AFFECTIVE COMPUTING

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***Abstract*- Some machine should interpret the emotional state of humans beings or human and adapt its behaviour to them, giving an appropriate response for the emotions. Affective computing is the study and development of systems and devices which could or can recognize, interpret, process, and simulate human affects. Affective computing is human-computer interaction where the device has the ability to detect and appropriately respond to its user's emotions and other stimuli. It is an interdisciplinary field spanning computer science, psychology, and cognitive science. A motivation is the ability to simulate empathy.**

I. AREAS OF AFFECTIVE COMPUTING

DETECTING AND RECOGNIZING EMOTIONAL INFORMATION

Detecting emotional information begins with passive sensors that captures the data about the user's physical state or behavior without interpreting the input. The data gathered is analogous to the humans use to perceive emotions in others. For example, a video camera might capture facial expressions, body posture and gestures, while a microphones or mike may capture the speech. Other sensors detect emotional cues by directly measuring physiological data, such as skin temperature and galvanic resistance etc.

Recognizing emotional information requires the extraction of meaningful patterns from the gathered data. This is done using machine learning techniques that process
different modalities, such as speech recognition, natural language processing, or facial expression detection, and produce either labels or coordinates in a valence-arousal space.

EMOTION IN MACHINES

Another area within affective computing is the design of computational devices proposed to exhibit either innate emotional capabilities or that are capable of convincingly simulating emotions. A more practical approach, based on current technological capabilities, is the simulation of emotions in conversational agents in order to enrich and facilitate interaction between the human and the machine. While human emotions are often associated with surges in hormones and other neuro peptides, emotions in machines is associated with abstract states associated with progress in autonomous learning systems.

II. TECHNOLOGIES OF AFFECTIVE COMPUTING

EMOTIONAL SPEECH

One can take advantage of the fact that changes in the autonomic nervous system indirectly alter speech, and use this information to produce systems capable of recognizing affect based on extracted features of speech. For example, speech produced in a state of fear, anger or joy or in a happy moode becomes faster, louder, with a higher and wider pitch range. Other emotions such as tiredness, bored or sadness, lead to slower, lower-pitched and slurred speech. Emotional speech processing recognizes the user's emotional state by analyzing speech patterns of the user. Vocal parameters such as pitch variables and speech rate are analyzed through pattern recognition.

Speech recognition is a one of the best method of identifying affective state, having an average success rate reported in research of 63%.This result appears fairly satisfying when compared with humans' success rate at identifying emotions. Many speech characteristics are independent of semantics or culture, which makes speech recognition technique a very promising one to use.

Algorithms

The process of speech/text affect detection requires the creation of a reliable database, knowledge base, or vector space model, which allow for quick and accurate emotion identification.

The most frequently used classifiers are linear discriminant classifiers (LDC), k-nearest neighbour (k-NN), Gaussian mixture model (GMM), support vector machines (SVM), artificial neural networks (ANN), decision tree algorithms and hidden Markov models (HMMs). The list gives a brief description of each algorithm:

- **LDC** – Classification happens based on the value obtained from the linear combination of the feature values, which are usually provided in the form of vector features.
- **k-NN** – Classification happens by locating the object in the feature space, and comparing it with the k nearest neighbours .The majority vote decides on the classification.
- **GMM** – is a probabilistic model used for representing the existence of sub-populations within the overall population. Each sub-population is described using the mixture distribution, which allows for classification of observations into the sub-populations.
- **SVM** – is a type of (usually binary) linear classifier which decides in which of the two (or more) possible classes.
- **ANN** – is a mathematical model,which is inspired by biological neural networks, that can better grasp possible non-linearities of the feature space.
- **HMMs** – a statistical Markov model in which the states and state transitions are not directly available to observation. Instead, the series of outputs dependent on the states are visible. In the case of affect recognition, the outputs represent the sequence of speech feature vectors, which allow the deduction of states' sequences through which the model progressed. The states can consist of various intermediate steps in the expression of an emotion, and each of them has a probability distribution over the possible output vectors. The states' sequences allow us to predict the affective state it is one of the most commonly used techniques within the area of speech affect detection.

III. DATABASES

The vast majority of present systems are data-dependent. This creates one of the biggest challenges in detecting emotions based on speech, as it implicates choosing an appropriate database used to train the classifier. Most of the currently possessed data was obtained from actors and is thus a representation of archetypal emotions. Those so-called acted databases are usually based on the Basic Emotions theory which assumes or take the existence of six basic emotions (anger, fear, disgust, surprise, joy, sadness). They offer high audio quality and balanced classes which contribute to high success rates in recognizing emotions.

For real life application, naturalistic data is preferred. A naturalistic database is produced by observation and analysis of subjects in their natural context. This database allows the system to recognize emotions based on their context ,goals and outcomes of the interaction. The nature of this type of data allows for authentic real life implementation, due to the fact it describes states naturally occurring during the human-computer interaction (HCI).

IV. SPEECH DESCRIPTORS

The complexity of the affect recognition process increases with the amount of classes (affects) and speech descriptors used within the classifier. It is therefore crucial to select only the most relevant features in order to assure the ability of the model to successfully identify emotions, as well as increasing the performance, which is particularly significant to real-time detection. It is crucial to identify those that are redundant and undesirable in order to optimize the system, and increase the success rate of correct emotion detection. The most commonly speech characteristics are categorized in the following groups.

1. **Frequency characteristics**
    - Accent shape – affected by the rate of change of the fundamental frequency.
    - Average pitch – description of how high/low the speaker speaks relative to the normal speech.

- Contour slope – describes the tendency of the frequency change over time, it can be rising, falling or level.
- Final lowering – the amount by which the frequency falls at the end of an utterance.
- Pitch range – measures the spread between maximum and minimum frequency of an utterance.

2. **Time-related features:**
   - Speech rate – describes the rate of words or syllables uttered over a unit of time
   - Stress frequency – measures the rate of occurrences of pitch accented utterances
3. **Voice quality parameters and energy descriptors:**
   - Breathiness – measures the aspiration noise in speech
   - Brilliance – describes the dominance of high Or low frequencies In the speech
   - Loudness – measures the amplitude of the speech waveform, translates to the energy of an utterance
   - Pause Discontinuity – describes the transitions between sound and silence
   - Pitch Discontinuity – describes the transitions of fundamental frequency.

V. FACIAL AFFECT DETECTION

The Detection And Processing Of Facial Expression is achieved through various methods like optical flow, hidden Markov model, neural network processing or active appearance model. More than one modalities can be combined or fused to provide a more robust estimation of the subject's emotional state or feelings.

VI. EMOTION CLASSIFICATION

The emotions are biological in origin and can therefore be safely and correctly categorized into six basic emotions,such as

- Anger
- Disgust
- Fear
- Happiness
- Sadness
- Surprise

However in the 1990s the newly included emotions are:

1. Amusement
2. Contempt
3. Contentment
4. Embarrassment
5. Excitement
6. Guilt
7. Pride in achievement
8. Relief
9. Satisfaction
10. Sensory pleasure
11. Shame

VII. FACIAL ACTION CODING SYSTEM

Defining expressions in terms of muscle actions in order to formally categorise the physical expression of emotions. The central concept of the Facial Action Coding System, or FACS,is a contraction or a relaxation of one or more muscles and devoid of interpretation emotional identification system.

By identifying different facial cues, scientists are able to map them to their corresponding action unit code and they have proposed the following classification of the six basic emotions, according to their action units

Emotion	**Action units**
Happiness	6+12
Sadness	1+4+15
Surprise	1+2+5B+26
Fear	1+2+4+5+20+26
Anger	4+5+7+23
Disgust	9+15+16
Contempt	R12A+R14A

VIII. CHALLENGES IN FACIAL DETECTION

As with every computational practice, in affect detection by facial processing, some obstacles occurs in order ,to fully unlock the hidden potential of the overall algorithm or method employed. The accuracy of modelling and tracking has been an issue, mainly in the incipient stages of affective computing. As hardware evolves, as new discoveries are made and new practices introduced, this lack of accuracy fades, leaving behind noise issues. It is generally known that the degree of accuracy in facial .Without improving the accuracy of hardware and software used to scan faces, progress is very much slowed down.

Other challenges include

- The fact that posed expressions, as used by most subjects of the various studies, are not natural, and therefore not 100% accurate.
- The lack of rotational movement freedom. Affect detection works very well with frontal use, but upon rotating the head more than 20 degrees, “there’ve been problems”.

IX. BODY GESTURE

Gestures can be efficiently used as a means of detecting a particular emotional state of the user, especially when used in with speech and face recognition. Depending on the specific action, gestures could be simple reflexive responses, like lifting the shoulders when the answer to a question is not known, or they could be complex and meaningful as when communicating with sign language. A computer should be able to recognize the gestures, analyze the context and respond in a meaningful way, in order to be efficiently used for Human-Computer Interaction.

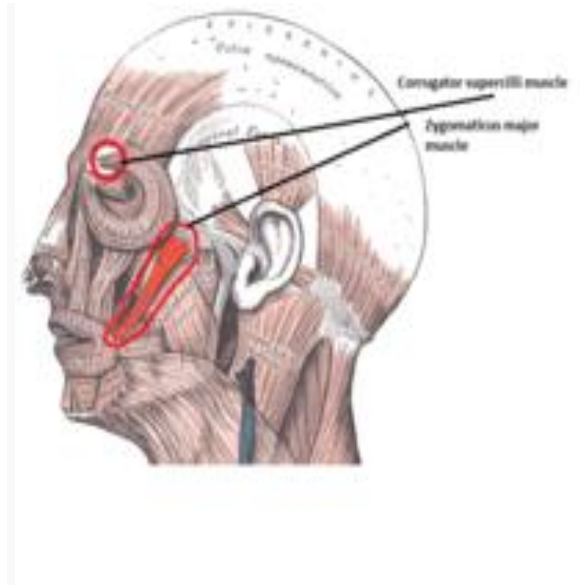
There are many proposed methods to detect the body gesture. Some literature differentiates 2 different approaches in gesture recognition**: a 3D model based** and an **appearance-based.** The foremost method makes use of 3D information of key elements of the body parts in order to obtain several important parameters, like palm position or joint angles. On the other hand, Appearance-based systems use images or videos to for direct interpretation. Hand gestures have been a common focus of body gesture detection, apparentness methods and 3-D modeling methods are traditionally used.

X. PHYSIOLOGICAL MONITORING

It is used to detect a user’s emotional state by monitoring and analysing their physiological signs. The signs range from pulse and heart rate, to the minute contractions of the facial muscles. The three main physiological signs that can be analysed are:***blood volume pulse, galvanic skin response, facial electromyography***.

Methodology

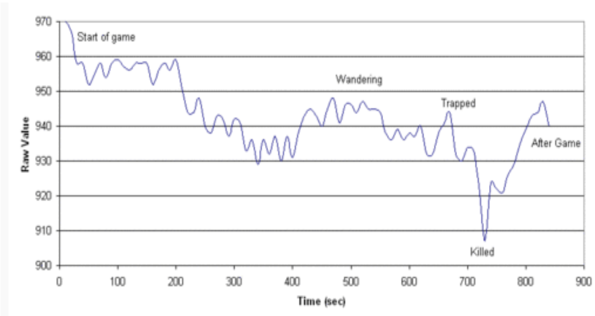
Infra-red light is passed on the skin by special sensor hardware, and the amount of light reflected is measured. The amount of reflected and transmitted light correlates to the BVP as light is absorbed by hemoglobin which is found richly in the blood stream.



The corrugator supercilii muscle and zygomaticus major muscle are the 2 main muscles used for measuring the electrical activity, in facial electromyography.

XI. FACIAL ELECTROMYOGRAPHY

Facial electromyography is a technique used to measure the electrical activity of the facial muscles by amplifying the tiny electrical impulses that are generated by muscle fibers when they contract. The corrugator supercilii muscle, also known as the ‘frowning’ muscle is the best test for negative, unpleasant emotional response. The zygomaticus major muscle is responsible for pulling the corners of the mouth back when the person smile, and therefore is the muscle used to test for positive emotional response.



In this fig a plot of skin resistance measured using GSR and time while the subject played a video game. For example, at the start of the game where there is usually not much exciting game play, there is a high level of resistance recorded, which suggests a low level of conductivity and therefore less arousal. This is in clear contrast with the sudden trough where the player is killed as one is usually very stressed and tense as their character is killed in the game

XII. GALVANIC SKIN RESPONSE

Galvanic skin response (GSR) is a measure of skin conductivity, which is dependent on moisture of the skin . As the sweat glands produce this moisture and the glands are controlled by the body's nervous system, there is a correlation between GSR and the arousal state of the body.

It can be measured using two small silver chloride electrodes placed somewhere on the skin, and applying little amount of voltage between them. The conductance is measured by a sensor. To maximize comfort and reduce irritation the electrodes can be placed on the feet, which leaves the hands fully free to interface with the keyboard and mouse.

XIII. VISUAL AESTHETICS

Aesthetics, in the world of art and photography, refers to the principles of the nature and appreciation of beauty.They extract certain visual features based on the intuition that they can discriminate between aesthetically pleasing and displeasing images.

POTENTIAL APPLICATIONS

- In e-learning applications, affective computing can be used to adjust the presentation style of a computerized tutor when a learner is bored, interested, frustrated, or pleased.
- In Psychological health services, i.e. counseling, benefit from affective computing applications when determining a client's emotional state.
- Robotic systems capable of processing affective information exhibit higher flexibility while one works in uncertain or complex environments.
- Affective computing has potential applications in human computer interaction, such as affective mirrors allowing the user to see how the user performs; emotion monitoring agents sending a warning before one sends an angry email; or even music players selecting tracks based on mood.
- Affective computing is also being applied to the development of communicative technologies for use by people .

XIV. CONCLUSION

The affective computing focuses primarily on computer-mediated inter-personal communication and the measurement and modeling of physiological variables. The interactional affective computing is concerned with emotions as complex subjective interpretations of affect, arguing that emotions, not affect, are at stake from the point of view of technology users. Thus the affecting computing helps in measuring the human emotions.

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