AFFECTIVE COMPUTING

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Emotions have a stigma in science. They are believed to be inherently non-scientific. Scientific principles are derived from rational thought, logical arguments and repeatable experiments. There is room alongside science for non-interfering emotions such as those involved in curiosity, frustration, and the pleasure of discovery. In fact, much scientific research has been prompted by fear. Nonetheless, the role of emotions is marginalized at best. Why bring “emotion or affect" into any of the deliberate tools of science? Who wants a computer to be able to feel angry at them?

By definition affective computing is human computer interaction in which a device has the ability to detect and appropriately respond to its user's emotions and other stimuli. It is a computing that relates to, arises from, or deliberately influences emotion or other affective phenomena.

A computing device with this capacity could gather cues to user emotion from a variety of sources. Facial expressions, physiological parameters, posture, gestures, speech, the force or rhythm of key strokes and the temperature changes can all signify changes in the user's emotional state, and these can all be detected and interpreted by a computer.

Emotion is fundamental to human experience, influencing cognition, perception, and everyday tasks such as learning, communication, and even rational decision-making. However technologists have largely ignored emotion and created an often frustrating experience for people, in part because affect has been misunderstood and hard to measure. Therefore it is important to study and review the present scenario of importance of affect in various technologies. The aim is to restore a proper balance between emotion and cognition in the design of technologies for addressing human needs.

There are various domains to this field, like designing new ways for people to communicate affective-cognitive states, especially through creation of novel wearable sensors and new machine learning algorithms that jointly analyze multimodal channels of information, Creating new techniques to assess frustration, stress, and mood indirectly, through natural interaction and conversation, Showing how computers can be more emotionally intelligent, especially responding to a person's frustration in a way that reduces negative feelings, Inventing personal technologies for improving self-awareness of affective state and its selective communication to others, Increasing understanding of how affect influences personal health and Pioneering studies examining ethical issues in affective computing.

HCI has traditionally been about designing efficient and effective systems. The designing of effective system deals with how to design interactive systems that make people respond in certain ways e.g. to be happy, to be trusting, to learn, to be motivated. Affective Computing deals with getting computers to recognize emotion, enabling technologies to have emotion and designing interactive systems which bring up human emotions. Human beings are capable to interact with the world by using its own sophisticated processing ability in which cognition and affect play two different but equally crucial roles. Cognition interprets and makes sense of the world while Affect evaluates and judges, modulating the operating parameters of cognition and providing warning of possible dangers. The study of how these two systems work together is main objective of affective computing, that provides guidance for the design of complex autonomous systems.

THEORIES ON EMOTIONS

Emotion is often defined as a complex state of feeling that results in physical and psychological changes that influence thought and behaviour. The emotion is not experienced in isolation in the brain. It is always associated with physiological changes it has in body. There are three major types of theories of motivation: physiological, neurological, and cognitive. Physiological theories suggest that responses within the body are responsible for emotions. Neurological theories propose that activity within the brain leads to emotional responses. Finally, cognitive theories argue that thoughts and other mental activity play an essential role in the formation of emotions. [1]

Some of the theories that describe emotions are as follows:

a) The James-Lange Theory of Emotion
   The theory says that emotions occur as a result of physiological reactions to events.
   According to the theory an external stimulus leads to a physiological reaction. An emotional reaction is dependent upon how one interprets those physical reactions. For example, a person walking in IIT campus sees a snake on road. He will get shocked and immediately jump away from it. The James-Lange theory proposes that person will interpret his physical reactions and conclude that he is frightened.

b) The Cannon-Bard Theory of Emotion
   The theory states that we feel emotions and experience physiological

reactions such as sweating, fast heart beats and muscle tension simultaneously. It is suggested that emotions result when the thalamus sends a message to the brain in response to a stimulus, resulting in a physiological reaction.

c) Schachter-Singer Theory
   The Schachter-Singer theory, also called as two-factor theory of emotion, an example of a cognitive theory of emotion. This theory suggests that the physiological arousal occurs first, and then the individual identifies the reason behind this arousal in order to experience and label it as an emotion.
d) Basic emotions
   In addition to understanding exactly what emotions are, researchers have also tried to identify and classify the different types of emotions. In 1972, psychologist Paul Eckman suggested that there are six basic emotions that are universal throughout human cultures: fear, disgust, anger, surprise, happiness, and sadness [2].

Emotions and Decision Making

Affect and cognitive mechanisms deal with interpretation, understanding, and remember things about the world. But the same time there is a second set of mechanisms, equally important and inseparable, that is the system of affect and emotion that evaluates events to provide an assessment of their overall value with respect to the personal feelings like positive or negative, good or bad, safe or dangerous, hospitable or harmful, desirable or undesirable, and so on.

Antonio Damasio has established somatic marker hypothesis as a mechanism by which emotional processes can bias behaviour, particularly decision-making [3]. The somatic marker hypothesis proposes there is an important connection between emotion, feeling and decision making. So a defect in emotion causes an impaired decision making.

When we make decisions, we must assess the value of the choices available to us, using cognitive and emotional processes. When we face complex and conflicting choices, we may be unable to decide using only cognitive processes, which may become overloaded and unable to help us decide. Often in presence of high number of choices, our emotions help us in prioritising a few because through which we can make a decision based on our cognition.

When making decisions in the future, these physiological signals or ‘somatic markers’ and its evoked emotion are consciously or unconsciously associated with their past outcomes and bias decision-making towards certain behaviours while avoiding others. For instance, when a somatic marker associated with a positive outcome is perceived, the person may feel happy and motivate the individual to pursue that behaviour. When a somatic marker associated with the negative outcome is perceived, the person may feel sad and act as an internal alarm to warn the individual to avoid a course of action. These situation-specific somatic states based on, and reinforced by, past experiences help to guide behaviour in favour of more advantageous choices and therefore are adaptive.

This leads to immense potential for HCI domain to take emotions into account for designing new systems. It can help user experience designers to consciously plan the product so that it evokes favourable emotions in the users. It can also be used for designing assistive device for ventromedial prefrontal cortex lesions patients, who develop severe impairments in personal and social decision-making.

The Turing test

In 1950 Alan Turing proposed to consider the question “can machines think”. He suggested that this problem can be thought of as a imitation game. It is played with three people, a man (A), a woman (B), and an interrogator (C) who may be of either sex. It is A's object in the game to try and cause C to make the wrong identification. He then proposes that what will happen when a machine takes the part of A in this game? Will the machine be able to perform as good as a man to deceive the interrogator?
If the interrogator is able to identify a machine from a human, then the machine fails the Turing test. The Turing test is a test of a machine's ability to exhibit intelligent behaviour equivalent to, or indistinguishable from, that of a human [4]. Clearly, a machine will not pass the Turing test unless it is also capable of perceiving and expressing emotions. Hence, a test that would ordinarily study a human-human interaction is used to study a human-computer interaction. In these experiments they have repeatedly found that the results of the human-human studies still hold. Their conclusion is that individual’s interactions with computers are inherently natural and social. Since communication of emotions is natural between people, the interaction should be natural with computers that aim to recognize and express affect.

Types of affective computers

The type of computers can be classified into four categories when looking from the point of view of affective computing. There are four cases, but it is not exhaustive list. [5]

I. No detection and no expression: Most computers fall in this category, having less affect recognition and expression than an animal. Such computers are neither personal nor friendly.

II. No detection but some expression: This category aims to develop computer voices with natural intonation and computer faces (perhaps on agent interfaces) with natural expressions. When a disk is put in the Macintosh and its disk-face smiles, users may share its momentary pleasure. Of the three categories employing affect, this one is the most advanced technologically, although it is still in its infancy.

III. Detection but no expression: This category enables a computer to perceive your affective state, enabling it to adjust its response in ways that might, for example, make it a better teacher and more useful assistant. It allays the fears of those who are uneasy with the thought of emotional computers, in particular, if they do not see the difference between a computer expressing affect, and being driven by emotion.

IV. Detection and expression: This category maximizes the sentic communication between human and computer, potentially providing truly personal and user-friendly computing. It does not imply that the computer would be driven by its emotions.

Challenges for affective computing

The issue for affective computing comes down to that currently it is not possible to measure cognitive influences, which depend on self-reports which are likely to be highly variable, and no one can read mind. However, we can measure physiological responses (facial expression, skin conductance etc.) which often arise during expression of emotion. One of the outstanding problems is that sometimes different individuals exhibit different physiological responses to the same emotional state. The experiments in identifying underlying emotional state from observations of physical expression still have to demonstrate consistent patterning for an individual in a given perceivable context.

The individual's personal computer can acquire ambient perceptual and contextual information (e.g. see if you're jogging, detect if the room temperature changed, etc.) to identify autonomic emotional responses conditioned on perceivable non-emotional factors. Perceivable context should include not only physical surroundings, but also cognitive surroundings (for example, if a person is watching a movie).

Alternate ways of how thoughts and feelings are expressed, are communicated through words, gesture, music, and other forms of expression, which are all imperfect, band limited modes. Although with the aid of new measuring devices we can distinguish many new activity levels and regions in the brain, we cannot, at present, directly access another's thoughts or feelings. However, the scientific recognition of affective state does appear doable in many cases, via the measurement of sentic modulation. These measurements are most likely to lead to successful recognition during voluntary expression, but may also be found to be useful during involuntary expression. If one can observe reliable functions of hidden states, then these observations may be used to infer the states themselves. Despite its immense difficulty, recognition of expressed emotional states appears to be much easier than recognition of thoughts. In pattern recognition, the difficulty of the problem usually increases with the number of possibilities. The number of possible thoughts you could have right now is limitless, nor are thoughts easily categorized into a smaller set of possibilities.

Applications of Affective Computing

i. Affective wearable

An 'affective wearable' is a wearable system equipped with sensors and tools which enables recognition of its wearer's affective patterns. In order to overcome challenge of measuring physiological parameters, ‘affective wearable’ was suggested [6]. A wearable device can hang from a belt, be worn like a wrist watch, in shoes, socks, gloves or other accessory. In either case it would be constantly be in touch with the user without hampering his day to day life. The challenges for wearable sensors are:

1. Since there are various physiological parameters, how to decide which one would give an appropriate response for a certain observation. For example ratio of skin conductance to heart rate gives accurate measurement of arousal state in rest condition but while in motion these readings may not give clear result.
2. How to separate physical motion changes from physiological changes. Since physical activities also cause changes in GSR, heart rate, temperature etc.
3. How to decide which part of the body for the sensors to be mounted. Hands are not always preferable due to various reasons.
4. It is very important to know the context when readings are being taken. As external conditions can cause noise. Like external temperature change can have effect on GSR reading.
5. The raw data from the GSR can’t be used, since the electrodes might not be in constant contact with the skin.

ii. PREDICTING ONLINE MEDIA EFFECTIVENESS BASED IN SMILE RESPONSES

"Facial Expressions can predict variables related to advertising success" has been already shown in research. By tracking facial responses, it can be easily predicted whether a person "likes" a commercial advertisement or not or if there is any "desire to view it again" or not [7]. The researchers selected a set of advertisements, uploaded them and asked users to switch on their webcams. Those facial expressions were recorded and through filtering and feature extraction, data is taken out. They haven't explored whether a person "dislikes" a message or not which I feel was more important to be explored. There is a very fuzzy boundary between liking and desire to view content again. Latter feeling is the outcome of liking something, and liking something only will lead to viewing content again. Almost 3268 videos of facial expressions were collected through internet. 6729 people opted in for the experiment. A concern for the experimenters was the curiosity raised by participants while asking permission to use the webcam. Even writers have mentioned this concern of asking for permission and then performing the test. Though all the answers were given by almost 47% people, they got more than 2400 videos to process, but authors have mentioned about "no control" in quality of video. They've only used those videos for feature extraction which satisfied 90% of their criteria. Low pass filters were used to extract feature and 20 segments and smile peaks.

While performing test, people were asked to let their webcam on and capture their facial movements, but in the end of every commercial, their manual feedback was also taken to test whether the result that they were expecting is matching with manual dieback or not. After their feature extraction process, they noticed about false positives and negatives. False positives are that situation where result out of feature extraction says that a user likes a video, but in the end of video user has rated it not likable. Hence, a false positive came out. Similarly, if a user has liked a video in the end of commercial showing process but feature extraction process on the contrary shows that it's not liked. This one is called false negatives. According to author these false positives and negatives came throughout the study.

Throughout the study there was a possibility of utilizing of other features of face completely using webcam. They could've also taken out pulse rates and made use of it. Pulse rates can be taken out using the change of colours over skin, this change is so fast that it's not visible by our eyes, but as frame rate of cams is pretty high and can go beyond 40fps, taking out such information wouldn't have been easier. They've mentioned that they'll make use of eyebrow raise and lowered, noise wrinkle in future which looks like a good sign. This will improve the existing research they've done. If a successful algorithm is made then it can help advertising industry a lot.

iii. AFFECTIVE COMPUTING AND SURVEILLANCE: THE FUTURE OF BIOMETRIC SURVEILLANCE?

People are now starting to use Affective Computing in Biometric Surveillance, in surveillance camera networks [8]. Combining ubiquitous computing, biometrics, face recognition and affective computing is now becoming a very powerful surveillance system. It's very evident that few crimes were reported when the camera was installed.

How Surveillance is achieved: By taking real-time pictures of faces from crowd, faces are extracted and then compared to the available pictures in database. This extracted face is called a probe and a probe gets compared to a huge database. Suppose if a terrorist is already there in database, if he is found in crowd, a positive will be detected. But one of the problems is false positive. False positive might detect a wrong person as terrorist. Author's ultimate motive is to come up with a system which can take multimodal real-time data of people and combine that data to predict motives or state of individual agents.

Software would be required to process so much of data. Author has explored 3 scenarios

1) "The first scenario for affect recognition systems might include cameras in the engine room of a train (or cockpit of a plane) that could relay footage of a possibly sleepy, intoxicated or distressed driver/pilot to a system designed either to alert security personnel or deliver a warning to the driver/pilot and crew about the nature of the person's state of mind."

2) "Affect recognition technology could also potentially become part of Group Decision Support Systems. Group decision making, though not specifically related to security concerns, is often susceptible to psychological factors such as 'groupthink'. 'An affect recognition system might provide a useful source of feedback to group members about the overall emotional state of the group. To preserve anonymity, such information could be synthesized and generated so that individual group members would not be identified. This type of information could also allow members of a decision making group, or a facilitator, to gauge the strength of support or dissent for particular positions as they are being discussed.

3) A final, though only remotely likely deployment scenario, could involve the installation of emotion recognition systems in the offices of senior executives at major corporations in the financial industry, or in the offices of high-level government officials. Because fraud and security violations perpetrated by 'insiders' are such a big problem, such a system might serve as a deterrent or provide early warning signs of potential problems.

iv. Emotion mark-up language

Computerized systems, to the extent that they can recognize, simulate or process emotion-related information, need a representation format. For this job several components are to work collaboratively on the information, the format must be well-defined. A long-running collaborative effort on defining and standardizing an Emotion Mark-up Language is undergoing standardization at the World Wide Web Consortium (W3C) [9].

Here the word “emotion” is used in a very broad sense, covering both intense and weak states, short and long term, with and without event focus. This meaning is intended to reflect the understanding of the term “emotion” by the general public rather than any specific scientific theory. EmotionML was made as a plug-in language, with the aim to be usable in many different contexts. All information concerning an individual emotion annotation is contained within a single tag ‘<emotion>’ element. Emotions can be represented in terms of four types of descriptions

‘<category>’, ‘<dimension>’, ‘<appraisal>’ and ‘<action-tendency>’. An ‘<emotion>’ element can contain one more of these descriptors; each descriptor must have a ‘name’ attribute and can have a ‘value’ attribute indicating the intensity of the respective descriptor. For ‘<dimension>’, the ‘value’ attribute is mandatory, since a dimensional emotion description is always a position on one or more scales; for the other descriptions, it is possible to omit the ‘value’ to only make a binary statement about the presence of a given category, appraisal or action tendency.

The following example illustrates a number of possible uses of the core emotion representations.

<category name="affectionate"/>

<dimension name="valence" value="0.9"/>

<appraisal name="agent-self"/>

<action-tendency name="approach"/> Emotion annotation is always about something “experiencing” (or simulating) the emotion. This can be a human, a virtual agent, a robot, etc. There is observable behaviour expressing the emotion, such as facial expressions, gestures, or vocal effects that can be used as a measurement tool.

Some ideas on affective computing

1. Life logging: life logging is the process of tracking personal data generated by our own behavioural activities. An example of lifelogging is taking photographs or videos. The problem with taking huge chunks of photographs and videos is that it is very difficult to organize. Till now people have suggested to organize these media according to location and time [10]. But here is an opportunity to organize the data according to the mood. If the lifelogging device can be paired with affective wearable device, then the data would be richer and could tell about the emotions that person felt while the event was recorded.
2. Truth analysis: It would be really interesting if truth analysis using Affective Computing can be applied to criminals. This can be used over criminals or terrorists by Police. Instead of using aggressive drugs over criminals, it would be a better way to analyze something without even their consent. This way their natural behaviour can be observed and their mental state can be read in a better way using their facial expressions. Since it has already been established that people from all over the world express same emotions it would be easy to scale up this system [2].
3. Affective Computing in Parliament: This can also be applied in parliament where mood of politicians and parliament can be detected. Even before session starts, speaker can see about an overall mood status of parliament at the moment and commence after taking care of it. If mood is really angry, speaker can ask people to calm down etc. Sometimes even after making a valid statement opposition opposes a party, and if mood of opposition as a whole can be taken then it can be judged whether they are doing what they really mean or they are not supporting because they are opposition. A better application can also be thought of.
4. Automatic likes and up votes in all the online social networks: This can be easily achieved by using webcams and affective computing as discussed previously.
5. Affective home automation: Our homes are becoming automated at fast pace. People can now control their electrical appliances with their mobile phones. User has to consciously control the appliance. It would be the next step in home automation to make the control based on humans emotion. The lighting, sounds, temperature and ambience can be set by the emotions that the user is going through.
6. One of the world's most popular forms of entertainment is large sporting events especially World Cup and 20-20 cricket matches etc. One of the pleasures that people receive from these events is the opportunity to express intense emotion as part of a large crowd. A stadium is one of the only places where an adult can jump up and down cheering and screaming,

and be looked upon with approval. Emotions, whether or not acknowledged, are an essential part of being entertained.

7. With affect recognition, the computer as music teacher could not only keep users interested longer, but it could also give feedback as they develop preciseness of expression. Through measuring gesture form, perhaps through finger pressure, foot pressure, or measures of inspiration and expiration as users breathe, it could help them compare aspects of your performance that have never been measured or understood before [5].
8. Emotional E-mail tool: Perhaps nothing has brought home this point more than the tremendous reliance of many people on Email that is currently limited to text. Most people who use Email have found themselves misunderstood at some point their comments received with the wrong tone. By necessity, Email has had to develop its own set of symbols for encoding tone, namely smiley such as :-) and ;-(. Even so, these icons are very limited, and Email communication consequently carries much less information than a phone call. Tools that recognize and express affect could augment text with other modes of expression such as voice, face, or potentially touch. In addition to intonation and facial expression recognition, current low-tech contact with keyboards could be augmented with simple attention to typing rhythm and pressure, as another key to affect.

Conclusions

This wide ranging, ambitious, topic ranges work from several disciplines, including impressive results, theoretical analysis and practical applications along with some of the ethical issues they raise. The majority of the discussion of emotions is based on the widely held assumption that they always involve externally detectable sentic modulation, as primary emotions do. This assumption, however, ignores the possibility of secondary emotions, which I believe are the most important emotions in our lives and certainly of most interest in much of our thinking about one another. From this viewpoint the emphasis on externally detectable patterns of physiological processes is unfortunate. However as an account of how primary emotions and some peripheral secondary emotions are expressed and how they might be detected it may be a good beginning. There are numerous application which are challenging and potentially extremely interesting and probably very difficult applications of affective computing e.g. automating the process of searching a library for a picture or a piece of music with a specific type of mood, for use in an advertisement or as background. Although there are some shortcomings, there is a lot of interest and value in the topic of people around the world. As a wide-ranging and provocative ground-breaker, the domain is new and presently we cannot believe everything we read! Even though the text and bibliography points to much relevant literature, the best literature on this topic has yet to be written. Such work requires a broad multidisciplinary background. Unfortunately there are still too few researchers like Picard willing to combine psychology, ethology, neuroscience, evolution, computer science, software engineering, AI and philosophical insight, in the context of creative engineering design. Maybe one day their numbers will reach a critical mass, they will discover a common conceptual framework within which to communicate, and the subject will really take off.

Works Cited

[1] K. Cherry, "Theories of Emotion," 14 04 2014. [Online]. Available: http://psychology.about.com/od/psychologytopics/a/theories-of-emotion.htm. [Accessed 05 06 2014].

[2] P. Eckman, "Paul Ekman: Outsmart Evolution and Master Your Emotions," 01 08 2013. [Online]. Available: https://www.youtube.com/watch?v=pVp5pGSwZkg. [Accessed 2014 06 05].

[3] A. R. B. J. E. a. D. B. Damasio, "he somatic marker hypothesis and the possible functions of the prefrontal cortex," *Philosophical Transactions of the Royal Society of London. Series B: Biological Sciences,* pp. 1413-1420, 1996.

[4] A. Turing, "Intelligent machines," *Mind* , pp. 433-460, 1949.

[5] R. Picard, "An essay on affective computing," *M.I.T Media Laboratory Perceptual Computing Section Technical Report No. 321,* 1995.

[6] R. P. a. J. Healey, "Affective wearables," *Personal Technologies, Volume 1, No. 4,* pp. 231-240, 1997.

[7] D. McDuff, "Predicting Online Media Effectiveness Based on Smile Responses Gathered Over the lnternet," *In Automatic Face and Gesture Recognition (FG), 10th IEEE International Conference and Workshops,* pp. 1-7, 2013 .

[8] J. Bullington, "Affective'computing and emotion recognition systems: the future of biometric surveillance?," *Proceedings of the 2nd annual conference on Information security curriculum development. ACM,* pp. 95-99, 2005.

[9] e. a. Paolo Baggia, "Elements of an EmotionML 1.0," 20 11 2008. [Online]. Available: http://www.w3.org/2005/Incubator/emotion/XGR-emotionml-20081120/. [Accessed 04 06 2014].

[10] Memeto, "Memoto Lifelogging Camera," Kickstarter, 30 11 2012. [Online].

Available: https://www.kickstarter.com/projects/martinkallstrom/memoto-lifelogging-camera. [Accessed 2014 06 05].

[11] D. A. A. O. a. D. M. R. Norman, "Affect and machine design: Lessons for the development of autonomous machines," *BM Systems Journal 42.1,* pp. 38-44, 2003.

[12] J. Bullington, "Affective computing and emotion recognition systems: the future of biometrics," *DoISGSU.*

[13] A. H. D. a. A. R. D. Bechara, "Emotion, decision making and the orbitofrontal cortex," *Cerebral cortex,* pp. 295-307, 2000.