THE UNIVERSITY OF UTAH
MECHANICAL ENGINEERING

ERGONOMICS AND SAFETY
THE UNIVERSITY OF UTAH

Smart H-Track

TETRADAPT™

Jacob Anderson, Branden Frieden, Mike McDonough, Mihir Pimpale, Alex Seeley, Dustin Sorensen
Advisor: **Dr. Andrew Merryweather**

Introduction

Many patients require assistance to safety transfer from a bed to a chair or toilet. For individuals living with spinal cord injury, this task is even more challenging, requiring support from others. Dependence on others may limit a person's ability to live independently. The purpose of the Smart H-Track system is to enable greater independence to persons who rely on lifts for transferring. The goal of this project is to provide a smart lift that responds and moves into place to perform a transfer without physical contact.

Team Focus

We developed a system to identify a known target in a room and move a motorized H-track to a desired location. We successfully demonstrated the ability to localize a target using a 3D depth camera and relay the coordinates to the H-track.

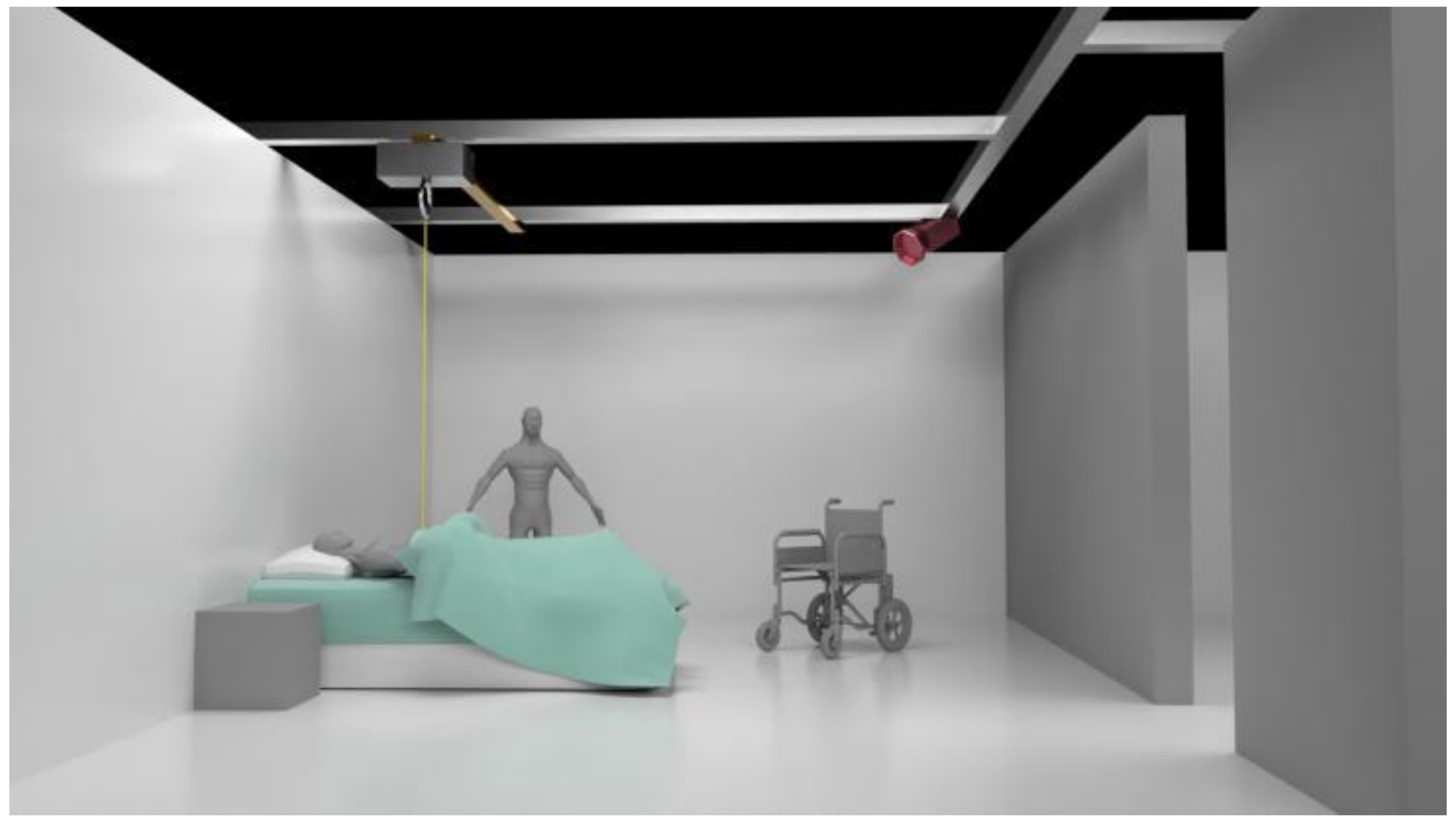

Figure 1. Example patient room with the overhead H-track lift system and a camera for object detection mounted in the corner

Approach

We automated the movement of the H-track to the target using a custom written object detection algorithm and open source deep learning framework for image processing. Once the location is determined, the system sends coordinates to the H-track motors to move the lift trolly to the correct location above the target. To test the effectiveness of this approach we designed a scaled prototype of an H-track lift (**Figure 2**). This consisted of a camera capable of object detection and depth sensing (**Figure 3**) coupled with a motorized trolley system to simulate a full sized H-track.

Prototype Design

A motorized prototype was designed and constructed to serve as a platform for testing and refinement of the object detection and image processing system.

The program runs in 3 steps:

1. Detect target and determine *x* and *y*-coordinates
2. Overlay depth field to determine distance from the camera
3. Convert distance to cartesian coordinates in the H-Track reference frame
4. Send coordinates to motor controllers to move the trolly to the target

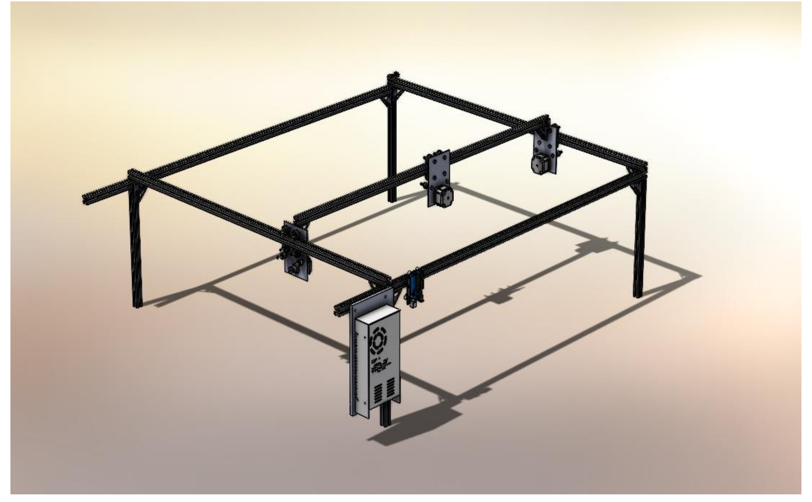

Figure 2. 3D model of prototype system

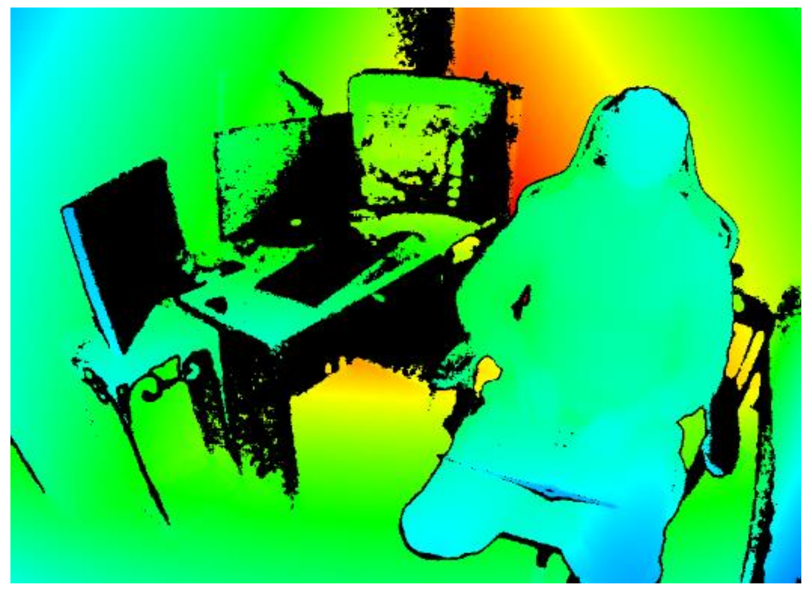

Figure 3. Depth field Image from Azure camera with color indicating distance

Testing and Verification

Motion Tracking

The accuracy and reliability of the object detection system was verified using a Vicon 7-camera motion tracking system. IR reflectors were placed on the frame and trolley as shown in **Figure 4**. These were tracked during motion to compare with the values reported by the object detection and image processing system.

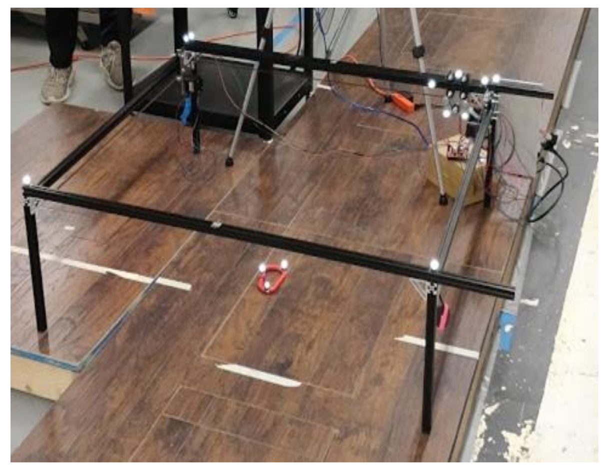

Figure 4. Prototype frame with attached IR reflectors

Variable Response Testing

We conducted a mixed-factorial experiment to evaluate the influence of 3 environmental factors expected to influence the performance of the system. These factors and their corresponding levels are listed in **Table 1**.

Table 1. The different factors and their associated levels that were tested.

Factor	Level 1	Level 2	Level 3
Ambient Light	High	Med	Low
Target orientation	Horizontal	-	Vertical
Target distance	Close	-	Far

Results and Analysis

Output Coordinate Analysis

All possible combinations of the factors and levels listed in **Table 1** were run to determine the accuracy of the position vector from the image processing system when seeking the center point of the target. The maximum error of the output coordinates was less than 5 cm in any cartesian direction, as seen in **Figure 5.**

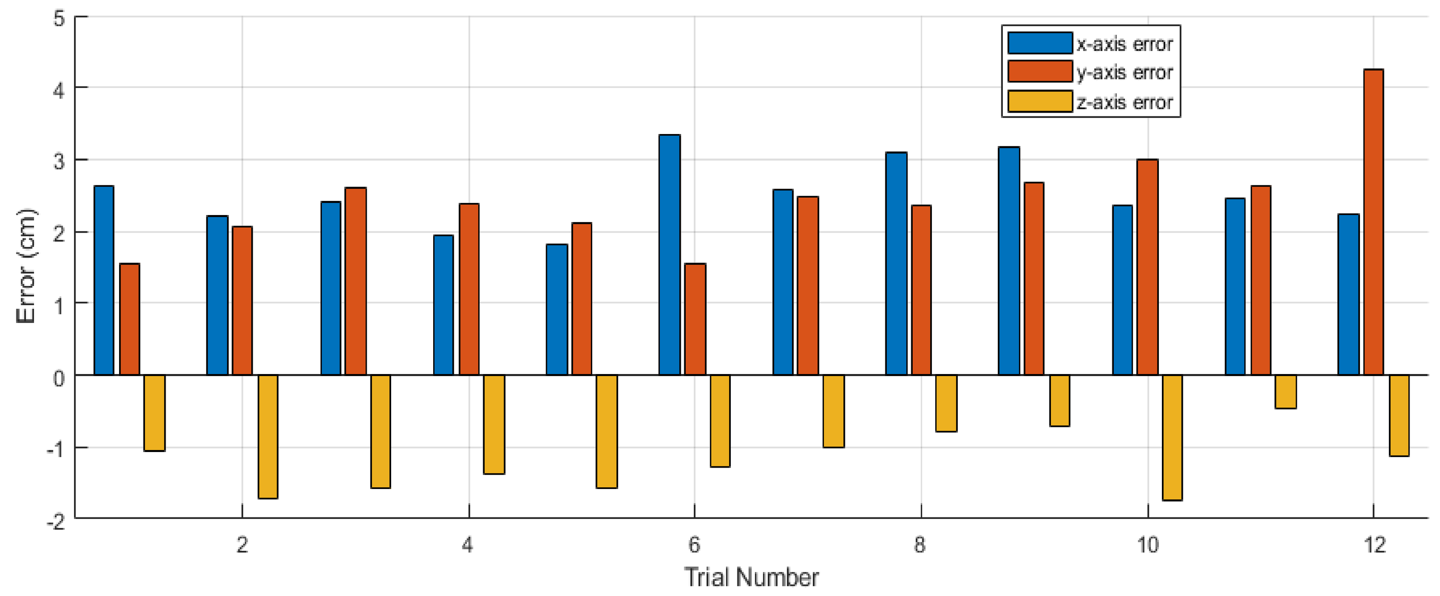

Figure 5: Error distances of target vector in cartesian coordinate directions

Total System Accuracy

Our design criteria required total system position error be less than 5 cm. The total error in position was within this limit as seen in **Figure 6.**

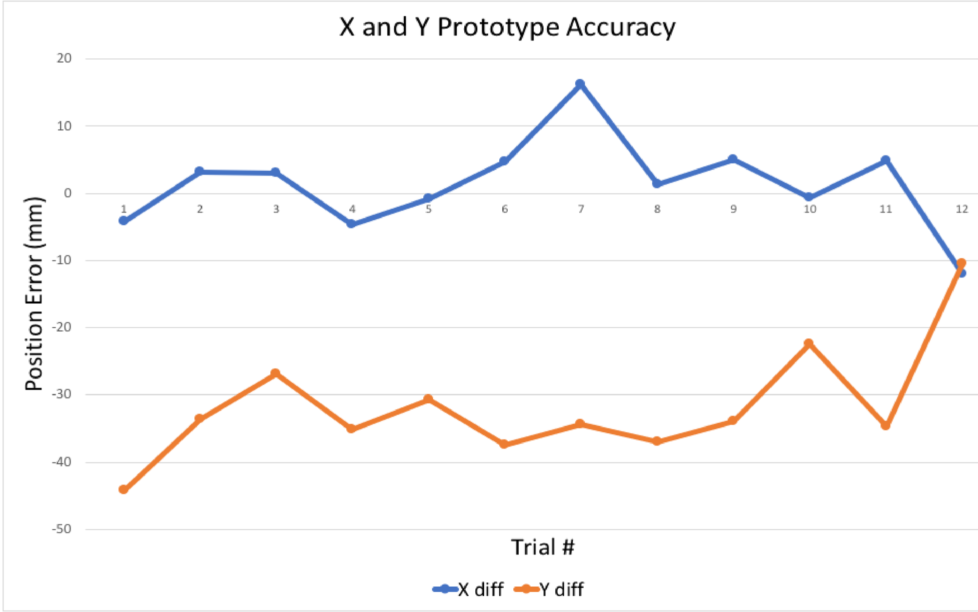

Figure 6. Total error in the system.

Summary & Future Work

We successfully proved our concept of object detection and motorized H-track movement to locate and move to a target randomly placed beneath a frame. The image detection and processing system developed will be passed on to future teams.
Future work will focus on scaling up the physical frame and motor control system to fit a room-sized H-Track lift. An automated clasping device will be designed to connect to a user's harness without requiring physical contact from an assistant.

Acknowledgement

Special thanks to Dr. Rosenbluth, the teams at TRAILS and TetraAdapt, and our advisor Dr. Merryweather for all the support throughout the development of the project.