CLASSIFICATION OF SENSORS IN EMOTIONS RECOGNITION AND ITS IMPLEMENTATION IN THE THE EDUCATIONAL SECTOR

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ABSTRACT. *Artificial Intelligence (AI) is entering a new era of intelligence. AI systems are being utilized to predict, identify, analyze, and react to various situations. Such advancement is tightly coupled with the improvement of machine perception and sensing technologies as smart sensors. Nowadays, sensors are deployed in an extremely wide range of domains, devices, and applications. One of the applications is using sensors in detecting human's feelings and emotions. This paper provides a survey on the usage of sensors in emotion recognition as well as its usage in educational institutions. While the deployment of such technology can have a great impact in many domains, this paper can be taken as a basis towards using sensing technology in emotions recognition and, in educational institutions, considering other evolving computer science field from big data, internet of things, cloud computing and so forth.*

Keywords: Sensors, Simulators, AI, Emotion Recognition, Educational Institutions.

1 INTRODUCTION

Artificial intelligence (AI) is the specific behavior and characteristics of software which simulates human mental abilities and modes of action [44]. One of the most important features of AI is the ability to learn, deduct, conclude and react to situations that have not been programmed into the machine in the first place [25]. Generally speaking, it can be seen that AI has inched itself further into our realities and day to day lives and there is now no doubt it is entering into a new age of intelligence.

From this point of view, the importance of AI appears in human life and also the many fields and aspects in which it can serve and contribute in helping humanity to develop and build a better future. AI includes various types of smart applications and devices that are in a continuous evolution. The scope of this paper will be on the usage of sensors particularly in emotion recognition including anxiety, stress, fear, etc. Furthermore, a review on the usage of emotional recognizing sensors in educational institutions will be presented. A sensor, in its most general form, is possessing systems for variable number of components [16]. Likewise, sensor element, sensor packaging and connections, and sensor signal processing hardware [4]. Accordingly, The American National Standards Institute (ANSI) standard MC6.1 defines a sensor as a device which provides a usable output in response to a specific measured [10]. Furthermore, one of the most important approaches in sensor technology in the last ten years has been the focused on development of smart sensors [13]. Therefore, sensors can be found in an extremely wide range of applications in industrial systems nowadays [22]. Moreover, sensors excel in several characteristics such as High Sensitivity, High Resolution, Linearity, Less power Consumption, Less Disturbance [5]. Additionally, there are various types of sensors with different uses and benefits that are typically providing accuracy and importantly, such as Smoke sensors [26], Gas and Alcohol Sensors [18], Temperature Sensors [31], Proximity Sensors [43], AccelerometerIR Sensors [1], Pressure Sensors [29], Light Sensor [11], Ultrasonic Sensors [2], Touch Sensors [45], Color Sensors [30], Humidity Sensors [32] and Flow and Level Sensors [34]. Moreover, Sensors are classified based on the nature of quantity they measure. For example:

- Temperature: Resistance Temperature Detector (RTD), Thermistor, Thermocouple [6].
- Pressure: Bourdon tube, manometer, diaphragms, pressure gauge [3].
- Force/ torque: Strain gauge, load cell [23].
- Speed/ position: Tachometer, encoder, LVDT [14].
- Light: Photo-diode, Light dependent resistor [33].

In this paper, after this abbreviated introduction, the related work will be presented in the next section. Then two classification reviews on the usage of sensors in emotion recognition and its usage in educational institutions will be discussed. Finally, the last section will contain the conclusion and future work.

2 Related Work

This section will review related work in two parts. Firstly, the usage of sensors in emotion recognition and, secondly, using sensors in educational institutions.

2.1 Sensors in Emotion Recognition

With the advancement of technologies, the ability to identify the emotions has been evolving rapidly from the variety usage of audio, image and big data. Additionally, the impact of sophisticated techniques and devices, which had been used in this field, is promising. A late research by Subramanian, R. et.al, used physiological sensors to present a multimodal database that uses emotional and personality attributes of an individual as a dataset. For the personality, the big five personality features were used, which are, Agreeableness, Extraversion, Openness, Conscientiousness and Neuroticism. To measure both emotional and personality states, they employed the participants heart pace (Electrocardiogram or ECG), galvanic skin response (GSR), EEG and facial expression model/activities model while watching a video clip that contained 36 clips. They used both commercial and wearable EEG, ECG, GSR sensors with a webcam and then feed the extracted features to Support Vector Machine (SVM) with Naïve Bayes and for the data quality they had rated it manually as the movement of the body can degrade the quality of the obtained data. Their proposed approach had resulted in an accuracy rate that is equal to 86%, highlighting the existents of the relationship between the emotions a person may feel due to change in his personality. Furthermore, they accentuate on the need of more researches that investigate the impact of other attributes such the age, gender and other bioinformatics data [38]. Another research by Betti, S. et.al, investigated the quality of physiological sensors in observing and classifying the stress. The sensors

they used to monitor the heart rate variability (HRV), electroencephalogram (EEG) and electrodermal activity (EDA), to estimate the level of the stress. Furthermore, in their research they study the changes in the cortisol which is a notorious biomarker for the stress with the physiological changes recorded by the sensors. The level of cortisol was monitored by continuously collecting salivary samples throughout the experiment. For classification, SVM was also used, and the outcomes of the experiment were satisfying with 86% rate of accuracy [7]. Moreover, Zangróniz, R. *et.al*, presented a new monitor sensor device that categorize two different emotions i.e. stress and calm using only one physiological mark which is the electrodermal activity (EDA) that indicates the stress state through the level of the sweat gland activity. Knowing that the skin conductance response (SCR) activities affect the sweat gland, it was considered while designing the prototype which led to the designing, the wearable to fit the participant wrest and the hand palm side as sweaty hand is one of the most commonly visible sign in a stress state and the rest so the sudomotor nerve is observed. Additionally, a decision tree classification was used and this approach resulted in 89% accuracy in distinguishing between calm and stress state [46]. Another study by Salafi, T., &Kah, J. C. Y. proposed a Smartphone application to be incorporative during the investigation on the classification of the stress level of the participants. In their proposed system, they used three types of physiological sensors. The first was for heart rate by monitoring electrocardiogram (ECG) and photoplethysmography (PPG). Secondly, was galvanic skin response sensor (GSR) by measuring the skin electro dermal activity (EDA). All these sensors were connected to the application via Bluetooth which allowed the application to guide the participants during their experiments from notifying them on their stress level and alert them if the stress level passes 80% and provide a game and a breathing page with an animated bar that will help in decreasing the stress level. After collecting the data SVM as well as the previously chosen classifier was used with K-means and the obtained results was 91.26% accurate [35]. Numerous other researches had been conducted to explore the usage of sensors in detecting human's emotions which are a relatively new and more yet to come due to outstanding results that will guide the researchers to discover its utility in undefined circumstances with different variables, techniques, tools, data and so on. Table 1 presents a summary of reviewed relevant studies on the usage of sensors in identifying various human emotions.

2.2 Sensors in Educational Institution

Learners require comprehensive practice before they go and experience their insight, in a real-life situation. They require a protected and controlled environment where they can assess themselves in various situations and get pragmatic learning. Simulators could be utilized in all fields, at all dimensions of training. They can help school students to better comprehend physical science ideas and other complex materials. They can likewise enable restorative students to figure out how to perform heart medical procedure, without the risk of any life misfortune. There are numerous uses of simulators in the educational environment. The principle advantage of giving students a chance to connect with simulators is that it draws them in deep learning. On the off chance that students are allowed to experiment with what they have realized hypothetically, they will have an overview on the material and along with these views they will get a more profound comprehension on how things function as a general rule.

Educational sensors have specific set of requirements, in view of the requirements of target clients. These simulators improve the learning process and increase the awareness of students by simulation of genuine circumstances in an effective way. Moreover, these simulators can be used to enhance the university education process with courses and laboratory exercises. Overall, simulators that utilized for instructive reason ought to have some consistent necessities, for example: flexibility, intractability, scalability, efficiency-ability, and adaptability [39]. In order to build up a social and emotional association with learners, mentors ought to perceive learners' influence and react to them at a profound dimension. Therefore, a minimal effort multi-modular sensor platform had been built and incorporated into the educational institutions. A famous example is the Wayang Tutor platform that incorporates a uniquely delivered Pressure Mouse, a Wireless BlueTooth Skin Conductance sensor, a Posture Analysis Seat, and a Facial Expression System [12]. The aim is to give a superior comprehension of understudy conduct and influence and to decide the commitment of every sensor to the displaying of effect [20].

The pressure mouse is utilized to identify the expanding measures of weight clients put on their mice identified with their expanded dimensions of dissatisfaction [47]. The pressure mouse framework has six power delicate resistor sensors and an installed chip [12]. It utilizes the standard correspondence channel of a USB mouse for pointing and clicking capacities and afterward in parallel uses a second channel, a sequential interchanges port, to give pressure information at 20ms interims from every one of the six sensors. Pressure sensors situated under the mouse catch measure the power of the clients click notwithstanding their general pressure over the outside of the mouse [12].

A remote skin conductance variant of a prior glove that detected conductance was produced via Carson Reynolds and Marc Strauss at the MIT Media Lab, in a joint effort with Gary McDarby, at Media Lab Europe [12]. While the skin conductance flag isn't valenced (for example does not depict how positive or negative the emotional state is), it is emphatically related with excitement [12]. Large amounts of excitement will in general go with huge and eye-catching occasions [8]. With outward appearance Camera, an individual's psychological state isn't straightforwardly accessible to a spectator; rather it is construed from a scope of non-verbal signals including outward appearances [12]. An outward appearance acknowledgment framework has been utilized to joins a computational model of mind perusing as a structure for machine observation and mental state acknowledgment [21]. This facial activity investigation depends on a mix of base up vision-based handling of the face (for example head gesture or grin) with best down expectations of mental state models (for example intrigue and perplexity) to decipher the importance hidden head and facial flags after some time [21]. A staggered, probabilistic design (utilizing dynamic Bayesian systems) imitates the progressive way with which individuals see facial and other human conduct [47] and handles the vulnerability intrinsic during the time spent crediting mental states to other people. The yield probabilities speak to a rich methodology that innovation can use to speak to an individual's state and react in like manner. The subsequent visual framework induces mental conditions of individuals from head signals and outward appearances in a video stream progressively. At 30 fps, the deduction framework finds and tracks 24 include focuses on the face and uses movement, shape and shading disfigurements of these highlights to distinguish 20 facial and head developments (e.g., head pitch, lip corner force) and 11 open motions (e.g., head gesture, grin, eyebrow streak) [47]. Dynamic Bayesian systems show these head and facial developments after some time, and gather the understudy's "covered up" full of feeling intellectual state [12]. Stance Analysis Seat was created and was presently tried a minimal effort/low goals weight delicate seat pad and back cushion with a fused accelerometer to quantify components of an understudy's stance and movement [41]. This framework catches numerous understudy developments significant to instruction that were recently caught by the TekScan framework, that utilized an incredibly costly. Posture Investigation Seat, created for medicinal and car applications [12]. The past framework utilized example acknowledgment methods while watching characteristic practices to realize which practices would in general go with states, for example, intrigue and fatigue. We are presently creating comparative calculations dependent on the amazing failure cost stance examination seat.

3. Classification of Sensors

3.1 Sensors in Emotion Recognition

Table 1: Summary of Reviewed Relevant Studies

Simulator Type	Example	Knowledge Taught
Physical Procedures Simulator	ATC-600 - a hardware device that is used to test aircraft transponder on the ground.	procedural knowledge in term of operating of tools or devices
Software Emulation	Tutorial for Microsoft office	procedural knowledge with software characteristics and its usefulness
Operational Simulator	madden 2007	procedural knowledge with suitable procedures for completing a wanted task
Principle-based Simulator (Social Simulator)	invigorated group meeting with specific advances	Improves the principles, and skills used throughout communicating
Problem-Solving Simulator	Roller Coaster Tycoon	Learner is required to solve a new problem

Emotion(s)	Reference	Year	Device	Sensors/Parameters	Classification/Processing	Accuracy
Joy, anger, sadness, fear, relax	[40]	2004	Headphones, headband with electrodes, clip, a touch type electrodes	EEG sensor, SC sensor, pulse oximeter sensor	SVM	41.7%
Disgust, Happy, surprise, sad, anger	[28]	2009	EEG sensor with 64 electrodes	63 bio-sensors	Neural Network (MPL-BP)	56.65 %
Anxiety	[19]	2013	GSR device based on LEGO NXT Mindstorms	GSR sensor to measure SC RCX sensor	K-means GMM SVM Decision tree	70%
Anxiety	[37]	2013	Wristband	Accelerometer Data (ACC) ,Skin Conductance (SC)	-SVM with linear kernel -SVM with Radial Basis Function -k-nearest neighbors -Principal component analysis (PCA) and SVM with linear	75%

					kernal -PCA and SVM with RBF kernel -PCA and k-nearest neighbors	
Anxiety	[36]	2015	Wristband with two electrodes situated on two fingers	Electro Dermal Activity sensor (EDA), Skin conductance (SC), Galvanic skin PPG Pulse Plethysmograph sensor	SVM	82%
Anxiety	[35]	2015	physiological sensor, microcontroller and Bluetooth transmitter.	HRD, Skin Conductance (SC)	K-means	91.2%
Anxiety	[27]	2017	Wristband and Badge	Electro-dermal activity (EDA),Photoplethysmogram (PPG)	AdaBoost RBF kernel SVM Linear kernel SVM KNN	94% 93% 85% 87%
Anxiety	[46]	2017	Wristband with two electrodes situated on two fingers	electro-dermal activity (EDA) Features from skin conductivity response (SCR)	Decision tree	89%
Anxiety	[7]	2018	Headset, chest belt, shimmer sensor	ECG, EDA, EEG, cortisol level	SVM	86%
Anxiety	[9]	2018	A single dry-electrode EEG device	Multi sensors to measure EEG, ECG, GSR	SVM Naïve Bayes	86%

3.2 Sensors in Educational Institutions

In this section, a review on a classification of the usage of sensor in educational institutions to monitor and predict is presented. This classification is illustrated in Table 2 below.

Table2: Classification of the Usage of Sensor in Educational Institutions to Monitor and Predict.

Sensors Type	Eligible Learning States	Biological Markers
Chair sensors Camera	**Most eligible** (Joy, Aha moment, Concentrated Actively engaged) [12]	Incline toward hand; Little seat/head motion; Sit in center of seat; Head in center; Neutral face; [12]
Camera, Pressure mouse; Chair Sensors	**Medium eligible** (Frustrated, angry) [12]	head and seat motion; crushing of mouse [12]
Skin conductance; Camera; Chair sensors; Microphone	**Least eligible** **(**Bored, tired) [12]	talking; vast seat development; head motion; go to side or head up; Smile [12]

4. CONCLUSION

Emotions recognition is considered as a challenging process. It requires an effort to detect the emotional state of the people we interact with. In this paper an investigation on how sensors work in detecting human emotions and whether they can be suitability employed in education. Throughout the studies investigation process, it had been found that many researches had been concentrated on enhancing human health by applying sensing system that has a direct contact with human body. The sensing system provide an accurate emotion detection of the person such as happiness, surprise, sadness, or anger by the psychological measures signals obtained from the sensors found in EEG, GSR sensor, SC sensor, pulse oximeter sensor and Accelerometer Data (ACC).

Also, a discussion of the uses of simulators in the educational environment and how they improve the learning process was presented in the previous sections [24]. Simulators can increase the awareness of students in an effectively way and enhance the university education process with courses and laboratory exercises.

For Example, participating in a resource distribution activity, students might gain an understanding of inequity in society. Simulations can support other skills indirectly, such as Debating, a method associated with some large-scale simulations, and research skills [42].

In addition, the paper summarizes the simulators classifications gathered based on their role on educational institutions.

Furthermore, with the rapid development of sensing technology over the past years that led it to have vital role in any learning environment [17]. Also, the findings have indicated that there is a brawny link between learning support and the best in class of sensor-based stages models. We have examined three domains of a classification framework along with the sensors used in each domain [9]. Additionally, sensors can detect students' emotions in the classrooms and help them to tackle their negative emotions, thus supporting them to get back to their normal state. As a result, the need of using sensing system will have an impact on motivating the students and enhancing their learning performance overall. While the deployment of such technology can have a great impact in many domains, this paper can be taken as a basis towards using sensing technology in emotions recognition and, in educational institutions, considering other evolving computer science field from big data, intent of things, cloud computing and so forth.

5. Future work

In the near future we are attempting to involve the sensing system for the students who have any kind of disabilities or learning difficulties either a health condition or an interaction issue such as sensory, physical, or cognitive disability. For example, sensing system can assist the students who have sensory needs (hearing loss) to improve their listening experience. Students with hearing loss can hear and interact with the speaker easily through a sensor "sound receiver" that is attached to the student's ear and a microphone wearable by the speaker which works on radio waves. Using such technology, the student can hear the transmitted sounds from even a distance.

Therefore, we believe that sensing technology marks an important step in educational institutions. A study suggested that emotional state regulation may be an important factor in implementing the adaptivity of learning activities by the development of a device Galvanic Skin Response (GSR) that could collect and evaluate bio- signals by people engaged in learning activities. Students' performance during learning activities can be affected by their emotions either positively or negatively. For instance, negative emotions such as stress, shame, and anger may exert ambiguous effects, reducing the attention and limiting students' engagement to the learning activity [15]. It is intended to move forward with this GSR sensor and use it as a device for maintaining the students' positive emotional state and how to help them overcome their negative ones during learning activities. We also interested to examine how emotions recognition technology contribute to the workplace improvement in term of employee satisfaction and productivity.

Such technology could tell us how someone feels and assist us to understand their emotions. Computer Science and Artificial Intelligence Laboratory (CSAIL) researchers have developed a system that can predict human emotions by using wireless signals to monitor breathing, heartbeats and it is 87 percent accurate at detecting a person's emotions [48].

Our curiously intent should go much deeper relying on this study that can help us in not only recognizing the emotions but also how to change someone's emotional state from negative to positive after detecting the negative ones.

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