A Generalized Framework for Performance Assessment in Computer-Based Rehabilitation Training

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Introduction

Patients undergoing rehabilitation are assessed very infrequently, due to the time-consuming (and costly) nature of most current assessments. This can lead to inappropriate choice of therapy and sub-optimal patient outcomes. Computer-based rehabilitation systems offer an opportunity to assess patients during training, but are currently limited by heterogeneous methods for scoring and performance measurement which prevents comparisons across games or training platforms. A reliable in-game method for tracking patient progress would reduce the need for in-clinic testing and provide more frequent feedback to patients and therapists, thus improving treatment and patient motivation. The goal of this project was to define a highly generalizable set of equations describing difficulty, efficiency, and performance that could be applied across many different computerized therapy systems despite differences in input devices and training applications.

Methods

We defined a general method for the quantification of performance in virtual reality systems by specifying matrices to represent the difficulty of the virtual scenario, the impairment of the physical inputs, and the interface between the two. These were combined with the scoring in the in-game task to create an overall performance measure. The equations were validated on patient training data from a clinical trial of 10 chronic stroke patients using YouGrabber, an upper limb rehabilitation system featuring two data gloves (10 degrees of freedom each) and 6 different training games. The subjects trained on the system for 4 weeks (4 1-hour sessions per week) and were assessed using a battery of standard outcome measures including the Chedoke Arm and Hand Activity Inventory (CAHAI) and the Box and Block Test (BBT) at 5 time points (baseline, start of training, midpoint of training, end of training, 3 month follow-up). We calculated the percentage change in performance from the first week of training to the last week and correlated that value with the percentage changes in the outcome measures from the average of the first two timepoints to the end of training.

Results

A positive correlation was found between CAHAI improvement from baseline to the end of training and increase in performance from the first to last week of training ($R=0.7734$, $p<0.01$). Change in BBT score showed no significant correlation with performance. Additionally, a negative correlation was found between the BBT and CAHAI baseline scores and the percentage performance improvement over the course of therapy (BBT: $R=-0.8472$, $p<0.001$; CAHAI: $R=-0.8017$, $p<0.005$).

Conclusion

We found that our generalized method for quantifying subject performance in virtual reality rehabilitation training could be applied to six different training games, and produced results that correlated with a standard rehabilitation assessment. Further work is needed to test our method for different indications with larger numbers of patients. Our method of quantifying performance can be used to assess patients and therapy across many indications and platforms, and could be used to develop a completely automated combined rehabilitation and assessment system.