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Review of the Application of Multimodal Biological Data in Education Analysis

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Abstract. Under the trends of quantitative learning, multimodal biological data is increasingly being applied to educational analysis. As this concept is generally accepted, biological data collection for educational analysis has become a research hotspot. Based on the relevant literature from 2014 to present, this article collates and exemplifies hot biological data for domestic and exotic learning analysis. The biological data used for learning analysis gradually evolved from single mode to multimodal mode. According to the relevant literature, this article will analyze the application of single mode and the application of multimodal. And will give relevant conclusions and forecasts.

1. Introduction
Quantitative learning refers to the usage of appropriate strategies and methods to obtain explicit and implicit behavioral characteristics of learners, and to satisfy learners' individualized needs through analysis, intervention, and provision of learning services \cite{1}. Quantitative learning is an educational innovation trend driven by emerging information technologies such as Internet of things and big data, and it is also an inevitable trend for the development of personalized learning. “Increasing attention to measurement of learning” has become an important trend in education reform. Under the trend of quantitative learning, multimodal biological data has been increasingly applied to the study of education analysis. Quantitative learning based on data makes it possible to examine educational process. Through data, we can understand, analyze, and predict the inherent laws of process and comprehensiveness. It can provide scientific basis for monitoring students' self-learning, making teacher's teaching decision-making, and managing educational institutions \cite{2}. Based on different sensory biological data, it can display the information of the learner more accurately and precisely. And it is conducive to accurately grasping the changes of the learner's emotional state and cognitive state during the human-computer interaction process.

With the development of the artificial intelligence technology, brain cognition, and sensor technology, learning behaviors and psychological characteristics based on multi-dimensional biological data have become the trend of educational technology research. Biological data is an electrical or magnetic signal generated by the biological activity of human body. Biological data is very sensitive to the change psychology, negative or positive emotions, attention and workload. It can
be used to find system usability factors and interaction events that induce the changes in user emotions and cognitive status, and it has advantages like objectivity, accuracy, real-time and so on [3].

2. Domestic and Exotic Current Research Status

Worldwide, many European and American countries have successfully applied eye movement data and expression data to education analysis, and have made great progress as well as some excellent results. Fang-Ying Yang et al. (2013) used eye-movement technology to study the attention distribution to PPT of student in university classrooms [4]. The study focused on the analysis of the viewing time, number of fixations, average fixation time, fixation time, and total fixation, and the percentage of these eye movement indicators. And through the analysis of the saccadic path can further reveal the differences in information integration patterns among different professional learners. Jamet (2014) used eye movement techniques to assess the attention distribution of learners in a multimedia learning environment which provides visual cues [5], and studied combined the eye movement indicators such as average fixation time and total fixation time for learners including several questions in advance, and analyzed it, then concluded that the introduction of visual cues reduced the time for the eyes to watch the unrelated regions. Lucia Mason et al. used eye movement techniques to examine the process of student learning science courses in the e-Learning environment [6], focusing on visual behavioral models which identified different individual differentiation (including reading level, existing knowledge, and three-dimensionality of spatial ability). MIT first tried to introduce emotional computing into distance learning and computer-assisted training [7]. They launched a project called “MYSELF” which includes multiple emotion detection modules that can capture learners’ facial expressions, sounds (such as frequency, intensity), oral speech content, and other behaviors (such as clicking mouse). It can identify the emotional state through combined features of physiological signals and speech.

Since 2013, China has gradually begun to apply biological data extracted computers in the field of educational analysis. As research continues to deepen and expand, it has also gone to some excellent research results. Han Li (2017) uses multi-pose face detection and facial expression recognition technology to acquire students' emotional changes in the learning process timely and help teachers accurately and comprehensively grasp the participation status of all students in classroom teaching [8]. Han Yinghong, Liu Nina et al (2017) have discovered some laws of preschool children's reading picture books through eye movement analysis methods, such as the characteristics of attention to pictures and texts, various factors that affect textual attention, etc. [9]. Liu Nina (2017) uses the disappearance text paradigm and manipulate the rendering time of words n-1 and n+1 (0m/40ms), to examine the reader's processing of the time history of both sides of the subfoveal information. Studies have found that it is very important for reading Chinese text to have a longer fixation time [10].

3. Development Trend

3.1. The Type of Biological Data Used for Research is Gradually Increasing

With the successful application of eye-movement technology and a lot of valuable research results in learning analysis and research, more and more biological data has been tried to be applied in educational research, such as: electroencephalogram (EEG), event-related potential (ERP), galvanic skin response (GSR), myoelectric signal (EMG), electrocardiogram (ECG), etc. Different biological data indicators can describe the learner's emotional changes from different dimensions: The research focus on the detection of “micro-expression” for facial expression recognition. “Micro-expression” refers to the expressions with a duration of only 1/25 s to 1/5 s, expressing the true emotions people are trying to suppress and hide [11]. EEG allows the computer to directly recognize the learner's emotional state. The ERP study showed that individuals exhibited emotional differences within 200 ms after the presentation of emotional stimuli. This shows that the EEG signal has the immediacy that we can grasp the current learner's emotional changes through measurement. Yu Dongchuan (2016)
designed a head-worn wireless EEG sensor to obtain students' EEG rhythms in real time, using the $\beta/\theta$ ratio as a parameter for assessing the level of attention of students in real time [12].

3.2. From Single Modal Biological Data Evaluation to Multimodality Evaluation
Researchers have found that the determination of complex indicators such as emotions and attention are often difficult to be accurately characterized using a biological data. Multi-modal analysis technology is a cross application of many research fields including computer vision, neuroscience, and artificial intelligence. Multimodality refers to the simultaneous measurement of more than two biological data of the learner, and it provides a comprehensive evaluation of the learner's learning status based on all data measurements [13]. Wang et al. (2014) used modalities feature information of expressions and speech modalities, and the SIFT feature and lS-SVM classifier to perform emotion recognition on expressions, and the open SMILE toolkit and sparse representation SR classifier to carry out emotional recognition of speech. Both obtained better results [14]. Beijing Normal University School of Education and Technology also established the "Multimodal Integration Analysis Laboratory." EEG can quantify the information transfer status between neurons, and has a very high time resolution; the collection of skin electricity, myoelectric and ECG acquisition is simple and the obtained data is stable. Through "distributed" multimodal data, it is beneficial to accurately grasp the changes of individual emotional states and cognitive states in the process of human-computer interaction [15].

4. Conclusion
With the rapid development of computer technology and bioelectricity measurement technology, multimodal biological data has been increasingly applied to the study of educational analysis. At present, commonly used biological data include: eye movement signals, facial expression recognition (FER), electroencephalogram (EEG), event-related potential (ERP), and electrocardiogram (ECG) etc. The process of analyzing multi-modal biological signals for learners is often more objective than a single modality. The usage of expression recognition aiding EEG signals to determine learner's emotions and attention tends to be better than a single modality.

The biological data in learning analysis has the characteristics of natural situation source, visualization, accuracy, and multi-dimension, which may hopefully enable researchers to open the cognitive black box hidden behind the complex learning process. The application of multimodal biological data in learning analysis will be a new trend in educational research.

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