3D-PRINTED MOBILE ASSISTANCE PLATFORM (MAP) FOR REHABILITATIVE ROBOTICS

Dr. Patrick Benavidez
(presenting for Eric Wineman)
Before anything starts, choose the essential hardware and software to use

Picking core components is necessary for the following design process

If components change during the design process, that’s okay…but you might have setbacks in your schedule

Also, have an idea of how you are going to build your robot (3D Printing, CNC, etc.)
Ideally perform hardware and software design concurrently

Undertake individual unit testing for functionality

Integrate units piece by piece then execute combined testing

Combine all prior integrated pieces into functional platform

Execute platform testing
WHY A WALKER?

- In 2050, approximately 37% of the population is predicted to be composed of elderly people [6]
- Without any disabilities, the average cost from year 70 until death is around $136,000
- Reduce cost with an affordable platform
- Increase safety while remaining connected
- Allow elderly to act independently by providing obstacle avoidance and navigation
- Integrate with home cleaning/support systems
DESIRED FEATURES OF A MOBILE WALKER

- Be safe to use
- Provide powered motion for the elderly
- Simple to use interface for control
- Open-source for easy development
- Provide navigation and obstacle avoidance
- Integrate new design techniques
- Ascetically pleasing to elderly
- Auto-charging capability
- Be able to remove obstacles or pick-up objects
IMPLEMENTED FEATURES OF MOBILE WALKER

- Uses Robot Operating System to make the software Open-Source
- Uses Android Studio to allow application development for Android tablets
- Powered motor drive so the elderly do not have to push the walker
- Powered steering to allow easy turning
- Utilizes ODROID (mini-pc) for computation and future development
- Integrated Kinect for future development of feature recognition, mapping, and navigation
- Main interface is through a touch-screen Android tablet for easy management
- Simple joystick control for moving the walker
- Has electronic part files for more 3D-Printing or future manufacturing
SolidWorks was chosen as the design software for the Mobile Assistance Platform for the following reasons:

- Allows 3-dimensional visualization of parts
- Provides a simulation suite
- Compatible with ROS for navigational simulation/implementation
- Exports files suitable for 3D printing
- Customizable interface and units (IPS, MGS, etc.)
- Provides support and training
- Provides realistic rendering for demonstration purposes
- Design analysis features
- Produce manufacturing documents
MECHANICAL DESIGN

- A model of the walker without modifications was first created
- Parts were designed to meet with the objectives for the mobile assistance platform
- Once the parts were designed, they were placed into an assembly and simulated
- Once results were verified, the parts moved on to be 3D printed
MECHANICAL SIMULATION 1

Do I need to simulate?

What kinds of simulation can be performed?

- Static
- Thermal
- Frequency
- Buckling
- Drop Test
- Fatigue
- Nonlinear
- Linear Dynamic

What kind of tests should I do?
Mechanical simulations were executed
- Material was assigned to a part
- Fixtures were added to faces of a part
- Load was calculated and added to assembly
- Simulation was executed and results were evaluated
- Was the assembly strong enough?

Weight of an average man = 185 lbs.
(≈ 84 Kg)
Leads to a down-force of 823.2 N on the assembly
What is a 3D printer?
What types of 3D printers exist?
Why should I use a 3D printer?
Which kind of materials are available?
Major benefit is a savings in time and money
Cube 3D Printer

Printer Specifications:
- Build Volume: 152.5 x 152.5 x 152.5 mm
- Material: ABS and PLA
- Heated Bed: No
- Layer Resolution: 70 to 200 microns
- File Format: .cube3
- Wireless: Yes

Additional Features:
- Automated Calibration
- Enclosed Printing Cartridge
- Dual Extrusion
- Wash-away Supports

UP BOX 3D Printer

Printer Specifications:
- Build Volume: 255 x 205 x 205 mm
- Material: ABS and PLA
- Heated Bed: Yes
- Layer Resolution: 100 to 400 micron
- File Format: .stl, up3, upp
- Wireless: No

Additional Features:
- Hepa Air Filter
- Fully Enclosed Printing Volume
- Automated Calibration
Walker has power turning and steering
- Controlled via a joystick interface (swappable)
- Touch-screen tablet interface
- Microsoft Kinect for sensing
- ODROID for processing
- PID Controllers in each servo for controlling angular position
BENEFITS OF SMART SERVOS

- Ease of control for angular position and speed
- Tunable PID in each servo
- High torque
- Custom response time
- Can daisy chain servos
POWER SYSTEM

- Features a 5V, 7.4V, and 12V bus
- Expandable to power more systems
- Integrated quick-stop switch for emergency
- Can be net-listed to create a PCB
- Improves appearance for elderly
ELECTRICAL DESIGN (SOFTWARE)

- Robot Operating System (ROS) and associated packages
- Android Studio
- Arduino IDE
- Cadences’ OrCAD Capture
- Cadences’ OrCAD PCB Editor
COSTS

- The prototype was created for less than $1,000
- Less than Dynamaid at $3,500
- Surpasses cost of similar assistive platforms
- ARM = $26,000
- Overall cost excludes the user tablet
- Cost may increase during actual build (attributed to tooling costs, part cost would decrease though)

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Total Cost for Mobile Assistance Platform: $946.61
PROTOTYPE DEMONSTRATION
FUTURE WORK

- Increase strength of wheel base for mobile wheelchair properties
- Make MAP aesthetically pleasing
- Add a robotic arm for object and obstacle manipulation
- Include ROS navigation package for navigation and SLAM
- Could have a health monitoring systems for emergencies
- Voice control
CONCLUSION

- Took a standard COTS walker and made a prototype Mobile Assistance Platform
- Minimal modifications to the walker frame
- Demonstrated conceptual model was valid
- Integrated Open-Source Software
- Electronic Part Files
- Manufacturing Ready
- Cost-efficient Design
QUESTIONS?