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Survey on Student Learning From Facial Expressions

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Abstract: Learning is an integral part of education for students of any age. Facial expressions are closely interwoven with student learning, as they are like a window to the tutors who train them. If the relation between facial expressions and student learning can be analyzed and captured by an automatic facial expression recognition system, then it could revolutionize the education field by letting tutors set the pace and content of teaching according to their students' interest levels. Survey on both these areas, separately and together, are discussed in this paper.

Keywords: Learning, Student, Facial expressions, Automatic Facial Expression Recognition.

I. INTRODUCTION

There are two sides to the coined expression - Learning from facial expressions: one would be what we can comprehend from human facial expressions, and the other would be the analysis of the human learning process with help from facial expressions. This survey paper tries to catch a glimpse of both sides of the coin! To put it short, what can we learn from our facial expressions about the human learning process? Researchers have done detailed studies regarding this interesting but significant topic to enhance the student-teacher relationship for an improved means of parting knowledge. It has been found that a variety of affective states transpire in learning contexts incessantly, and can have both pros and cons on students' learning ability. For example, students repeatedly come across exercises that require knowledge or skills with which they are not accustomed. Apathy, boredom, confusion, frustration, lethargy are some affective states that are evoked in response to these predicaments. Such affective experiences have a great impact as such emotions are inevitably bound to learning by suggesting students' perceptions of a learning environment and changing their ability to learn from it.

As the human face is a good mirror to all the emotions that are welled up inside, the affective expressions associated with learning are also visible to the outside world and to the keen eye that cares to see. If the connection between these positive and negative emotions, that fly across the face while learning something, can be connected, then we may find a way to strengthen the fortes of our modern education systems and improve the flaws that are currently nagging the students. This is of particular relevance today in our world of revolutionizing teaching methodologies where intelligent tutoring systems have come to play a crucial role.

The paper is divided into sections. Section 2 discusses briefly about learning. Section 3 explains the relation that learning involves knowledge construction and meaning decipherment from their own personal experiences by relating new information to what they already know. It is paramount to remember that all learners are capable of using both deep and surface approaches, and it is their perception of the worthiness of a task that largely influences which of the two approaches they actually use. [8]

According to Project RED 2010, the key implementation factors of which technology factors improves learning the most - in the rank order of predictive strength include nine points. They are: (1) intervention classes (2) change management leadership by prinicipal (3) online collaboration (4) integration of technology into core curriculum weekly or more often (5) online formative assessments (6) lower student/computer ratios (7) frequent virtual field trips (8) usage of search engines (9) principal training.

One area of affective computing that has drawn considerable excitement and research is the field of affect-aware advanced learning technologies, such as intelligent tutoring systems and educational games[9]. Psotka et al. have defined an intelligent tutoring system (ITS) in their book as,

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between facial expressions and student learning. Section 4 highlights the significance of automatic facial expression recognition in student learning. Section 5 concludes the survey.

II. LEARNING

Learning is a process that should both be fun and ignite the human mind for a thirst for knowledge. According to R. Karban, "Learning is the act of acquiring new, or modifying and reinforcing, existing knowledge, behaviors, skills, values, or preferences and may involve synthesizing different types of information. The ability to learn is possessed by humans, animals, plants and some machines." [2] In the book by Schacter et al. [3], they discuss that human progress itself tends to follow a learning curve over time, and is built upon and shaped by previous knowledge.

"The test of successful education is not the amount of knowledge that pupils take away from school, but their appetite to know and their capacity to learn," is a very thought-provoking quote by Sir Richard Livingstone (1941). The pursuit taken by students to learn something is an important factor in determining learning outcomes according to research done by the psychology society. Two approaches have been identified: surface approach and deep approach. The former focuses on discrete pieces of knowledge and on learning unrelated facts, without seeking an integrated approach. Students who see learning as an external process of increasing knowledge or memorization, tend to use surface approaches as their sole target is about doing well in academics. Counter to this is the deep approach to learning, where the student takes a holistic view by looking for underlying meaning and structure in all that is to be learned. Such students see learning as an internal process that requires their interaction with subject content. This theory contends Learning. Facial expressions have proven to be quite helpful in investigating affect, mostly because of the universality of facial expressions observed and the non-interfering nature of video recording. These recordings are then usually evaluated using self-reports or the popular Facial Action Coding System (FACS), which lists out probably all the yet possible movements of a human face called as action units (AUs).

In a research done on facial indicators of frustration done by Grafsgaard et al., the results reveal three convincing relationships between facial expression, the emotion of frustration, and learning: outer eyebrow raise was negatively correlated with learning gain, eyebrow lowering was positively correlated with frustration, and mouth dimpling was positively correlated with both frustration and learning gain. The research results of the early prediction models used show that the facial expressions during the first five minutes of the tutorial itself were notably prognostic of frustration and learning displayed at the end of the tutorial class. [6]

Affective computing used has two basic tenets. The first one is that a computer can detect and respond to users' emotions to produce more engaging and satisfying interactions. The second tenet is that such intelligent "a computer system that aims to provide immediate and customized instruction or feedback to learners" [4], generally without intrusion from a human teacher. Learning from any such ITS draws frequent affective feedback from students and wide variations in their behavior. A human teacher is quite capable of observing students' affect and behaviour in a classroom or vis-à-vis tutorial, and can determine who needs help and adjust the pace or content accordingly. Contrarily, computerized learning systems seldom assimilate such benefits into their teaching methods, and so are incapable of noticing and reacting to the affective states of students.

III. RELATION BETWEEN FACIAL EXPRESSIONS AND STUDENT LEARNING

Emotions are a part and parcel of our daily lives. Facial expressions are what conveys the emotional state of an individual to observers and is the primary non-verbal means of conveying social information between humans. The past two decades has seen the psychology research community embracing the science of emotion (also known as affect)[9]. It is from them that we have been able to get the major chunk of data required for affective computing and ideas for new computer vision techniques. The learning sciences field is thus impacted upon in a great way too. Albeit traditional focus for most learning technologies were on supporting cognitive processes and results, the role of emotions during learning is being increasingly researched on nowadays.

A great number of investigations have been held on the learning-centered facial affective states like joy, frustration, doubt, boredom (or disengagement), awe, elation, and flow (or engaged concentration). Each of these bestows to the elaborate interlace of emotional and innate steps involved in results obtained were compared, identifying correlations of AU1 (inner eyebrow raising) and AU2 (outer eyebrow raising) with frustration, and correlations of AU4 (eyebrow lowering) and AU7 (eyelid tightening) with confusion. [6]

Few studies have been conducted in the third category, which focuses on application of automated methods of detecting facial expressions related to learning. Woolf et al. checked the cognitive affective states of students using the

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MindReader tracking software. Posed facial expressions and head movements of states such as interested or concentrating, were used for training the MindReader. Authors of CERT have also used their creation to track facial expressions of students interacting with a human teacher with an iPad during cognitive game tasks. While the CERT output bequeaths us with an insight into facial expressions during learning, the tasks may not have drawn out the full complexity of cognitive processes involved during an academic learning session.

IV. Significance Of Automatic Facial Expression Recognition In Student Learning

If the student engagement and emotional state can be read from the facial expressions displayed, then "automatic recognition of student engagement could revolutionize education by increasing understanding of when and why computers can make more effective human-like decisions compared to their purely rational counterparts. These systems use current computational techniques to model how emotions ensue from cognitive evaluation of real-world events. [9]

According to the research done by Grafsgaard et al. [6], three categories can be defined for the studies of facial expressions associated with learning-centered affective states: 1) observation and interpretation of affective behaviors; 2) scrutiny of facial action units involved in learning-centered affect; and 3) application of automated methods to detect affective states. The first category of studies involves observing and analyzing student behavior like head nodding, verbalization, and smiling. These researchers use natural video clippings taken during self-study and tough mental tasks, and have identified confusion, joy, interest, and surprise as the most frequent cognitive affective states. The observation protocol, developed over many years, involves viewing students through computer vision techniques and interpreting their posture, gesture, facial expression, and eye contact. It has been applied to worldwide student populations, and in turn, provided crucial understanding regarding matters like the adverse effects of boredom in learning universally.

The second category of studies involves investigating facial action units in learning-centered affect. Designing affective tutoring systems can then be achieved with the help from the resultant detailed data obtained. Researchers have compiled correlations of facial action units and learning with the help of FACS coders and multiple human expert judges, from video recordings of students in tutorials - both in traditional classrooms and online conference classes. The -sion Recognition Toolbox (CERT), made use of by the research community. [6]

In the recent cutting-edge innovative research done by Whitehill et al. [5], they have developed an automatic facial expression recognition software for student engagement. Their study included training an automatic detector, which measures how engaged a student appears, using a webcam video, while performing cognitive skills tasks on an iPad. Students' facial expressions were analyzed on a frame-by-frame basis, and their engagement levels were predicted. A real-time engagement detection technology that processes facial expressions was thus created, which could demonstrate its performance accuracy as comparable to that of human observers. Sweeping possibilities for its application in education and beyond are yet to be realized with full force.

The prevailing challenges in automatic facial recognition are head-pose variations, illumination variations, registration errors, occlusions and identity bias. Casual student behaviour often comprises of head-pose variations, which have to be taken care of first before facial expressions can be analyzed. Illumination variations can be dubious even if there is constant illumination due to head movements. Registration techniques generally have some inherent registration errors. Occlusions or blocks may occur due to movement of the head or camera, or accessories like sunglasses. Identity bias requires the ability to tell identity-related texture and shape cues by itself from expression-related cues for examinee students get disengaged," as said by Dr. Jacob Whitehill, Machine Perception Lab researcher in UC San Diego's Qualcomm Institute and Emotient co-founder. "Automatic engagement detection provides an opportunity for educators to adjust their curriculum for higher impact, either in real time or in subsequent lessons. Automatic engagement detection could be a valuable asset for developing adaptive educational games, improving intelligent tutoring systems and tailoring massive open online courses(MOOCs)". [5]

As the automated student emotion recognition can be used in real-time and provides inconspicuous evaluation to teachers, both in traditional classrooms and in online learning environments, it may also help to pinpoint segments of a lecture that are really good or needs improvement.

Advancement in automated facial expression recognition research has been booming in recent years. Popular techniques range from facial feature tracking to automatica emotion interpretation systems. Facial feature tracking methods have helped develop machine-learned models of facial expression recognition. Such systems are of use in many spheres, and is especially of service to mankind

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in education of the future. Unfortunately, it has been noted that the six most frequently studied emotions (e.g., Ekman emotions of happy, sad, angry, surprise, disgust, neutral) are rarely present in learning. Of late, automatically detecting FACS facial action units that may be correlated with learning-centered affective states are also developing. One such automated FACS coding system is the Computer Express-logical underpinnings of embodied emotions, and the contextual constraints that give rise to particular emotions. New devices and software techniques will increasingly provide high-fidelity affect-detection capabilities that are less expensive, less intrusive, and more scalable than the ones we have today. Affect detection and generation (that is, in animated pedagogical agents) have been integrated into several applications that epitomize how affective computing can improve different aspects of learner interactions. [9]

Recent research also shows that the intensity of the displayed emotion or facial action during learning is also very important for the automatic recognition of the student's engagement and interest level analysis. For AU recognition, significant enhancement can be done on the output by providing the temporal phase of the displayed AU. Moreover, combinations of AUs, rather than individual AUs, are also made use of as spontaneously displayed AUs rarely appear in isolation. Barring a few unsupervised knowledge-driven methods, all affect recognizers employ machine learning techniques. The performance of such an affect recognition system depends on the quality and quantity of training data of students available, along with the selected machine learning model. [8]

V. Conclusion

The new momentum toward developing affect aware learning technologies has been driven by a general appreciation for the inextricable link between emotion and cognition and by improved affect-detection techniques. Computers can automatically detect affective states through numerous signals: the same facial expressions and speech patterns we humans are sensitive to, the words we write or say, the physio.

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