Project Maverick

Applying robotics to help people with disabilities

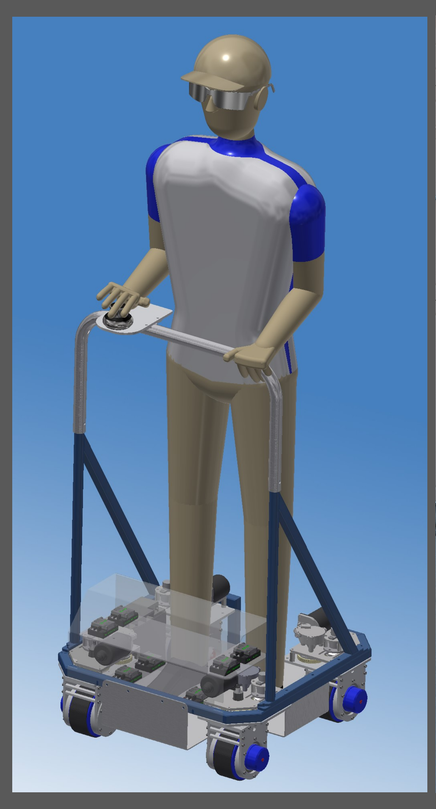
An Omni-Directional Robotic Mobility System

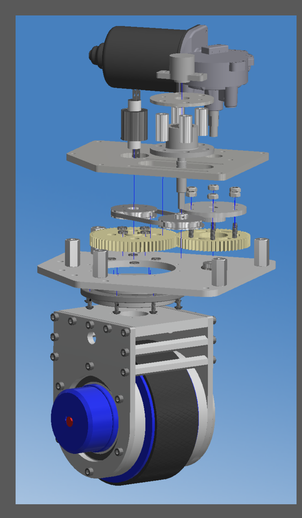
My Inspiration

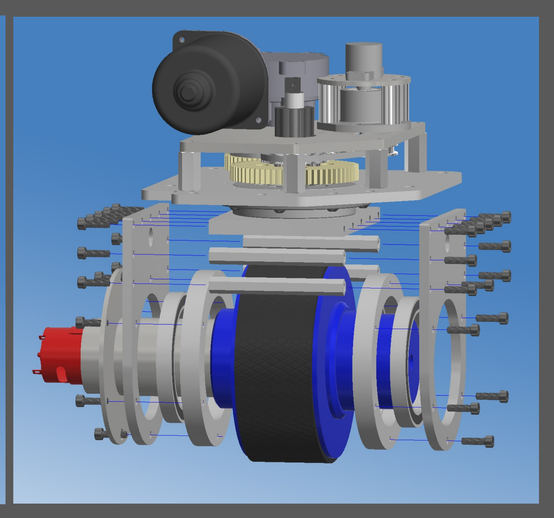
Every idea has a story to tell. My inspiration stems from an experience that changed my life forever. My grandfather was diagnosed with Parkinson's disease few years ago. I remember playing chess with him and noticing his hand trembling when making the next move. A couple of years ago, while I was visiting him during my summer vacation, I was shocked about the transformation due to Parkinson's disease. He was struggling to perform his daily tasks and seeing his suffering eyes, I wanted to do something for him. Maneuvering a wheelchair in tight spaces around his apartment was difficult and after losing a lot of weight, he had a hard time handling a walker. So already a natural tinkerer, I envisioned a device that would better suit the needs of my grandfather and others like him.

I am a robotics fan, and during my participation in the FIRST Robotics Competition I learned how to design and build robots and became passionate about it. I remember talking to my grandfather, discussing about the advantage of using such a device. I learned that it was important for him to regain his independence and that performing his normal routine was all he would wish for. We talked about how many people could benefit from a device like this and how I can make a difference in their lives.

Unfortunately, my grandfather is no longer with us to benefit from my idea. But I continue to live with the hope that other people like him can benefit from a mobility solution like this.







Medical Research

Mobility impairment can include any or all of the following:

- inability to move easily
- limited movement of arms or legs
- decrease in strength or control of the muscles and bones
- abnormal or impaired coordination

Mobility impairment may be due to a wide variety of conditions, illnesses, or injuries. These may include:

Image taken from Mayo Clinic,

Parkinson 's disease (PD) - a progressive nervous system disease that causes debilitating movement symptoms.

Muscular Dystrophy (MD) - a group of diseases that cause progressive weakness and loss of muscle mass

Multiple sclerosis (MS) - a disease in which the immune system attacks the protective sheath (myelin) that covers the nerves.

Rheumatoid Arthritis (RA) - a chronic inflammatory disorder that typically affects the small joints in the hands and feet.

Spinal Cord Injury - a damage to any part of the spinal cord or nerves at the end of the spinal canal causing permanent changes in strength, sensation and other body functions

Stroke - occurs when the blood supply to part of the brain is interrupted or severely reduced, depriving brain tissue of oxygen and nutrients and causing mobility impairment.

Aging - The changes that occur with aging can lead to problems affecting a person's ability to move around.

Sources of Information:

www.mayo.edu

www.webmd.com

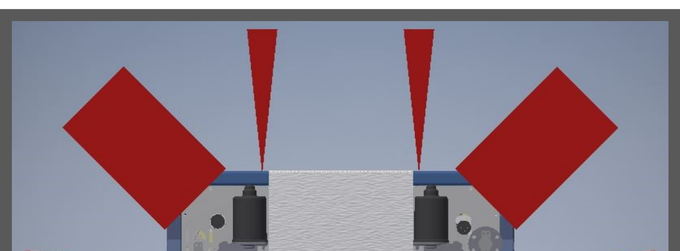
Collision Detection And Autopilot

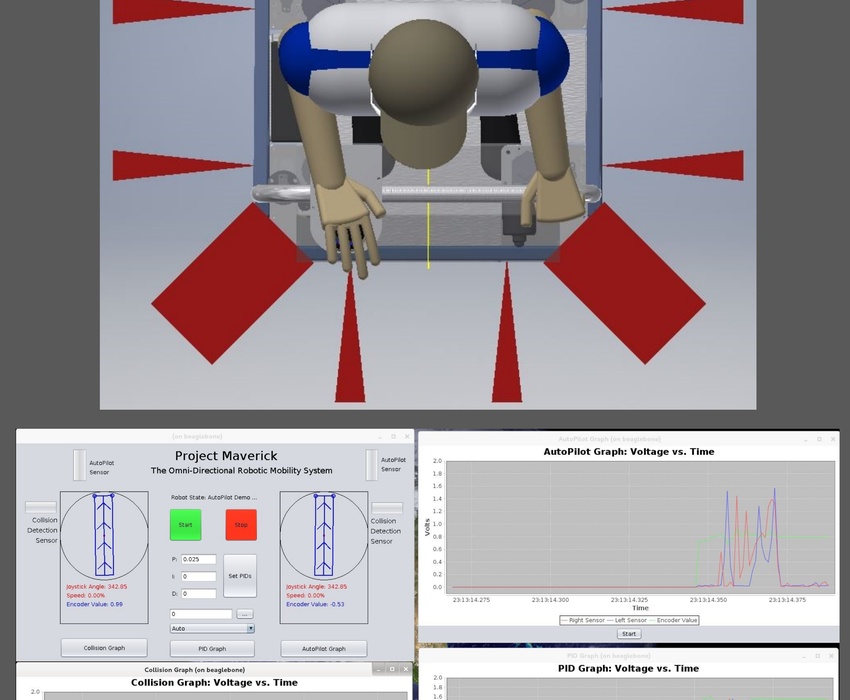
Project Maverick has 2 main safety features:

Collision Detection: For safety reasons, considering that people can sometimes make driving mistakes, I decided to design a collision avoidance system to keep the users safe and avoid damages around the house. As an object gets closer to the analog infrared sensors, the drive speed of the robot is proportionally decreased. When an object is less than 50mm from the sensor, the robot completely stops.

Autopilot: I also recognized that driving a mobility system in tight spaces, doorways and narrow hallways is difficult, so I decided to design an autopilot system that will automatically drive in tight spaces. The user can switch between normal driving and autopilot at a push of a button. The autopilot system calculates the difference between the left and the right I2C infrared distance sensor values, and then applies the appropriate correction to center the robot through the doorways or hallways.

The picture below shows the position and range of the sensors used for collision detection and autopilot systems.





Project Development

Mechanical Engineering and Design

- 3D Modeling assemblies and components using Autodesk Inventor Professional
- FEA (Finite Element Analysis) for load-bearing parts to make sure they could support the weight of a wide range of people
- Development of manufacturing and assembly drawings
- Selection of purchased parts (gears, pulleys, belts, bearings, gearboxes, motors etc.)

Electrical Engineering

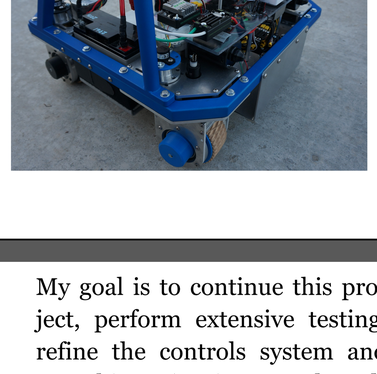
- Selection of the control system. Some of the options considered were Arduino, Raspberry PI, CRIO, Advantech Windows 7 Controller, BeagleBone Black. The final decision was to use the BeagleBone Black because it provided sufficient processing power and was able to interface with 8 motors and 4 analog inputs from absolute encoders.
- Selection of motor controllers: Talon SR with PWM input
- Selection of the encoder that provides the position feedback from the drive system. The advantage of an absolute encoder consists of maintaining the angle value of the drive module even after the robot is powered off. The final selection was the Vishay 981 HE hall-effect sensor.
- Selection of distance sensors: Sharp 0A51SK F 38 Infrared analog sensor
- Selection of a slip ring, used to transmit the power from a stationary frame to the rotating wheels. A key requirement was the maximum current transmitted. The final selection was the Mercotac Model 230, with a maximum current rating of 30 Amps at 240 Volts.
- Selection of an input device. The design required a simple and intuitive input device with at least 3 axis of movement. The final decision was the 3D Connexion Space Navigator.

Manufacturing

- A full size prototype was built to demonstrate the feasibility of the product.
- Drive system components were either 3D rapid prototyped or machined.
- The frame is a welded construction

Programming

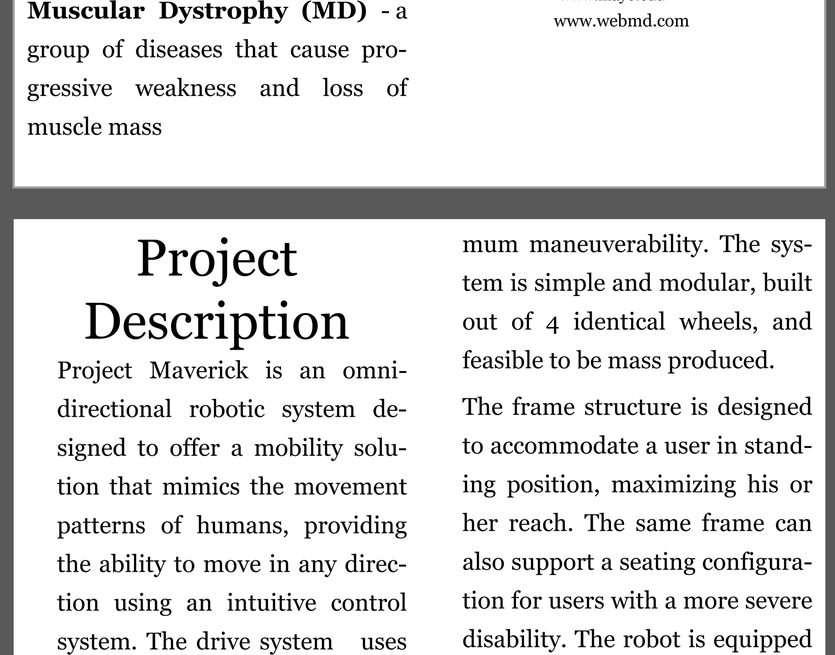
- Language: Java 7
- Environment: Debian 7 (Linux)
- NetBeans IDE with remote debugging capabilities
- User interface development to display key operation parameters of the robot running in a separate thread from the robot code
- Software interface for 3D Connexion Space Navigator
- Software interface for the analog input of the Vishay 981 HE absolute encoder
- Software interface for the Talon SR PWM motor controller
- Software interface for Collision Detection. The robot would slow down proportionally to the distance to the nearest object in the field of view.
- Software interface for autopilot guiding through doorways.
- Setup the controller for remote access from tablet or phone (VNC server on the BeagleBone Black robot controller and VNC client on the phone or tablet)



Project Description

Project Maverick is an omni-directional robotic system designed to offer a mobility solution that mimics the movement patterns of humans, providing the ability to move in any direction using an intuitive control system. The drive system uses 4 wheels and 8 motors. Each wheel has two independently-controlled motors for steering and driving, providing maximum maneuverability. The system is simple and modular, built out of 4 identical wheels, and feasible to be mass produced.

The frame structure is designed to accommodate a user in standing position, maximizing his or her reach. The same frame can also support a seating configuration for users with a more severe disability. The robot is equipped with a collision detection feature and an intelligent autopilot system to guide itself through doorways.



Conclusion

The testing I have performed using the fully functional prototype proves that it is feasible to build a mobility system using the design shown above.

The omni-directional drive system provides a more natural style of motion, with the same range of mobility as walking. The collision detection and autopilot system used in the concept prototype will ensure a safe operation of the robot.

My goal is to continue this project, perform extensive testing, refine the controls system and turn this project into a real product.

Project Maverick has been developed with a clear objective in mind: to help people with limited disability improve their lives, increase their self-esteem and most important – regain their independence.

All pictures and diagrams are made by Alex Tacescu unless otherwise noted