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Developing Robot Motion Models and Gesture Recognition System for a Human-Robot Interaction System to assist in Play Therapy

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Abstract: Studies show that children with low-functioning Autism Spectrum Disorder (ASD) have problems with their motor skills and social development. Play therapy is a technique used to aid the development of children with special needs through play, as play helps children develop cognitive, social and perceptual skills. This study aims to assist therapists in the process through a follow-the-leader type game with an interactive robot system. This paper tackles the results of two main experiments: the data extraction of natural human motion as basis of robot motion model and the evaluation of Hidden Markov Model (HMM) gesture recognition algorithm to enable human-robot interaction. Natural movement is defined as a robot trying to achieve human-like motions as close as possible. This process can be done by collecting a total of fifteen sample video of human actions, tracking specific joints and manipulating the robot's actuator such that the velocity, acceleration, and torque are controlled based on the action provided. The primary goal is to identify whether the robot can reach arm accelerations of $5m/s^2$ to $20m/s^2$ and $-5m/s^2$ to $-20m/s^2$. The arm should also reach elbow angles ranging 35^o to 50^o during the transition of the robot's arm toward its body and 86^o to 116^o during the transition away from the body. The values are taken from the conducted experiments to produce the desired output with natural human movement. A direct attempt to reproduce the same movement patterns from the data collected from the test subjects produced a lot of jitter as the robot tries to move as fast as possible such as reaching the peak acceleration of $20m/s^2$ and $-20m/s^2$. Aside from producing natural movement, the system also needs to detect and recognize gestures that are given by the child. Gesture recognition requires machine learning algorithm such as HMM to be able to train gestures efficiently. To evaluate the HMM gesture recognition algorithm, a total of 65 gesture data per gesture were collected to use for training and testing. The HMM algorithm yielded low accuracy rate on determining the Lateral Raise gesture wherein only one out of five Lateral Raise were correctly classified while Hand Wave has four out of five. The result could be influenced by the small training set or the complexity of the gestures which made it hard to attain more than 50% accuracy rating.

Key Words: machine learning; gesture recognition; natural robot motion; human-robot interaction; play therapy