World Academy of Science, Engineering and Technology
International Journal of Computer and Information Engineering
Vol:10, No:06, 2016

Cost-Effective Mechatronic Gaming Device for Post-Stroke Hand Rehabilitation

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Abstract : Stroke is a leading cause of adult disability worldwide. We depend on our hands for our activities of daily living(ADL). Although many patients regain the ability to walk, they continue to experience long-term hand motor impairments. As the number of individuals with young stroke is increasing, there is a critical need for effective approaches for rehabilitation of hand function post-stroke. Motor relearning for dexterity requires task-specific kinesthetic, tactile and visual feedback. However, when a stroke results in both sensory and motor impairment, it becomes difficult to ascertain when and what type of sensory substitutions can facilitate motor relearning. In an ideal situation, real-time task-specific data on the ability to learn and data-driven feedback to assist such learning will greatly assist rehabilitation for dexterity. We have found that kinesthetic and tactile information from the unaffected hand can assist patients re-learn the use of optimal fingertip forces during a grasp and lift task. Measurement of fingertip grip force (GF), load forces (LF), their corresponding rates (GFR and LFR), and other metrics can be used to gauge the impairment level and progress during learning. Currently ATI mini force-torque sensors are used in research settings to measure and compute the LF, GF, and their rates while grasping objects of different weights and textures. Use of the ATI sensor is cost prohibitive for deployment in clinical or at-home rehabilitation. A cost effective mechatronic device is developed to quantify GF, LF, and their rates for stroke rehabilitation purposes using off-the-shelf components such as load cells, flexi-force sensors, and an Arduino UNO microcontroller. A salient feature of the device is its integration with an interactive gaming environment to render a highly engaging user experience. This paper elaborates the integration of kinesthetic and tactile sensing through computation of LF, GF and their corresponding rates in real time, information processing, and interactive interfacing through augmented reality for visual feedback.

Keywords : feedback, gaming, kinesthetic, rehabilitation, tactile
Conference Title : ICSR 2016 : International Conference on Social Robotics
Conference Location : New York, United States
Conference Dates : June 06-07, 2016