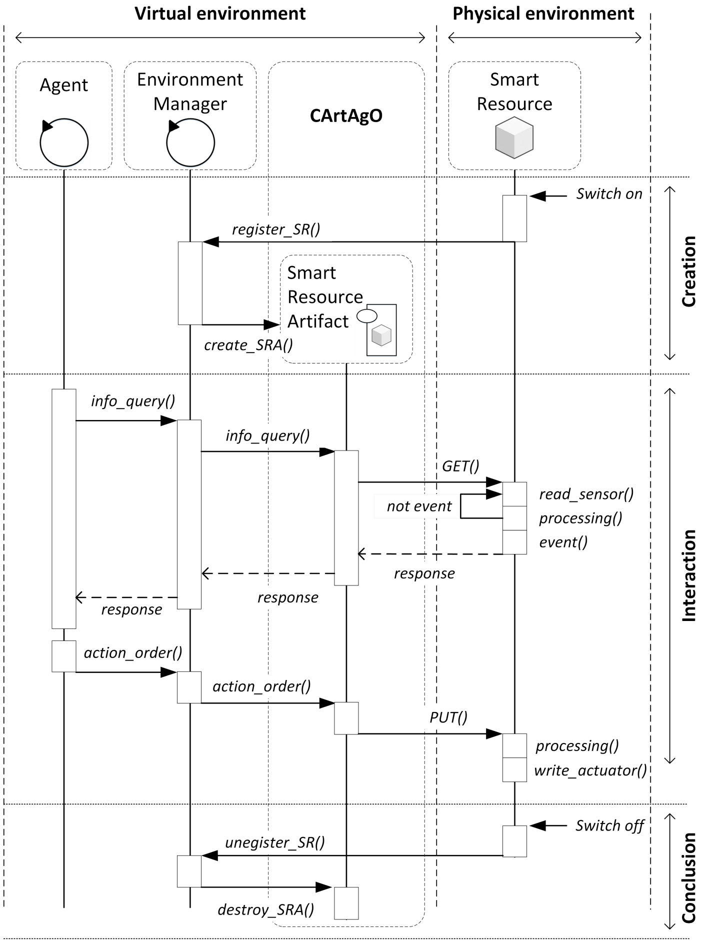


Figure 3: Protocol to work with a SRA based on a smart resource.

When a smart resource is switched on, it initializes sensors, actuators and communications and then connects to the *environment manager* agent in order to register itself in the virtual environment. For that, *SRAs* only need to know the IP address of the *environment manager* that is public in the system. Once connected, the smart resource sends to the *environment manager* an XML message with its identification, location, and the resources or services

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[1] http://pulsesensor.com/

[2] http://www.arduino.cc/

[3] http://www.esp8266.com/

it offers. The *environment manager* then creates a SRA associated to the smart resource. With the information of the XML message, the *environment manager* knows how to access the resources/services offered by the registered smart resource. The XML message indicates the base URI (uniform resource identifier) of the smart resource and a different identifier for each resource/service. A resource/service can be applied for by adding to the base *URI* its identifier (for example, the temperature could be obtained with *http://192.168.1.14/resources/temperature*). Every resource/service has its own URI in the same way that representational state transfer (*REST*) services work (the sw architectural style of the WWW) (Richardson et al., 2013).

SRAs work with resources/services through standard *HTTP* operations such as *GET* (to obtain the value of a resource: for example, the current temperature) or *PUT* (to send data to update a resource: for example, to switch on/off an specific sensor). When an agent needs to access a resource, the agent makes a request to the *environment manager* that knows the associated SRA. The *environment manager* translates the request to the corresponding SRA and then this *SRA* uses the resource URI by sending a *GET* or *PUT* operation to the smart resource. In the case of a *GET* operation, the smart resource responds to the SRA with the content information of the resource by means of an *XML* message and, in the case of a PUT operation, the SRA sends to the smart resource an *XML* message with the information to be updated. In a *GET* operation, the SRA can apply for the smart resource response when an specific event happens (for instance, to receive the value of the temperature only when changes in one grade). For that, the SRA has to add to the *URI*, associated to the *GET* operation, the necessary parameters. These parameters have to include the required event that the smart resource will have to detect before sending the response to the SRA (in the case of the example *http://192.168.1.14/resources/temperature?changes=1grade*).

3.2 Multi-Agent System

This section describes the three types of agents that forms the proposed MAS. These agents are: the *Environment Manager*, the *Human-immersed agent*, and the *SEtA*. The Human-Immersed agent is mainly in charge of: (i) capture some emotional information from the environment and specifically from a specific individual, this is done by interacting with the real world through the employed *SRA*s. These interactions allow the agent to capture the different bio-signals, that will be used to detect the emotion of a human being. To do this, the agent obtains the signal preprocessing sent by the *SRA*, after this, the agent executes a signal filtering process and obtains a feature vector; and (ii) predict the emotional state of the individual form the processed biosignals. To do this, we take into account that the variation of human emotional states is a modification of our biochemistry (Carter and Porges, 2012). This modification makes that our body and our bio-signal change(Zhao, 2013). In order to analyze these changes and predict emotional states, the Human-Immersed agent employs a classifier algorithm that has been previously trained. The classifier has been trained using a specialized database defined in (Koelstra et al., 2012). This database stores a set of bio-signals obtained after different experiments using a series of music videos and 32 volunteers. The stored data gives us a set of training of 40 x 40 x 8064 entries (corresponding to *video x trial data x channel*). The database has 4 output labels that correspond to the emotional value, composed by an array of 40 x 4 with the following labels: valence, arousal, dominance and liking. This learning capability allows the agent to predict an emotional state according to current bio-signals.

Once the emotion has been obtained, it is sent to the agent which is in charge of calculating the social emotion of the agent group. This agent is called *Social Emotion Agent* or *SEtA*. The main goal of this agent is to receive the calculated emotions from all the human-immersed agents and, using this information, generate a social emotional state for the agent's group (details of how this social emotion is calculated can be seen in (Rincon et al., 2015b)). Once this social emotion is obtained, the *SEtA* can calculate the distance between the social emotion and a possible target emotion. This allows to know how far is the agent's group of the target emotion. This can be used by the system to try to reduce that distance modifying the environment. This modification of the environment is made by the *Environment Manager*. This agent is in charge of sending the appropriated actions to the corresponding *SRA*. Moreover, this agent is also in charge of registering all the agents and artifacts, and controlling where are located each one of them.

4. Conclusions and future work

This paper presents an agent-based application where humans emotional states are used in the decision-making of the intelligent entities. The application has been developed over the $JaCalIVE$ framework allowing an easy integration of the human in the multi-agent system and a visualization of the system in a virtual environment. The proposed system is able to extract (in a non-invasive way) and to analyze the social emotion of a group of persons and it facilitates the group decision making in order to change the emotional state of the group or only of a subgroup of the agents. The system incorporates automatic emotion recognition using biosignals through the use of smart resources. These smart resources are easily included in the proposed framework using an efficient interaction protocol. Moreover, as future work, we want to apply this system to other application domains, concretely in an industrial one, where it can monitor and simulate the individuals inside a factory.

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