Adaptation of Task Difficulty in Rehabilitation Exercises Based on the User’s Motor Performance and Physiological Responses

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Motivation, Background, and Goal:

• Although robot-assisted rehabilitation regimens are functionally as effective as conventional therapies, they still lack features to increase patients’ engagement in the exercise.
• From a motor learning point of view, to avoid boredom or frustration, one needs to be kept at one’s desirable difficulty by meaningful manipulation of exercise challenge [1].
• This desirable difficulty can be dependent on both task performance and a person’s affective state.
• Performing a reaching exercise with different levels of error amplification (EA) leads to different levels of motor adaptation and affective states. Participants report different levels of perceived difficulty for each error amplification level [2].

This work is an investigation of the potential to predict a user’s desirable difficulty, with the main focus on:

1. Which dataset (motor performance, physiological signals, a hybrid of both) as the prediction variable set returns the highest accuracy;
2. Which of three machine learning approaches – Neural Networks, k-Nearest Neighbor and Discriminant Analysis – predicts participants’ desirable difficulty.

Study Protocol and Methods:

• 24 able-bodied participants.
• Five EA levels used as levels of task difficulty: control (no EA), low-gain visual EA, high-gain visual EA, low-gain force feedback & visual EA, high-gain force feedback & visual EA.
• Decay of trajectory error over the training blocks was used to quantify motor performance (figure 3).
• Three physiological signals were used: SCR, breathing rate, and skin temperature.
• Trained machine learning algorithms to predict participants’ desired difficulties based on motor performance and physiological signals data.

Results:

Discussion and Future Work:

• From the most accurate to the least accurate, the three machine learning algorithms were found to be: Neural Network, Discriminant Analysis, and k-Nearest Neighbor.
• Results show that use of motor performance attributes as an input to the prediction models yields the highest accuracy.
• The authors believe that physiological signals can provide supplementary information in predicting desirable difficulty in rehabilitation tasks.
• Future work includes exploring additional ways of combining motor performance and physiological features to achieve higher accuracy rates, the exploration of more sophisticated machine learning methods such as Support Vector Machines (SVM), and studies involving stroke survivors to investigate long-term effects of training with a system capable of providing exercises at the user’s desirable difficulty level.