ASEE GSW Annual Conference Paper

The Engineering Design process for the EPICS' Motorized Art Table for Adults with Intellectual and Developmental Disabilities

Yuxin Jiao, Jiyah Starks, Danyal Syed, Reginald McKenzie II
The Erik Jonsson School of Engineering and Computer Science

The University of Texas At Dallas

Abstract

My Possibilities is a nonprofit organization that leads vocational education for adults with intellectual and developmental disabilities throughout North Texas. One sector of their organization offers classes to teach art to their students. Because of the range in disabilities of their students, traditional easels did not satisfy their needs. Thus, in the Fall of 2016, the My Possibilities Art Table project began. The objective of this project is to develop a motorized easel (i.e. art table) that will allow My Possibilities' students to self-sufficiently operate the table. The team solved this problem by developing an art table that would be wheelchair accessible, contain simple controls, and include vertical and rotational motion. In order to deliver the finalized product, the team segmented the system into subsystems to improve the design process. These systems included a vertical and rotational motion system, an electrical system, and the frame design. For brevity, this essay will discuss the design of the electrical and rotational systems as well as the testing process undergone to ensure the quality of each system.

Introduction

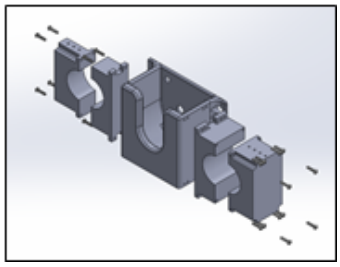

Figure 1: Rotational housing unit CAD Design

During the design phase of the motorized art table, the group had to consider many factors. The first was to ensure that the table was safe for the students at My Possibilities to operate. The table must be able to bear high point loads and tipping loads without compromising structural integrity. The table also had to have any wires be inaccessible to the students. Along with all the safety requirements, My Possibilities asked for an aesthetically pleasing design with a lighting system, a motor-controlled rotation system, and accessibility for wheelchair users. The motorized art table is a multi-system design that utilizes stepper motors, drivers, a sealed solenoid, a control system, and many other components. The group segmented the project into various part to produce the deliverable. The entire process included designing a vertical and rotational motion system, an electrical system, and the art table's structure. Though the design and implementation process included all the previously mentioned systems, this paper will highlight the rotational and electrical system designs.

Methodology

Rotational Motion Design

When designing the rotation system, the team had to ensure that the moving parts did not collide with the structure of the art table. To achieve this, the rotation system consisted of three axes in parallel to each other, each one containing a component; a stepper motor, sealed solenoid and a center ball bearing (Figure 1). The center ball bearing is held using a housing unit. The stepper motor and sealed solenoid are integrated into the rotation system using clamps that secure both parts to the center housing unit. Each component has one main input, rotation and locking. Each one is connected to a gear that meshes with a center gear that sits on the axial beam for the art table. The stepper motor allows the operator to control the rotational degree to a certain level of accuracy. The solenoid only allows linear motion; therefore, the gear will mesh with the center gear when de-energized, thus locking the system in place.

Testing Rotational System with Solidworks Simulation

In Solidworks, a computer aided design software, a Von Mises analysis was conducted on the table frame to ensure the torque applied from the rotational system while in operation did not affect the integrity of the frame. The frame material was simulated as Alloy Steel, used a Linear Elastic Isotropic model, and the failure criterion was Max Von Mises Stress. The volumetric properties of the body are a mass of 405 pounds and a volume of 1455 inches. This equates roughly to a density of 0.278 pounds per volumetric inch. From these simulations, we determined the table frame will withstand the expected amount of torque that would occur during operation

Electrical and Control Systems

When designing the electrical and control system for the initial table many factors were taken into consideration. The system had to be designed to operate three motors, their drivers, and the limit switches. Safety concerns require that all wires are tucked away and not accessible to the users. Due to using stepper motors to control the two different systems, three individual motor drivers needed to be used to control each motor safely. The need for these motor drivers increased the overall size of the electrical system. Using the MSP432P401R ADC Launchpad was used to accommodate the ports needed and improve the electrical system.

Summary and Conclusions

Above provide a high-level description of the designs used to provide My Possibilities with the tables they desired. Safety and structural integrity were a crucial part of our design and part sourcing process. In order to keep the rotation system from failing, we first set a few constraints, then selected parts to withstand loads that the users will apply. Since our table would be used by adults with disabilities, extra precautions were taken to design each system as safely as possible. Because of this priority, many challenges were faced during the development of each system for each table. From designing the locking mechanism in the rotational system, or the wiring for the of the electrical system, the cycle of designing and testing occurred until the finalization of each system. This continuous process eventually created the design that would deliver two art tables that are wheelchair accessible, contain simple controls, and include vertical and rotational motion.

YUXIN JIAO

Yuxin is currently an undergraduate student at the University of Texas at Dallas studying mechanical engineering. He has been working on the My Possibilities project for three semesters, primarily on the rotational system design. He also completed most of the CAD for the rotational system as well as the 3d-printing needed to complete the table.

JIYAH STARKS

Jiyah is currently an undergraduate student at the University of Texas at Dallas studying electrical engineering. She has been working on the My Possibilities project for three semesters, primarily on the design of the circuitry and the control system. She was also the group financial officer and maintained the budget and ordered any parts needed.

DANYAL SYED

Danyal is currently an undergraduate student at the University of Texas at Dallas studying mechanical engineering. He has been working on the My Possibilities project for six semesters. He primarily worked on the frame design and the new rotational system. Outside of the project, he works in a 3d-printing lab where he constructs and maintains the printers for his fellow lab members.

REGINALD MCKENZIE

Reginald is currently a graduate student at the University of Texas at Dallas studying material science. He has been working on the My Possibilities project for six semesters. He primarily worked on the frame design, simulation testing, and various other tasks. Outside of the project, He works in a lab that studies semiconductors for radiation detection.