Multiple Intelligence Learning

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Recently, the method to determine a person's intelligence and intellectual performance has been the usage of the intelligence quotient. There are many factors that this method does not take into consideration. Certain parameters related to the person, such as age, mental state, learning disabilities are not dealt with. Gardner's research points out that there may be more efficient ways to assess cognitive capabilities as it cannot be decided by regarding only one ability. Following this concept, our AdaptEd project approaches the issue by using biofeedback devices and automatized learning in order to enhance a person's learning process by stimulating different cognitive abilities and then adapting to them.

There is an increasing need for different teaching methods and a demand for schools which educate based on children's individual competences. We can see from the rising numbers of alternative schools, and the growing need for them, that both parents and decision-makers become aware of the need to teach each child according to her skills. It is important to obtain information about a child's cognitive performance before making a comparison to others in regard to intelligence. It is possible that with different teaching methods, children with disabilities could get similar results to their classmates.

It is necessary to analyse a person's mental workload during certain tasks and establish a model to be able to estimate her mental effort later. Using biofeedback data from sensors, such as heart rate monitoring and electroencephalography can be useful for establishing the model. If the person is required to do exercises of different difficulty level while this kind of sensor data is constantly being monitored, it is possible to separate different stages of mental workload. Given the fact that the levels of performance during these are personal characteristics, it is possible to adjust the model and thus, consider differences between people with different cognitive capabilities.

With measuring the different fields of intelligence, we are able to get a clear picture about a child's strengths and weaknesses, and provide for her the education that best fits her abilities. For creating this individually-optimised education, the use of today's technology, the use of tablets and smarthpones is required.

It is also an important step to determine to what extent and how exactly should the sensor data be used for the adjustment to the individual and for further estimation, what kind of processing and mathematical calculations can be considered. Our hypotesis is that with the use of biofeedback sensors and the AdaptEd framework we are able to test the multiple intelligence fields and make numerical measurements possible.

Our solution assembles, processes and stores biofeedback data in order to create a software environment where the mental workload can be estimated after a previous assessment of the person's abilities, then continuously estimates the workload and can adjust itself in difficulty to the person. The ideal result is to successfully find out if the given task matches the subject's cognitive abilities and then increase or reduce the difficulty.

We decided to build our solution on top of a framework, which integrates physiological signals into educational gaming on a mobile device. The software package has four major interfaces: for the biofeedback sensors, for the different (game) software components, one towards a supervisor machine and for the backend side. The application gathers data from the sensors, and uses a background process to upload them to the server.

In order to train the classification algorithm and also to measure the separate intelligence fields, we employ custom made cognitive games. Such games are N-back with symbols, numbers, characters or sounds, anagram guessing game, visual memory, or 3D abstraction games, which we implemented during our research. With the correct parametrization and setup of these games, we can infer on the intelligence and skills of the user. This wide variety of cog-

nitive games enables us to appropriately measure the following intelligence fields: musical-rhythmic, logical-mathematical, and verbal-linguistic. All of the games are available for mobile use as well.

To determine the actual mental effort we chose to use linear SVM (Support Vector Machine) for classiffication based on real-time sensor values measuring inter-beat intervals for heart rate and/or measured EEG values. First, a model needs to be established so the algorithm can learn what kind of values exactly can be linked to different stages of mental effort, meaning, a training period needs to precede the mental workload estimation. The training period consists of different phases, each one of them giving a certain exercise or activity that the person in question has to do or solve. To achieve a better set of training data, the exercises are of well separable difficulty.

The software environment can be used with various learning games with different kinds of tasks. For the individual and private experience, a feedback about the smartphone or tablet usage is required, and biofeedback sensors are the best way to get these results. By measuring a child's brain waves and heart signals, we can get a clear knowledge about her mental workload and mental state, and optimize our educational tools for better results and better experience.

We created the software and hardware environment for our solution, in which we focus on signal processing and estimation of the mental workload, as we consider these the biggest challenges. In the future we plan to fine-tune our model with further measurements and analysis of the data. Our objective is to be able help children with or without learning disabilities have better learning experience and better results in the long term.