Affective Computing: Optimizing Human-Computer Interaction through Non-Verbal Communication Based on Facial Analysis

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Abstract. Affective Computing is an Artificial Intelligence-related area that deals with the possibility of making computers able to recognize human emotions. Such task can be performed through several techniques like voice analysis, face recognition, heart beating, body temperature, and all other kinds of measurement for emotion. The present paper represents a work in progress, showing a software prototype that aims to make computers able to recognize some users' emotions through facial analysis. The main goal of this paper is to show how Affective Computing could contribute for the improvement of human-computer interaction, being part of the development of computer systems where information about users' emotion would be helpful.

Keywords: Affective Computing, Facial Analysis, Human-Computer Interaction, Artificial Intelligence.

1 Introduction

Joint studies about Artificial Intelligence and Human-Computer Interaction are obtaining a wider space in the Computer Science scenery. For many years, it was common to believe that computers could 'think' like humans in a manner they would be able to interact without the need of any intervention. Nonetheless, a very large range of difficulties were obviously found in these early studies; perhaps the most frequent one was the questioning about how to make computers able of being emotional and intuitive – which are some of human features – in order to make them 'so smart as their developers'.

One of the features that could make computers become 'like humans' is the ability to demonstrate emotions, having nearly the same emotional intelligence humans have. This is a key point in most of the researches that deals with different strategies to make possible for computers being able to talk to people, having the abilities of memorizing and learning, being adaptable, and mostly important, being able to infer what user is thinking or feeling.

Some examples of these studies can be seen through some software that show computers are already able to express some kind of emotions, like the robot Kismet, projected by MIT (Massachusetts Institute of Technology). Kismet is a robot designed to assist research into social interactions between robots and humans. It is able to, through camera-connected software, detect human emotions like happiness, sadness and surprise, and react to these emotions realizing the correspondent facial movements [7].

In fact, all conceptual basis over which these products were elaborated targets to reach a machine like HAL 9000, the supercomputer in the movie 2001: A Space Odyssey [4]. HAL was able to interact with humans in a natural way, driving the spaceship, talking with the astronauts and interacting with them in many ways like, for example, capturing their emotions at a moment and reacting according to them. This history shows that since the release of the movie, in 1968, men were already thinking about the hypothesis to create intelligent computers that would be able to understand and express the same characteristics of their creators. Researches at many Universities have been studying how to adapt features of human emotional intelligence to computers, not only to express emotions but also to recognize them for interacting with people and other computers that express emotions.

The non-verbal language, which is an important human communication feature, is the main problem that these studies try to solve. Human beings have feelings about things around them that computers don't have. A person knows if another one who is talking to him or her is happy, sad, stressed, or if he or she likes or not some situation, even though the other person says no word, nor write a thing. People simply know the nonverbal meaning about an attitude or gesture.

The most important aspect of such studies is therefore to understand the mechanism behind features of non-verbal human communication, in a way that a computer software would be able to be taught these techniques, improving the human-machine interaction, making computer use more effective, since virtually every application (from notepads through Internet browsers) would be directly connected with users' sentimental state.

This paper presents a prototype application that is designed to recognize users' faces through static images. To perform this task, it is necessary that image processing proceeds according to some rules to get an image with a better quality in order to be fit it some pre-defined emotion models, using Affective Computing techniques. It will be also discussed how this scenery of Affective Computing through image processing could be inserted in wider contexts like psychology, cognitive sciences and computer engineering.

2 Theoretical Background

Artificial Intelligence (AI) is one of the new scientific areas that attract a high number of curious people and new researchers, most of all because it studies how to understand and construct intelligent computer-based entities [8]. Many flavors of researches appeared since the first studies about AI. One of them had more repercussion and created a new, remarkable complete vision about Artificial

Intelligence, which was the classic article wrote by Allan Turing, in 1950, called "Computing Machinery and Intelligence" [10]. This paper aims to define and explain concepts now known as the Turing Test and Genetic Algorithms [8].

Turing Test refers to a test projected to evaluate the computational systems' intelligence. A computer is approved on the test if it is able to mislead a human, and make him thinks that he is talking to another human. In order to achieve this, the machine needs to have some human features like natural language processing, representation of knowledge, automatically reasoning, machine learning and computer vision [8]. The key point is to verify the technical requirements that a computer must have in order to be able to talk with someone, to have the capacity to memorize and learn things, being adaptable and to perceive what people are thinking or feeling.

Thus, the hardest challenge would be to 'put' some human emotional features in a machine. Despite the fact that some software nowadays already simulates a couple of these features, it is still an unsolved problem.

According to Turing: "'I grant you that you can make machines do all the things you have mentioned but you will never be able to make one to do X'. Numerous features X are suggested in this connection. I offer a selection: Be kind, resourceful, beautiful, friendly, have initiative, have sense of humor, tell right from wrong, make mistakes, fall in love, enjoy strawberries and cream, make someone fall in love with it, learn from experience, use words properly, be the subject of its own thought, have as much diversity of behavior as a man, do something really new." [10]

A lot of statements pointed by Turing are computationally possible nowadays, for instance, using words properly, doing something really new, learning from experience (computational learning), and other things that Turing didn't quote. A function that the computer didn't execute in the past now can be executed equally or better than a human does. Actual studies like Affective Computing, for instance, are studying how computers would be able to recognize feelings and emotions in an intuitive way through a field of perception [7].

After this small introduction about Artificial Intelligence it becomes easier to understand what Simon and Newell (1958) expected when they said: "It is not my aim to surprise or shock you – But the simplest way I can summarize is to say that there are now in the world machines that think, that learn and that create. Moreover, their ability to do these things is going to increase rapidly until – in a visible future – the range of problems they can handle will be coextensive with the range to witch the human mind has been applied." [9]

In other words, not only the researchers, but all interested in the theme expected that some day machines would be able to think, act or even substitute humans in some activities.

Under this utilitarian point of view, it becomes necessary to make computers as similar as possible to humans, simulating on them emotional intelligence humans inherently have. That's the point where this paper tries to reach, based on some theories studied in Affective Computing. The main questions are how to 'put' in the computer the ability to recognize some emotions, and how to use such emotions to interact with humans in an intelligent way according to his/her emotions expressed in a non-verbally way [5].

In order to reach the goal proposed in this research which is to create an application that is able to recognize emotions in a face, it's necessary to study topics like image processing, facial detection and other topics related to emotion recognition though different contraction points of face [3]. Such studies must be mixed in more comprehensive areas like psychology and biology. Computational approaches usually cross over the results of these studies, in a way that software would be able to understand facial expressions like a human does. Thus, through body-based, non-verbal language, it would be possible to extract different information about emotional and spiritual states from the people who is interacting to a computer.

Non-computational studies like the one done by Pierre Weil and Roland Tompakow (1989) retracts the most different humans' expressions in various situations of life. About the human body, the authors said: "By the body language, you say many things to the others and they have many other things to tell to you. Our body also is, firstly an information center by ourselves". [11]

3 Software Prototype

A software prototype is being currently developed in order to achieve this paper's proposed goals. The concept of this software is to analyze the human faces and, using a technique called FACS [1], presents the emotional state of the user. This study will be focused on the information provided through eyes, mouth and the combination of both. Figure 1 shows an UML Class Diagram with the main classes of the system.
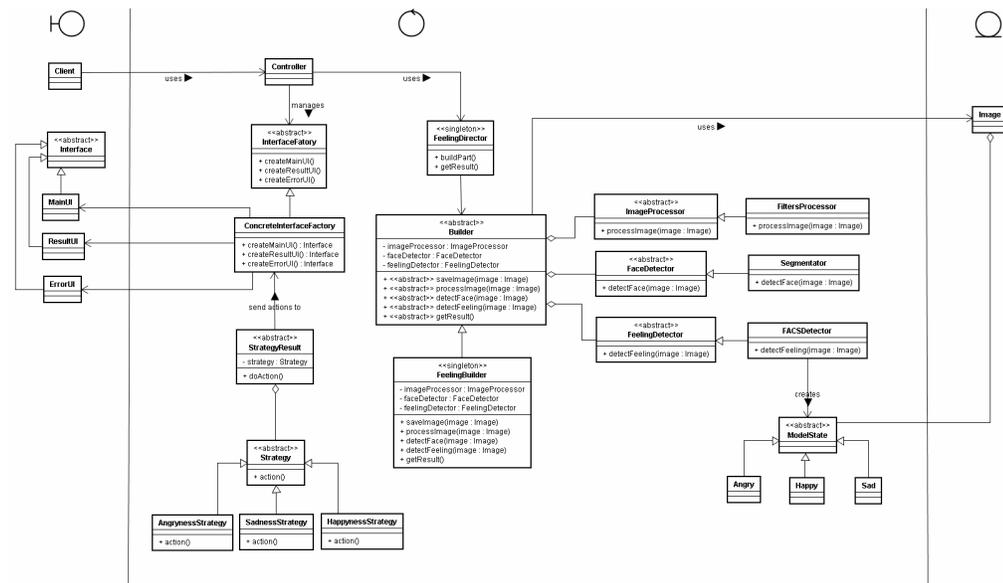

Fig. 1. UML Class Diagram

`FeelingBuilder` class is the core of the system: using the Builder pattern [2], it creates different parts of the final result. The first step on the software is to process the image using the `ImageProcessor` class. This class will be responsible to equalize the image, using basically Histogram Equalization and Fast Fourier Transform [3]. The second step will segment the image (already processed) so the face and the needed regions of it will be found (in this case, regions of the eyes and mouth). The third and most important step will be responsible to find the feeling of the recognized face.

In this final step, the emotion will be found using the Eigenface technique [3] working with the FACS images; in other words, the mouth and the eyes of the new image will be compared with FACS pictures of the face. So the system in this part will analyze the Upper Face results and the Lower Face results, and combine them. This combination will define the emotion of that face. Some FACS [1] examples can be seen in Fig. 2 below.

Fig.2 . Some FACS examples. From upper left, clockwise: Brow Lowerer, Upper Lid Raiser, Lip Stretcher, Upper Lip Raiser

With this emotional information, the computer can then help the user by means of properly applying State and Strategy patterns [2], and this information will be important because according to a user's state the computer will use the best strategy for the situation, helping your user in different situations.

Currently, the software is under development. Future works are meant to show the results obtained by its application.

4 Conclusion

This research could help in future works, like capturing non-static images in real time and, simultaneously analyzing these images according to affective computing techniques. By making these analyses some of the user's emotional states could be seen like joy, fear, angry, and with these probable results, assistants and computer optimizers could help users in the most different applications, like helping them to realize some task some person would feel difficulties in performing. In other words, the main goal is to optimize applications according to the actual user emotions.

It could be imagined future researches involving computers that could be able to understand some emotional states of users to help them to solve a certain problem, using past experience. To perform this, AI-based computer learning techniques must be used.

This research could also be useful to begin a discussion about how the present scenery of Affective Computing and Image Processing together could be useful for development of Human-Computer Interaction area, as well as how could they be inserted in outer contexts like psychology and cognitive sciences.

It is expected that this research will provide a functional application in the end. Such application would be able to handle an image to recognize some face in this image. When the computer already knows the face, he could then analyze this image to search the emotion that this face represents. In other words, if you post a photo of yourself in the program, the computer would say to you what you were feeling at the moment the picture has been taken, like if you were sad, happy or angry. With this result, it will be straightforward to implement some actions that would help users to do some work, using his/her feeling in the moment.

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