

A Novel Human Centric CPS to Improve Motor/Cognitive Assessment and Enable Adaptive Rehabilitation



PI: Fillia Makedon; Co-PIs: Vassilis Athitsos, Heng Huang, Dan Popa, Zhengyi Le
University of Texas Arlington

http://www.nsf.gov/awardsearch/showAward?AWD_ID=1035913

Award #1035913



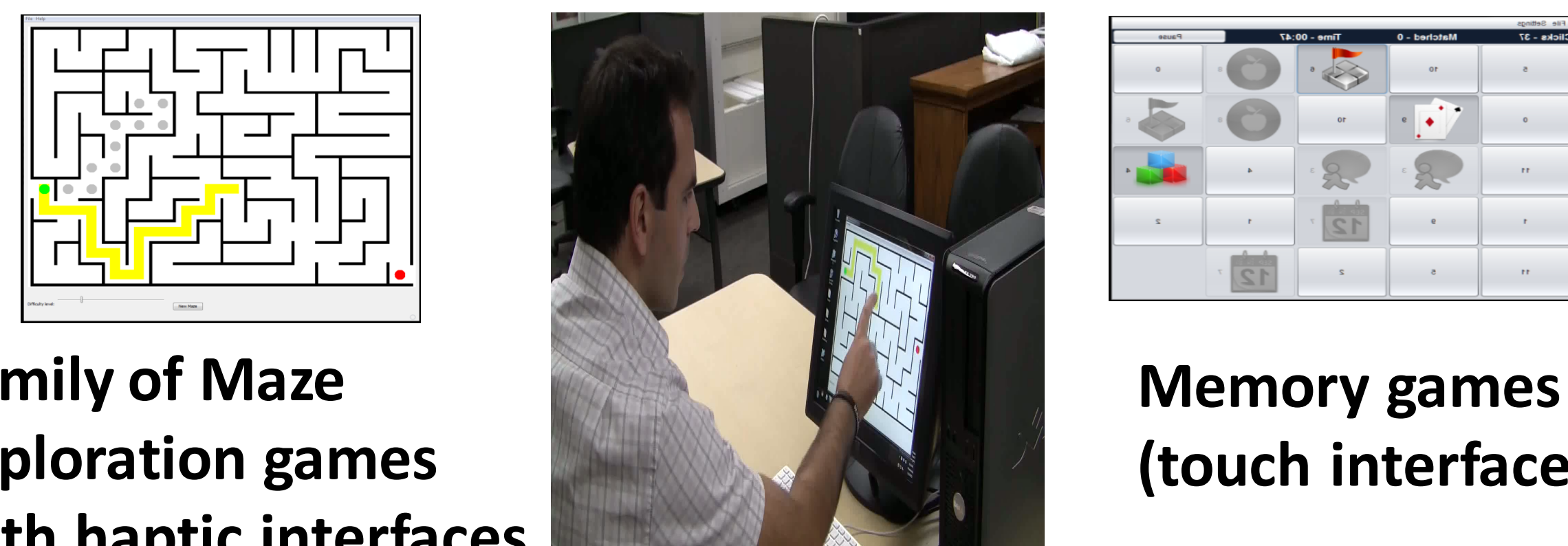
PROJECT SUMMARY

This project develops new methods and tools in motor/cognitive assessment for children 5-8 years old with Cerebral Palsy (CP). The aim is to develop a multimodal adaptive game-based diagnostic and rehabilitation system called CPLAY that integrates multiple views of cyber and physical components, multi-sensing and haptic data, in order to personalize progress and provide assessment mechanism of rehabilitation progression through the identification of changes in game activity.

Quantifying/monitoring progress: Therapist-compliant games for different platforms – touch screen, VR, haptic, etc. Measuring range of motion of arms, fingers and hands, hand-eye coordination, engagement, memory, speed of response, cognition, emotion, and other metrics using the Manual Ability Classification System (MACS).



Physiological Event-response therapy games (touch interface). Right: “Apple Picking” game (Kinect) tracks hand/ arm motion of retrieving apples on a tree in a virtual environment



Family of Maze exploration games with haptic interfaces

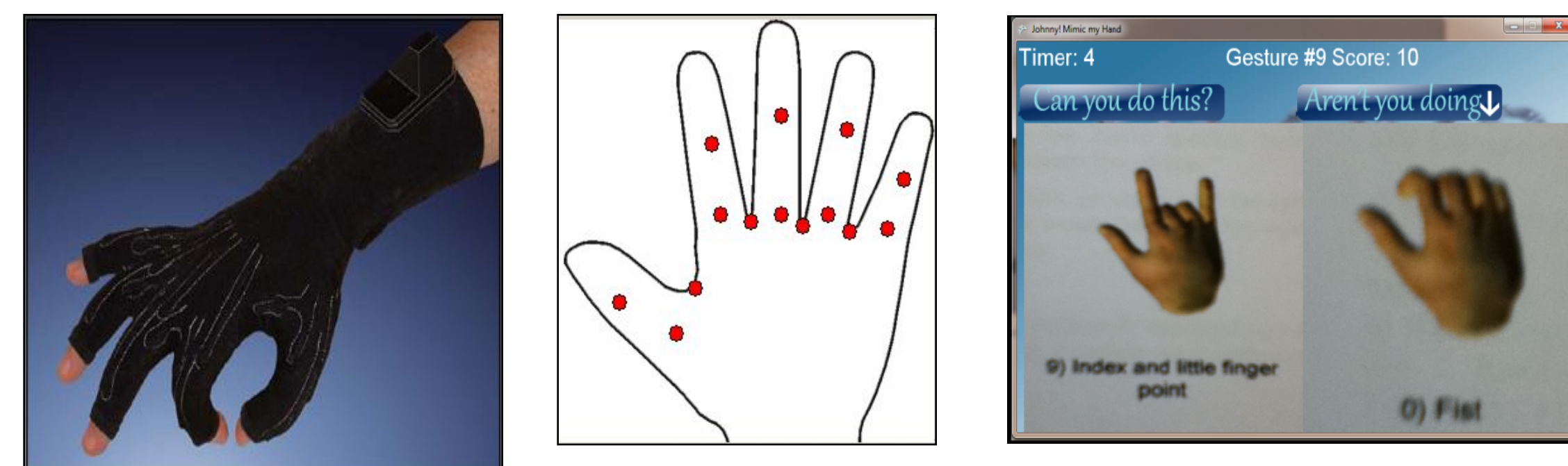
Memory games (touch interface)

SELECTED PUBLICATIONS

1. V. Metsis, D. I. Kosmopoulos, Vassilis Athitsos, F. Makedon: Non-invasive analysis of sleep patterns via multimodal sensor input. Personal and Ubiquitous Computing 18(1): 19-26 (2014)
2. Papangelis, G. Galatas, K. Tsiakas, A. Lioulemes, D. Zikos, F. Makedon: A Dialogue System for Ensuring Safe Rehabilitation. HCI (6) 2014: 349-358
3. D. Zikos, G. Galatas, V. Metsis, F. Makedon: A web ontology for Brain Trauma Patient Computer-Assisted Rehabilitation. ICIMTH 2013: 100-102
4. K. Tsiakas, L. Watts, C. Lutterodt, T. Giannakopoulos, A. Papangelis, R. Gatchel, V. Karkaletsis, and F. Makedon. A multimodal adaptive dialogue manager for depressive and anxiety disorder screening: a Wizard-of-Oz experiment. PETRA 2015: 82
5. S. N. Gieser, P. Sassaman, E. Becker, and F. Makedon. Pot hunter: a virtual reality game for analyzing range of motion. PETRA 2015: 3
6. G. Galatas, D. Zikos, F. Makedon: Application of data mining techniques to determine patient satisfaction. PETRA 2013: 41
7. M. Gardner, V. Metsis, E. Becker, F. Makedon: Modeling the effect of attention deficit in game-based motor ability assessment of Cerebral Palsy patients. PETRA 2013: 65
8. C. Mcmurrrough, S. Ferdous, A. Papangelis, A. Boisselle, F. Makedon, “A Survey of Assistive Computing Devices for Cerebral Palsy Patients”, Proceedings of the 5th International Conference on Pervasive Technologies Related to Assistive Environments - PETRA'12, 2012
9. V. Metsis, D. Kosmopoulos, V. Athitsos, and F. Makedon, “Non-Invasive Analysis of Sleep Patterns via Multimodal Sensor Input”, Personal and Ubiquitous Computing (2012)
10. K. Tsiakas, M. Huber, and F. Makedon. A multimodal adaptive session manager for physical rehabilitation exercising. PETRA 2015: 33
11. S.N. Gieser, A. Boisselle, F. Makedon. Real-Time Static Gesture Recognition for Upper Extremity Rehabilitation Using the Leap Motion. HCI 2015: 9
12. D. Ebert, V. Metsis, F. Makedon. Development and evaluation of a unity-based, kinect-controlled avatar for physical rehabilitation. PETRA 2015: 88

CP TELEREHABILITATION

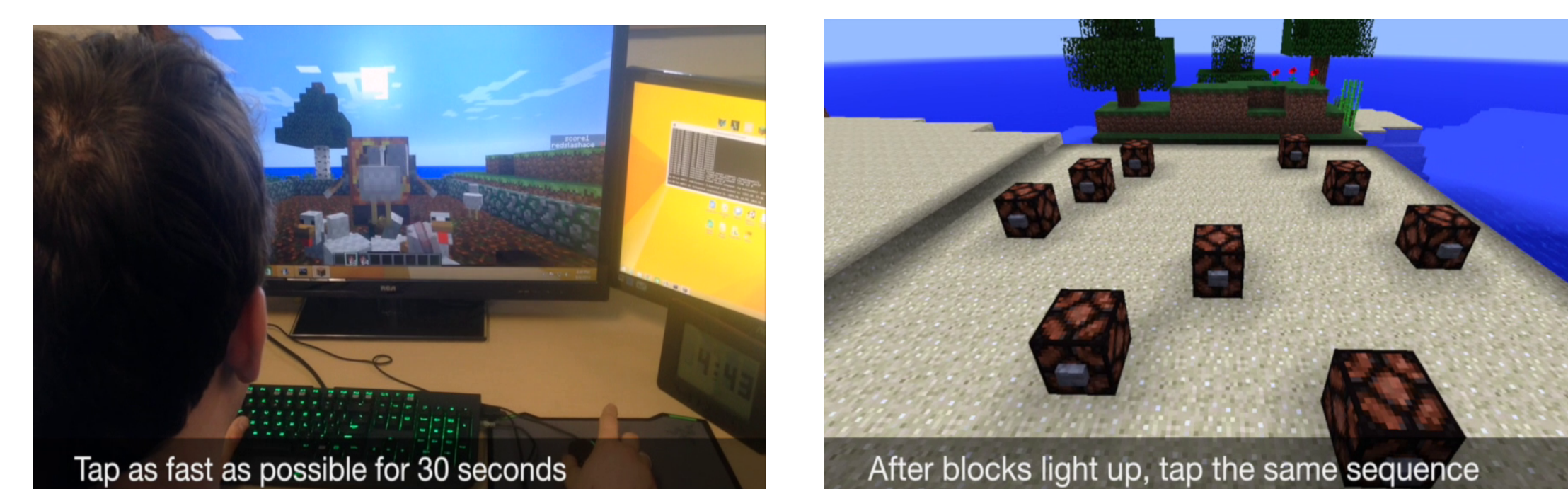
Developed multi-sensing and haptic game activities in order to increase compliance and ensure safety.



Above: To measure hand motion, we developed the “Johnny Mimic My Hand” game, with the 5DT Data Glove (left) and its sensor layout (middle). Players are asked to mimic (right), as accurately as they can, the hand gestures displayed on the screen. Therapist receives summary of progress. This helps measure Range of Motion, dexterity (pincer, finger isolation) and other functionalities.



Developed eye tracking and head motion tracking glasses for gaming using the Point of Gaze from user's eye and head movements



Above: Expanded the **MINECRAFT Gaming Environment** to enable assessment of cognitive and motor functions and coordination for children with disabilities.

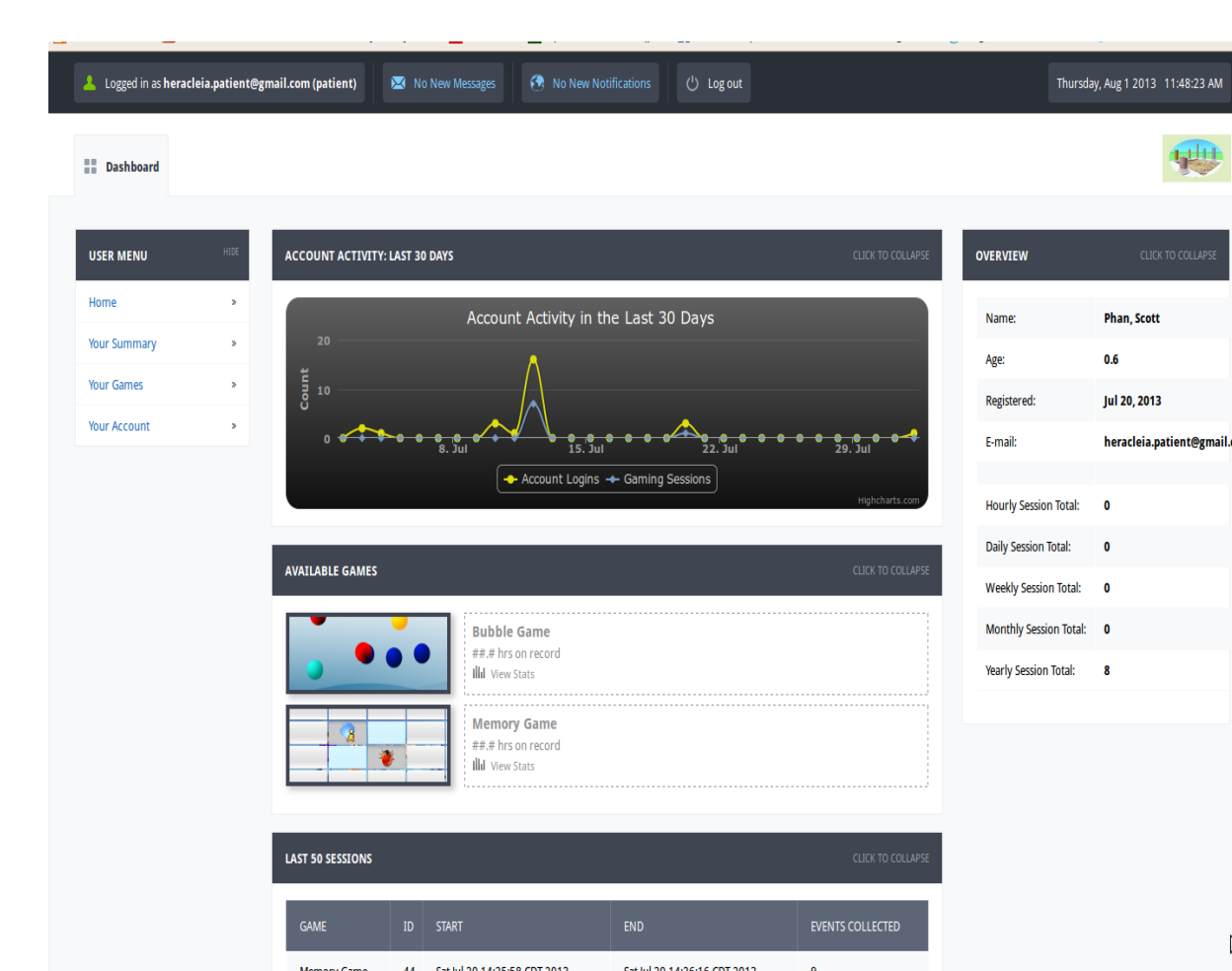
Right: Designed avatar coaches to promote game engagement and interaction during exergaming.



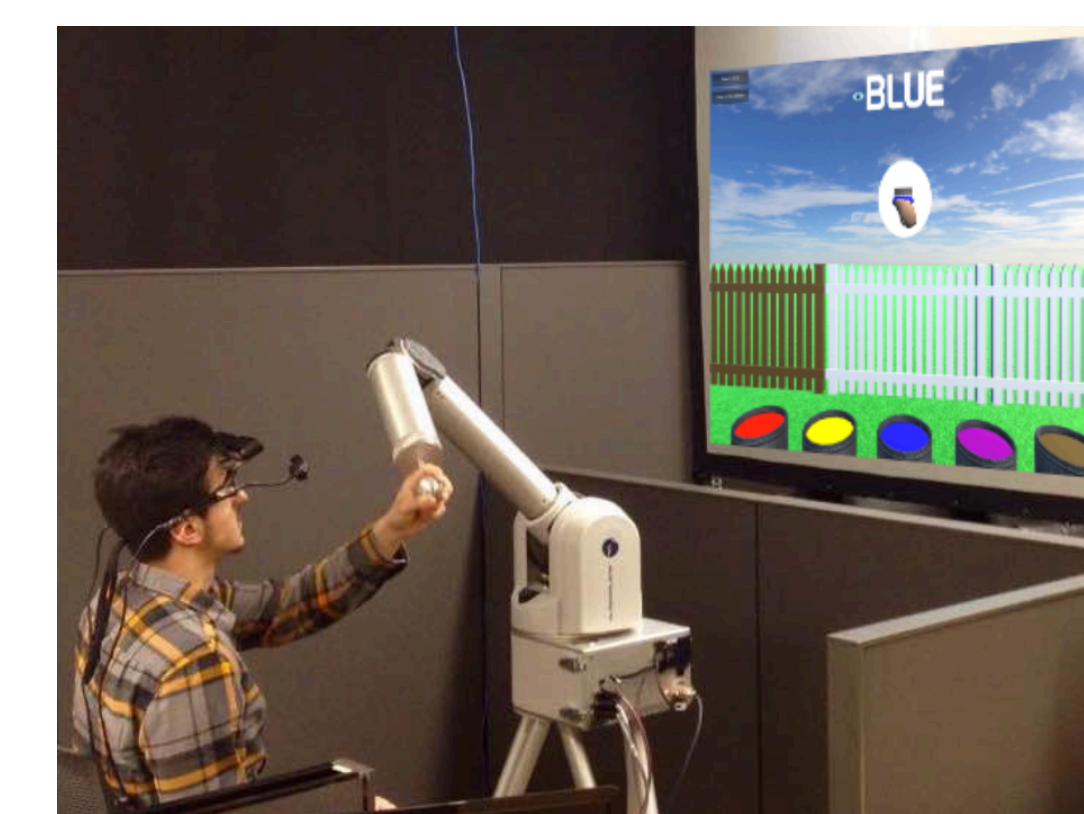
Left: “Pot Hunter”: an immersive reality game using CAVE. Range of motion of a person's arms and hands are analyzed when players reach up to grab colored pots and place them in a basket.

Right: Web interface for personalized game access

Backend System for Recording Game Performances
[\[http://apollo.uta.edu\]](http://apollo.uta.edu)

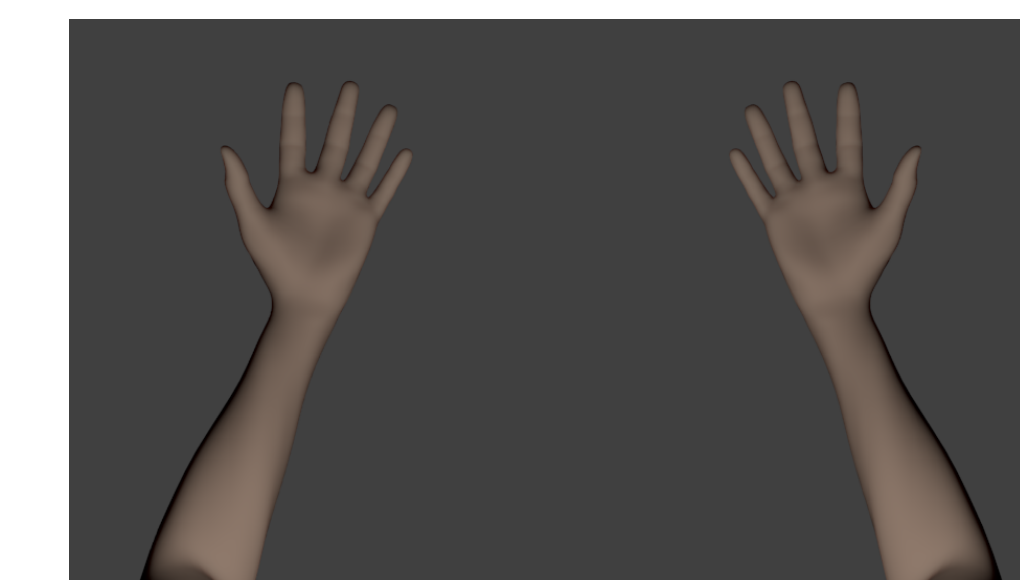
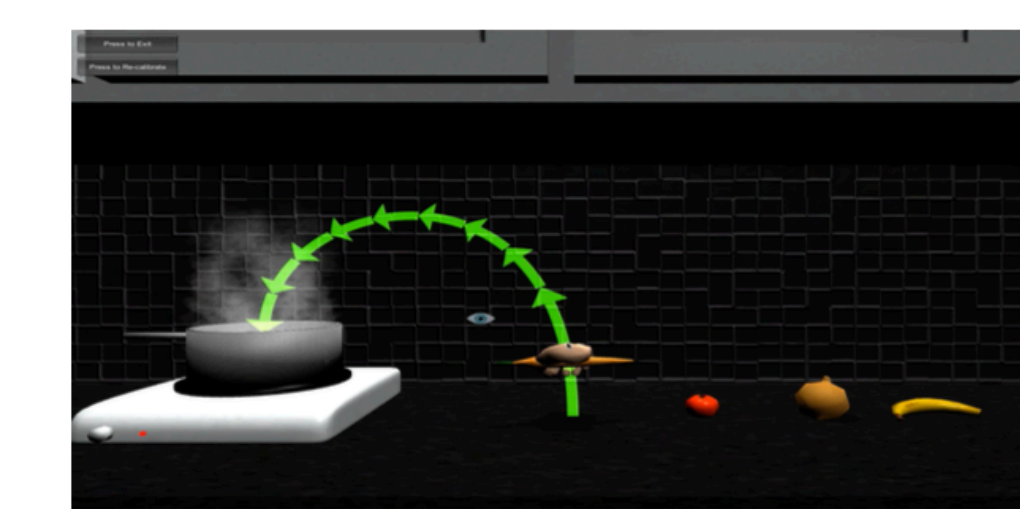


ROBOT-BASED HAPTIC REHABILITATION



Left: Smart robot-based assessment and training rehabilitation system based on “Gamification” and “Exergames”; the system is able to provide personalized training

Right. A battery of game-like structured activities that measure user's “behavioral signature” such as working memory, engagement rates, hand-eye coordination, reaction times, range of motion & predict ability to write.

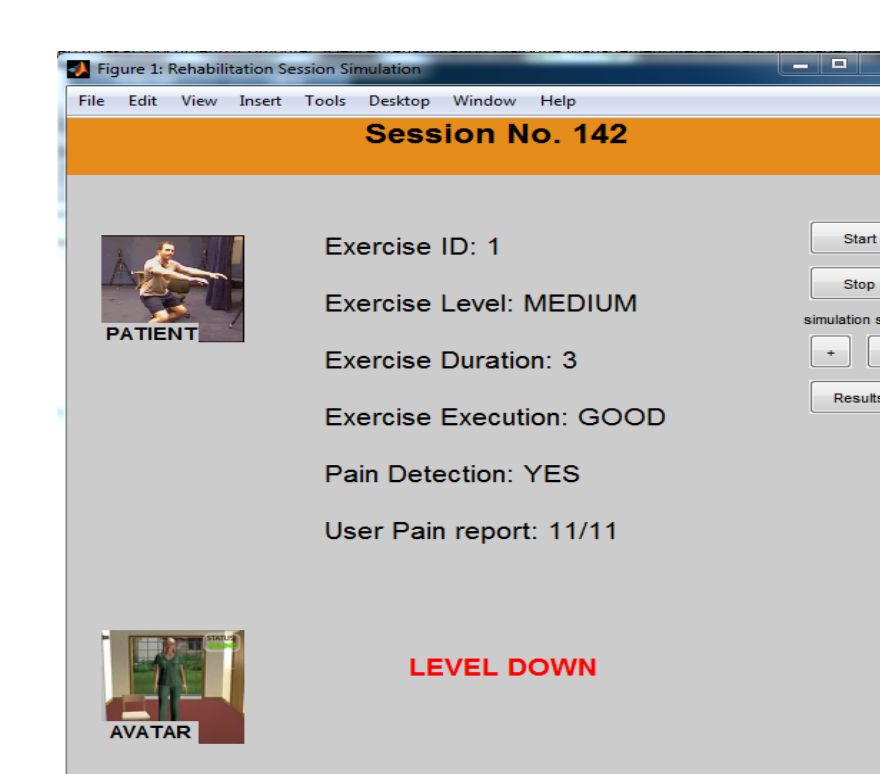


Use Myo armbands with Oculus Rift to simulate arms in a virtual environment, allowing a much more natural, immersive, and realistic system of interaction with the virtual world.

Multimodal Rehabilitation Session Manager



Interface for user to log in and retrieve his data: stored face image, current & previous login times; demographics and rehab information

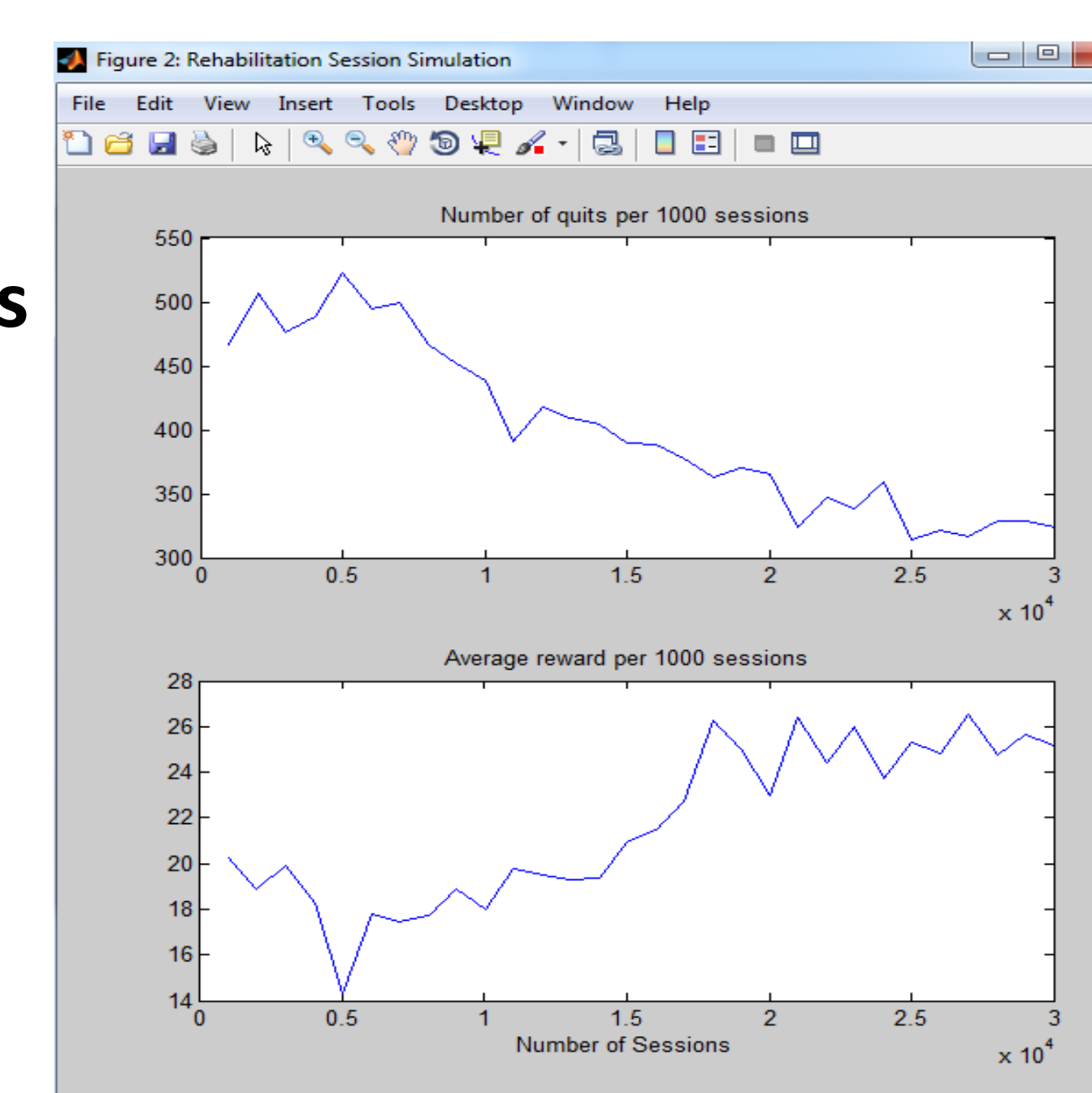


Session Manager: collects and analyzes multimodal data to optimize reward function. System adjusts difficulty level to engage patient & prevent injuries or pain

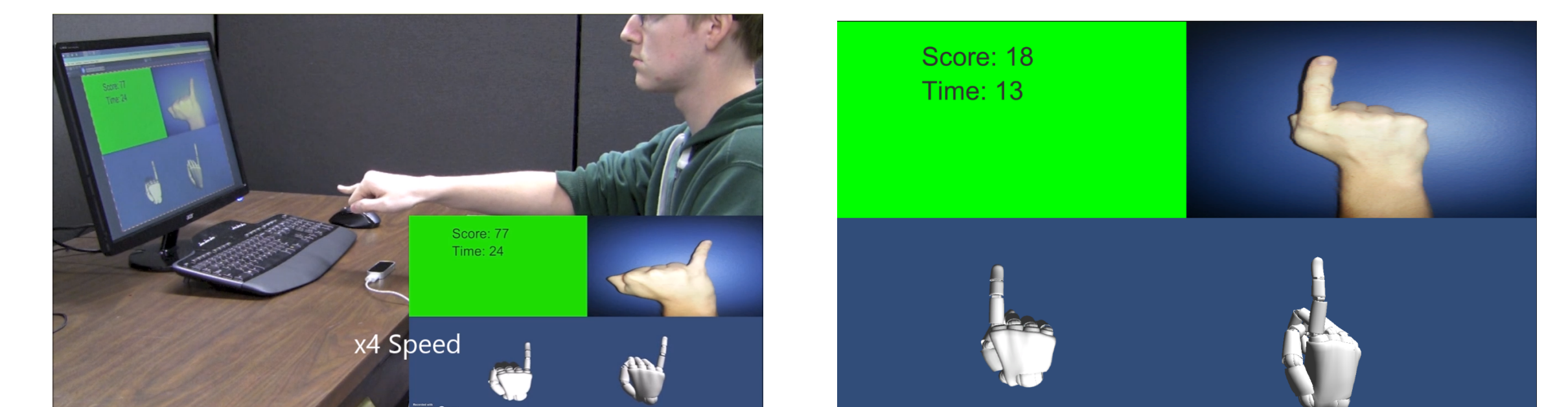
Results

The number of quits (per 1000 sessions) is decreasing (from ~50% to ~30%).

The average reward is increasing as the algorithm learns the optimal policy



CORRELATING WITH LIFE ACTIVITIES



Above: Leap Motion hand gesture analysis techniques are used in a matching game to increase motor control and dexterity of the hand for children with Cerebral Palsy and other disabilities.

Attention deficit experiments:

Children with CP are often diagnosed with Attention Deficit (Hyperactive) Disorder (ADD/ADHD) and get easily distracted during rehabilitation.

We performed ADD/ADHD simulation experiments with able-bodied users playing 3 rehabilitative games and proposed a methodology to model and eliminate the effects of attention deficit or distraction from the scoring scheme used to evaluate the patient's motor abilities and progress over time.

SYSTEM EVALUATION

We Introduced our tools & system of computer aided rehabilitation therapists at Cook Children's hospital and Scottish Rite hospital in order to evaluate. Parents had their children try the system. Pediatric occupational therapists and doctors were invited to use and evaluate it. Recruited student volunteers and collected data for further study.

FUTURE WORK

1. Expand mobile system to collect feedback from therapists, doctors, parents, patients
2. Collect BRAIN IMAGING data while children play games and correlate this data with data collected in the game for assessment and evaluation.

OUTREACH ACTIVITY

We presented many papers related to this work during the international conference on Pervasive Technologies Related to Assistive Environments (PETRA 2014 and PETRA 2015) and organized related Workshops. We presented our work in many other conferences. We supported about 12 REU students during 2014 and 2015 summers.

