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Development of a Robotic Motor Skills Assessment System for Children with Autism

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1 Background

Autism is a developmental disorder characterized by atypical social interactions and repetitive behaviors/restricted interests[1]. It is found that children with autism also experience delayed or impaired motor skills development [2]. It would be advantageous to develop methods that precisely evaluate these motor skills impairments. The use of robots for evaluating upper limb motor competency have been looked at in the stroke literature [3]. We would like to leverage robotic tools for motor skills assessment but with focus for children with autism spectrum disorder.

Robotic methodologies provide a unique way of testing upper limb motor skills. For instance, if a person holds on to the end of a robot arm and moves the robot arm in space, the robot can apply forces and prevent or assist the person with these motions. In this fashion, the robot can apply perturbations in a repeatable and precise manner with high fidelity.

Since individuals with autism have anxieties interacting with other individuals[4], using an impersonal robot would alleviate the anxiety of social interactions. These individuals learn motor skills best with consistent repetition and strong reinforcement, qualities that robots provide.

Therefore, a robot based evaluation strategy and therapy paradigm for children with Autism would be beneficial for the community.

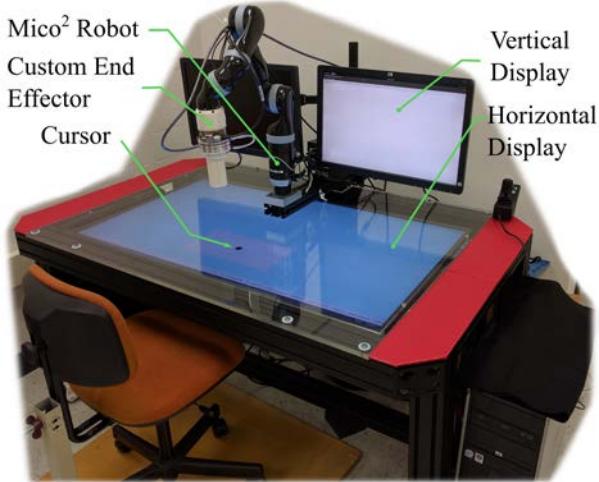


Figure 1. Robotic Motor Skills Assessment System

2 Methods

2.1 Design Motivation. The BOT-2 test [5] was used to motivate the methods we have developed for the Robotic Motor Skills Assessment for Autism. Since individuals with autism have problems in motor planning and coordination with sensory perceptions, we have developed a platform that can evaluate these skills. Keeping this in mind, we selected large shape drawing tasks for evaluating upper limb motion.

2.2 Hardware Design of Robotic Motor Skills Assessment System. The system is shown in Figure 1. The system consists of a 6 DOF Mico² robot arm mounted on a custom workstation. We designed a specialized robotic end effector to accommodate performing drawing tasks with the Mico² arm in admittance mode. The end effector has various sensors to measure applied forces on the robot as well as grip forces. A closer view of the end effector is shown in Figure. 2.

The end effector design consists of three six-axis force-torque sensors. Two of the sensors measure grip force and one sensor measures the forces applied on the robot by the participant. The entire assembly can freely pivot about the final robot axis to allow uninhibited rotation of the end-effector. The use of two force-torque sensors for grip force measurement provides improved force localization and increased overload capacity. While the robot has embedded torque sensors in its joints, we chose not to use these sensors, as their measurement characteristics would not be sufficient for our experiments.

We mounted the complete assembly on a custom workstation. We mounted a 50-inch full HD display horizontally on the workstation. A protective 12.7 mm thick acrylic sheet doubled as a working surface for the experiments and a protective sheet for the display. We used motion capture equipment from PTI Phoenix Technologies™ to capture upper limb motion.

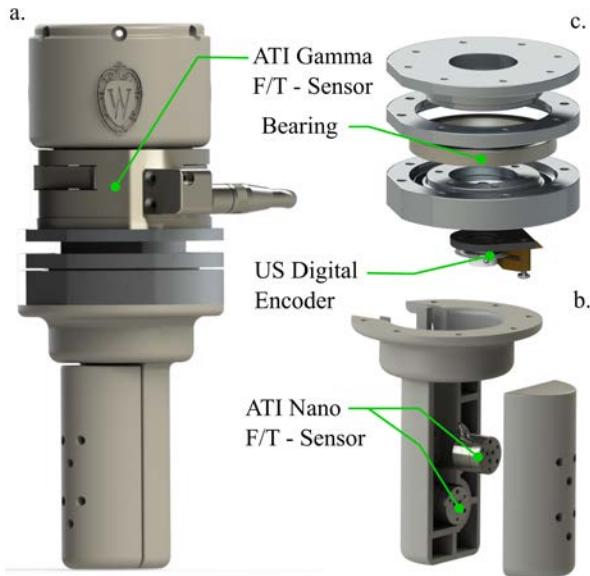


Figure. 2. a. End Effector Design. b. Handle. c. Bearing Housing

2.3 Software design for the Robotic Motor Skills Assessment System. The software design was motivated by both the requirement for quick prototyping and the availability of software options for interfacing between the Mico² robot via open source software Robot Operating System (ROS), the ATI – Force Torque sensors and motion capture software. We used LabVIEW for recording data and conducting experiments. Interfacing ROS and LabVIEW was accomplished by using software developed at Tufts University [6].

The Mico² robot comes installed with admittance control software. The admittance controller measures the applied forces on the robot and responds to these forces by moving the robot. Admittance control allows the robot to compensate for gravity and move in space emulating a mass immersed in a viscous fluid. The software allows changes to the impedance properties, which are inertia and damping of the robot end effector.

We developed the graphics software using RVIZ a package in ROS. We placed motion capture markers on the participant at anatomical references to measure joint angles. We used an NTP server-client network over LAN to synchronize the data-acquisition computer clocks for sub millisecond synchronization.

3 Results

3.1 Tasks. We selected large shape drawing tasks. The tasks are constrained to an x – y plane. These constraints are enforced by providing very large inertia and damping in the three rotation axes and the z - Cartesian axis. Impedance properties, including mass and damping, can be asymmetrically varied in the x and y directions. A cursor indicates the location of the robot during the experiments.

3.2 Data Visualization. We show superimposed position data from the robot's end effector x-axis and y-axis and force data to provide a clear picture of the patient-robot interaction during the experimental trajectory. Figure. 3 shows sample data collected for one of these tasks.

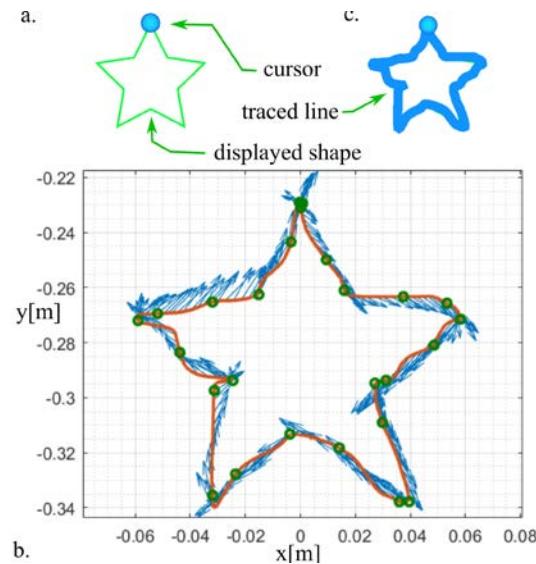


Figure. 3. Example Shape Trace Experiment: a. Screen shot of the horizontal screen with displayed shape. b. Collected Data: (Red Line - Robot Positon data[m], Arrows- applied force vector directions, Green Circles – Locations at one-second intervals) c. Screen shot of the horizontal screen with the trace.

4 Interpretation

From Figure. 3 we see that physically controlling the robot is challenging, making accurate reproduction of the displayed shape difficult. This is due to the limitation of the robot's admittance controller, which preferentially allows motion along the table-aligned x and y axes. However, we can leverage the different characteristics of the robot's admittance control to evaluate motor skill performance and learning in patients with autism. Experiments using the developed system will be conducted to evaluate learning and adaptation to the new motor tasks presented with the robot.

4 Acknowledgement

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