FEI University
São Bernardo do Campo, São Paulo - Brazil

EMG - Driven Wheelchair Project

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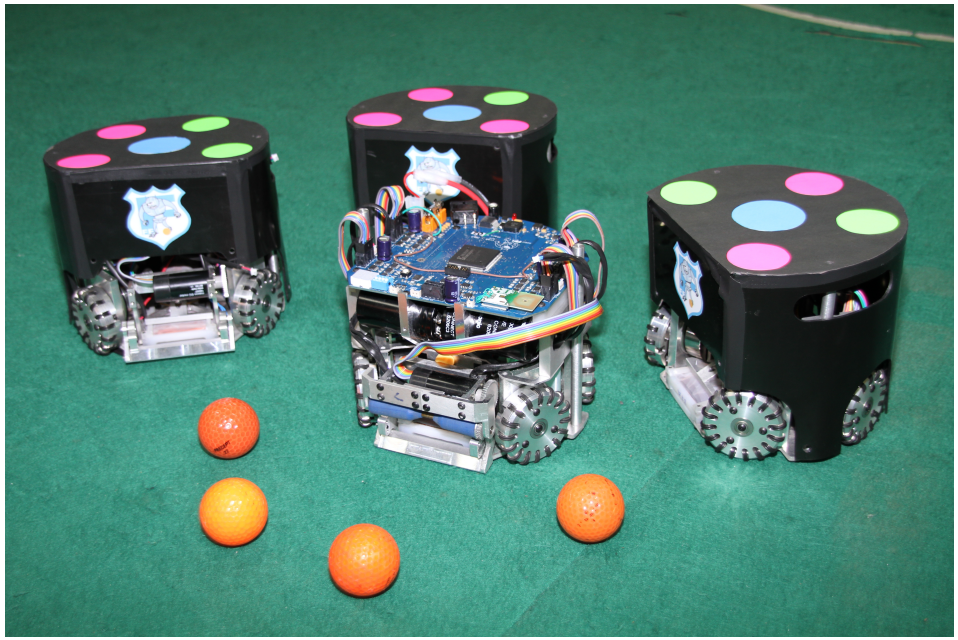
November 1, 2017

Content

Introduction
Overview Projects

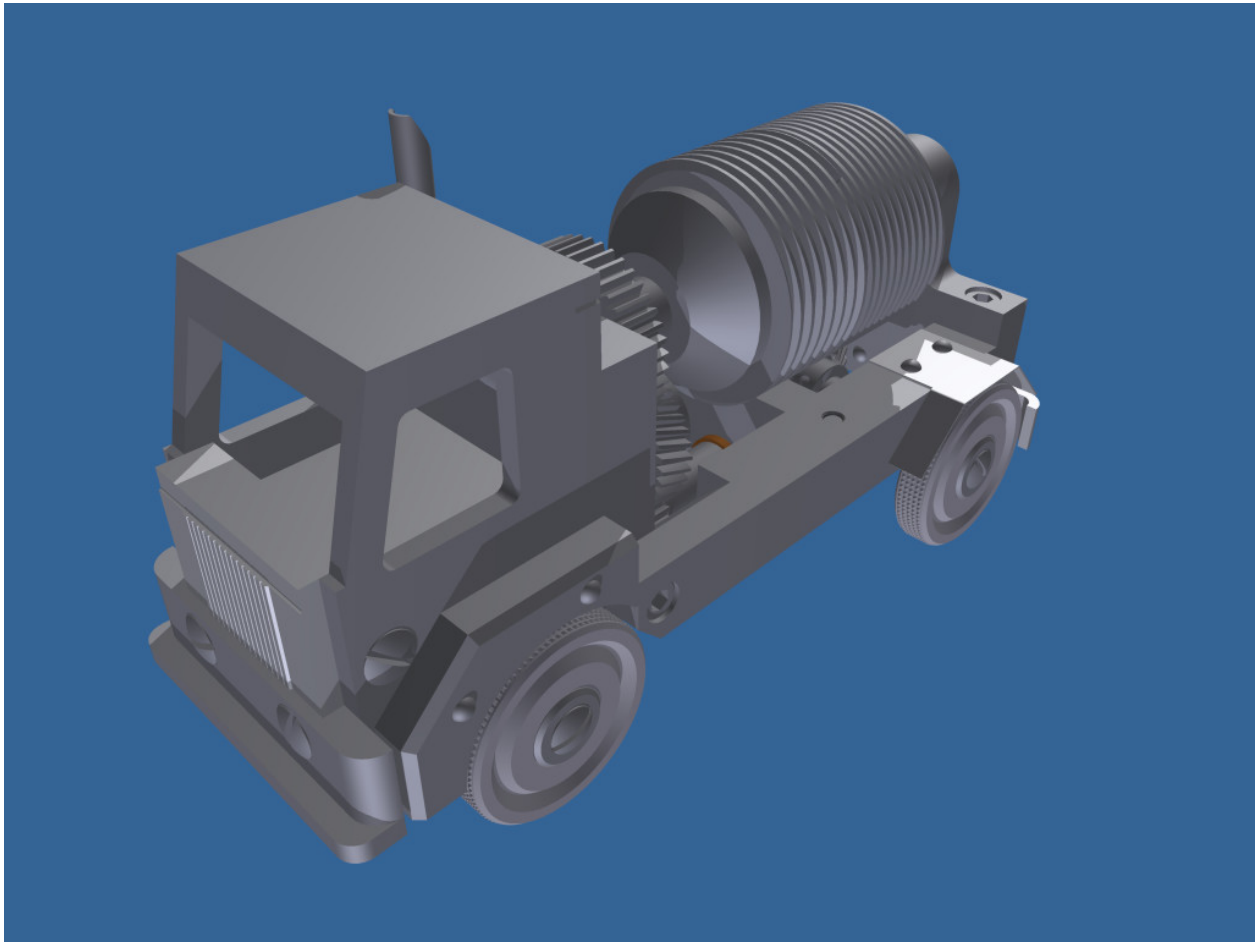
- B.S. Automation and Control Engineer at FEI University.

- B.S. Automation and Control Engineer at FEI University.
- Undergraduate Researcher at Robotic and Artificial Intelligence Laboratory.

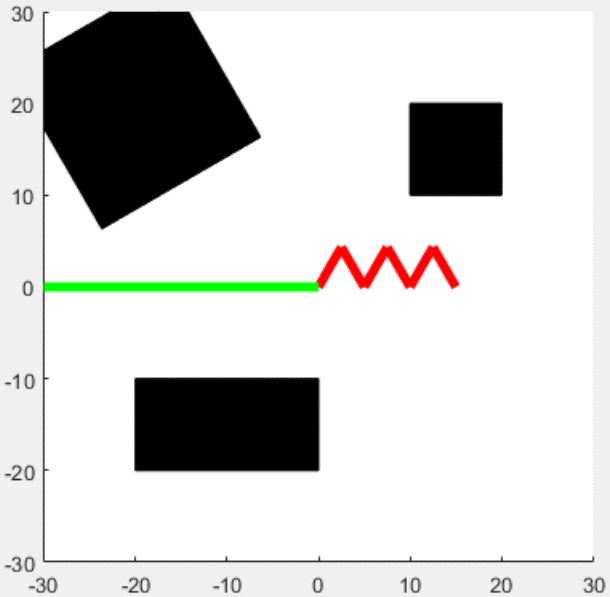


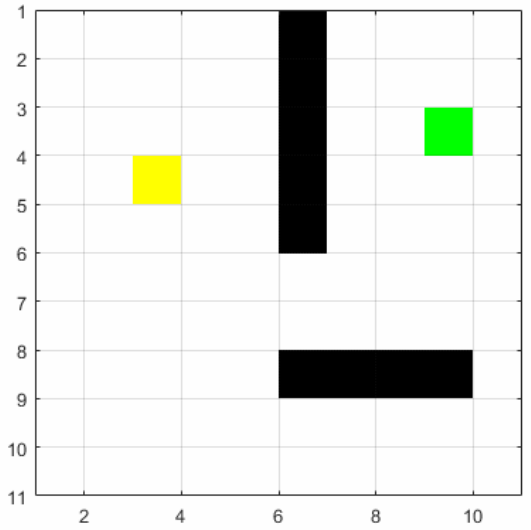
Introduction
Overview Projects

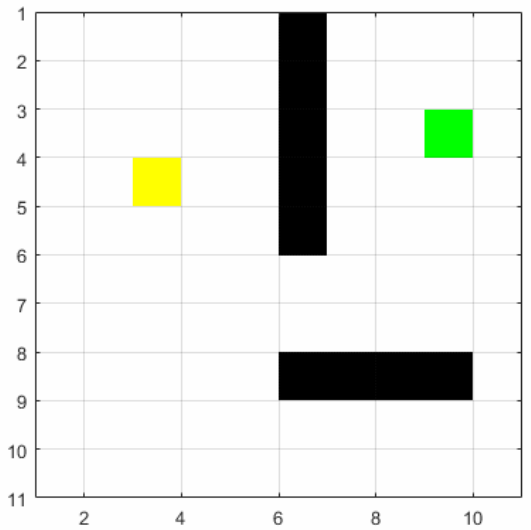
- Machining and fabrication experience.



- Path Planner Algorithms: Dijkstra, A* Grid and Probabilistic Roadmap (PRM).







- The group is formed by different departments, such as the Mechanical, Electrical and Computer Science department.
- Also, has collaborations with biomedical departments from Federal University of ABC:

- Create National Assistive Tecnology aimed the power-assisted wheelchair.

Figure: Biomechanics and Motor Control Laboratory

Motivation
Numbers

- 45.6 million people have some kind of disability.
- 14 million Brazilians have some kind of motor deficiency.
- 5 million are wheelchair users.
- 1 to 2% of the planet's population depends on a wheelchair.

Wheelchair
Classification

- Mechanically simpler and lighter;
- Allow Physical activity;
- Low Cost.

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- Heavy structure;
- Hard to carry;
- Users are those who suffered high injury in the spinal cord.

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- Hard to carry;
- Users are those who suffered high injury in the spinal cord.

- Operates like a M.W.;
- User accomplish more with less effort;
- Navigate uneven surfaces.

1. Brainstorm: Set the features of the wheelchair
   - Compensate the force of gravity on a hill;
   - Propose new control techniques;
   - Wheelchair wheelie to overcome obstacle.

Modeling Driven Wheelchair
Design Workflow

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2. Experiments: Estimate parameters of a manual wheelchair to estimate the motor characteristic.
   - Center of Mass;
   - Moment of Inertia;
   - Minimum Torque to lift-off the wheelchair.

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5. Electronic: Manufacture Electronic Boards
6. Control: Control device.

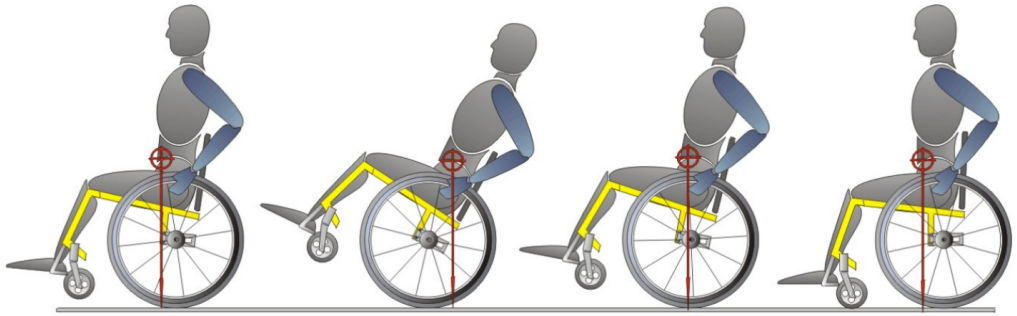


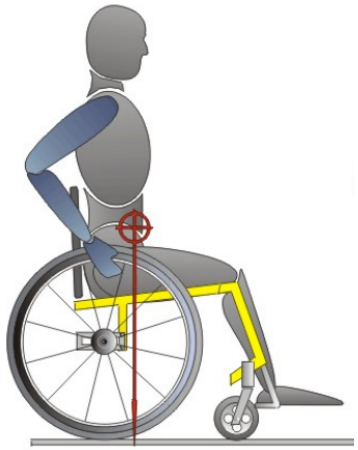
Figure: Wheelie manuever. (Denison, 2013)

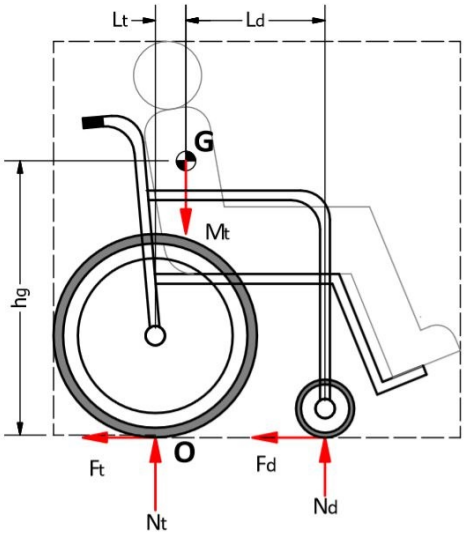
Figure: Wheelie in stairs.

Figure: Wheelie in descend terrains.

Driven Wheelchair Design

Model of Phase 1





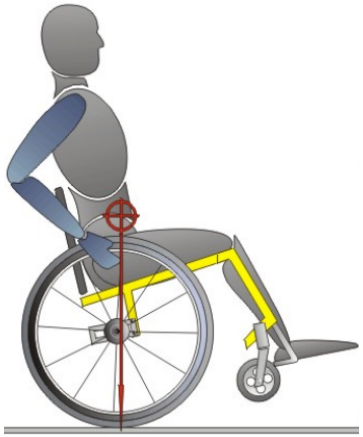
- Sagittal Plane (2D);
- 2 rigid bodies;
- Front wheels on the ground (stable);
- 1 DoF;
- Control: wheel torque;
- Equation of Motion:

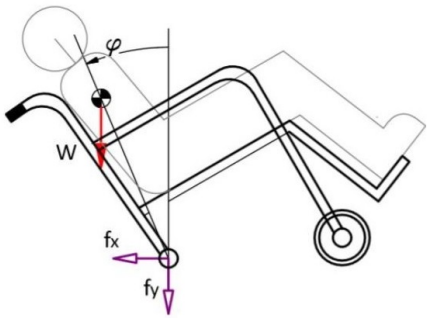
$$\frac{\tau}{R} = \left(M + \frac{J_R}{R^2} \right) \ddot{x} + F_R$$

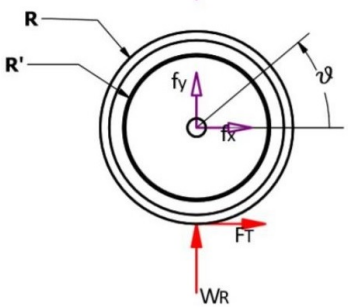
- Transition Acceleration:

$$\ddot{x_{nf}} = \frac{d_{xcg}}{h_{cg}} g$$

Driven Wheelchair Design
Model of Phase 2







- Sagittal Plane (2D);
- 2 rigid bodies;
- Front wheels off the ground (unstable);
- 2 DoF's;
- Control: wheel torque;
- Equations of Motion:

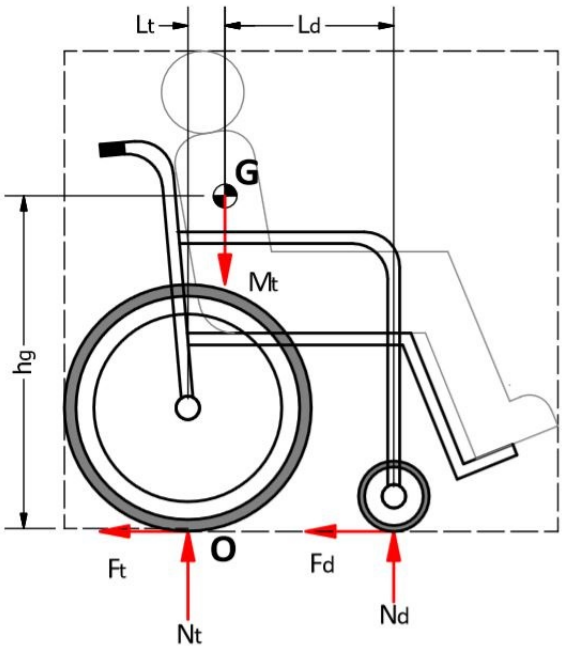
$$\tau - F_r R = \left[J_R + \left(M_r + M_c\right) R^2\right] \ddot{\theta} + \left(M_c R l cos(\phi)\right) \ddot{\phi} - \left(M_c R l \dot{\phi}^2 sin(\phi)\right)$$

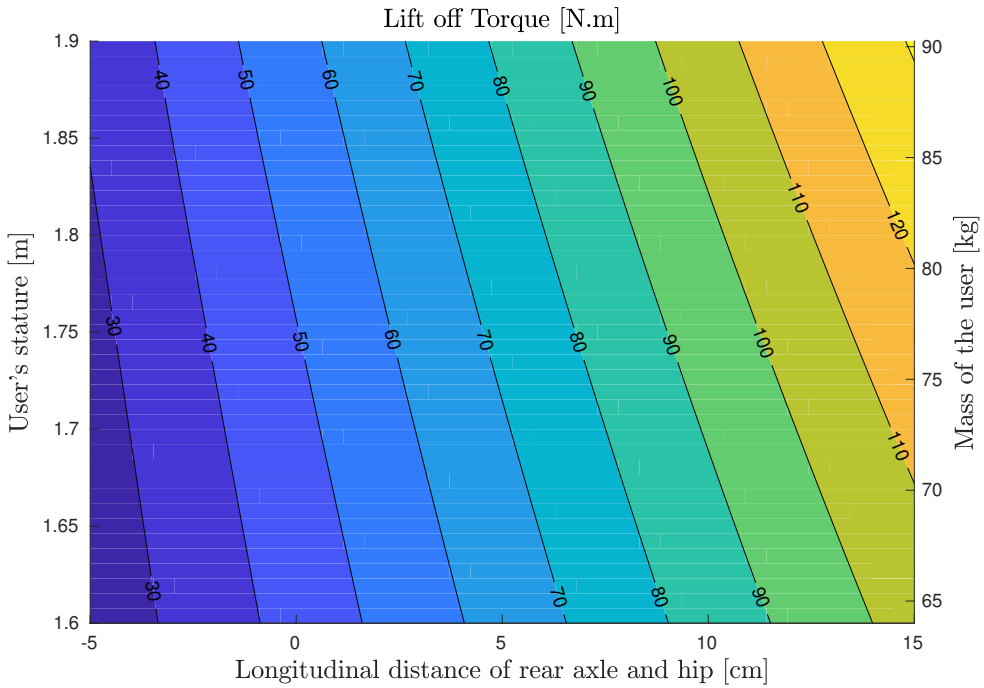
$$-\tau = \left(M_c R l cos(\phi)\right) \ddot{\theta} + \left(J_c + M_c l^2\right) \ddot{\phi} - M_c g l sin(\phi)$$

Driven Wheelchair Design

Lift-Off Torque

$$\left.\begin{aligned} \frac{\tau}{R} &= \left(M + \frac{J_R}{R^2}\right)\ddot{x} + F_R \\ \ddot{x_{nf}} &= \frac{d_{xcg}}{h_{cg}} g \end{aligned}\right\} \tau_{nf} = \left[\left(M + \frac{J_R}{R^2}\right)\frac{d_{xcg}}{h_{cg}} g + F_R\right] R$$

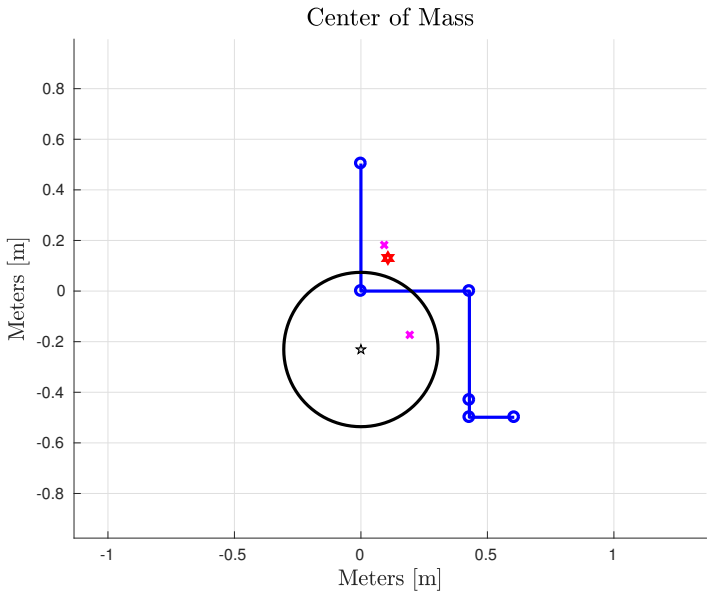




Driven Wheelchair Design

Estimation of Parameters

Figure: Suspended Experiment



Center of Mass

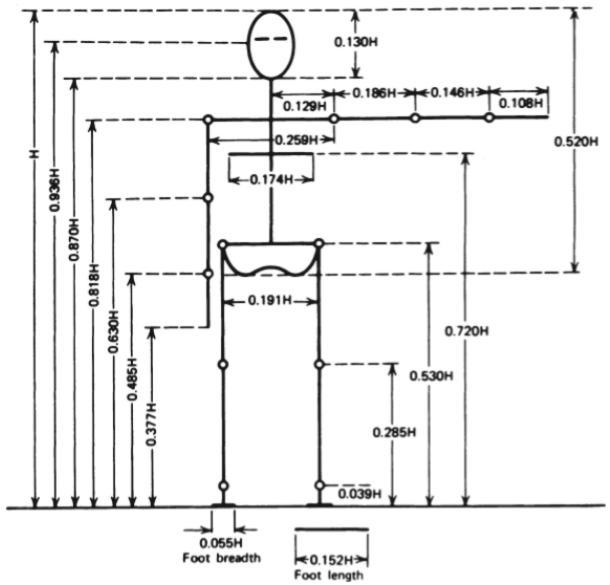


Figure: (Winter, 2009)

Moment of Inertia

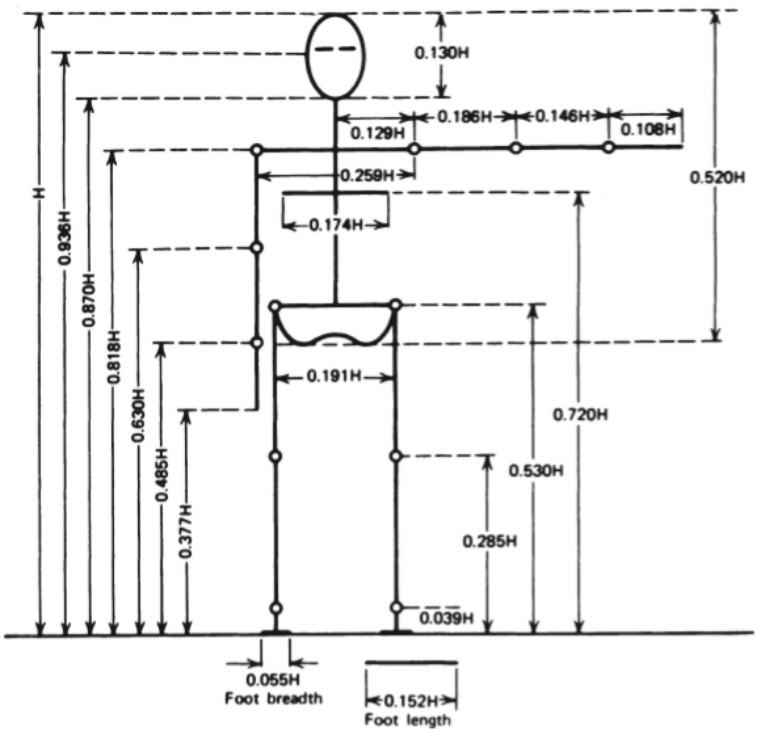
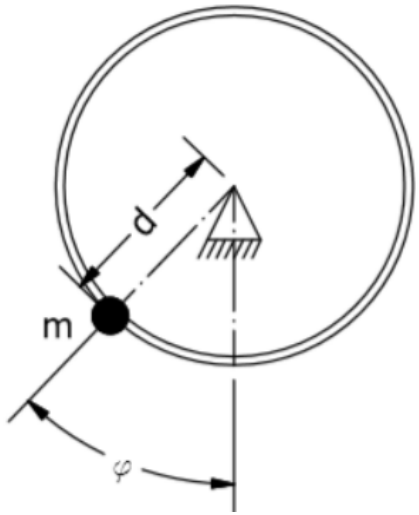


Figure: Oscillation Experiment



Driven Wheelchair Design
Project Drawing

- BLDC Motors 36V;
- SBL1360 60V 1x20A Brushless DC Motor Controller;
- Arduino Mega 2560 Microcontroller Rev3;
- MPU6050 3 Axis Accelerometer Gyroscope.

Driven Wheelchair Design

Project Drawing

- BDLC Motors 36V;
- Arduino Mega 2560;
- Lithium Battery 10Ah;
- Fork structure.

Controller
HMI

- There are several approaches of Human-Machine Interfaces to control a wheelchair using electro- biological signals.

Controller
HMI

- There are several approaches of Human-Machine Interfaces to control a wheelchair using electro- biological signals.

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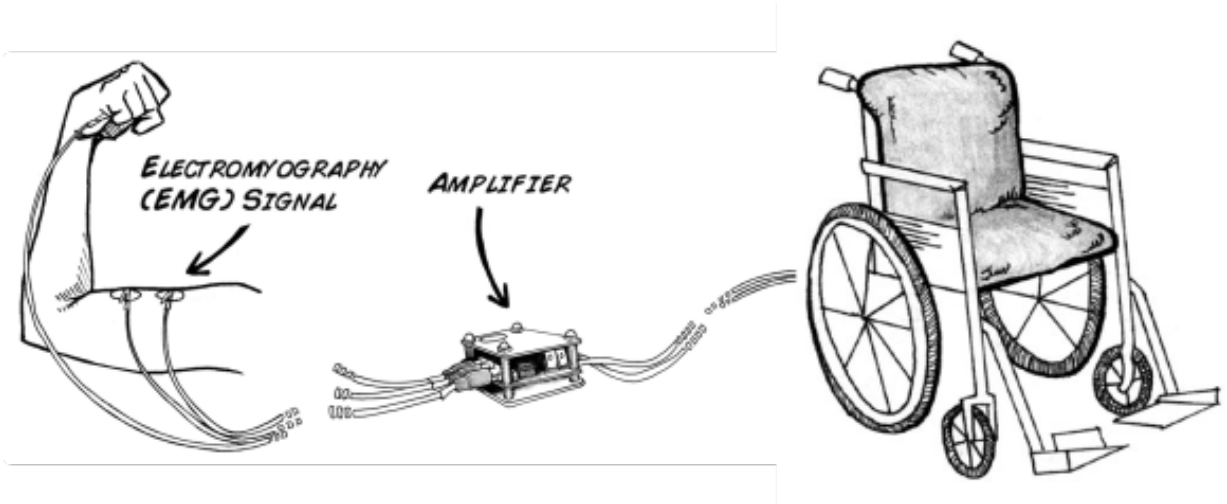
HMI

- There are several approaches of Human-Machine Interfaces to control a wheelchair using electro- biological signals.

Controller
EMG Board

- The myoletric signal originates in the region of the brain and is transmitted through the central and peripheral nervous system to the muscle.



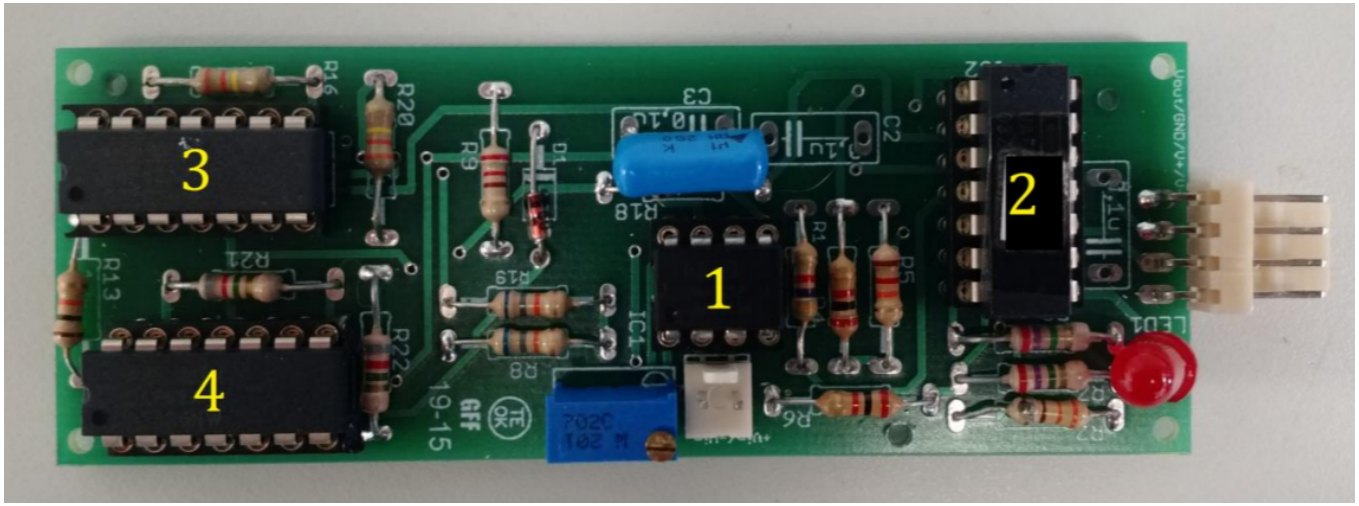
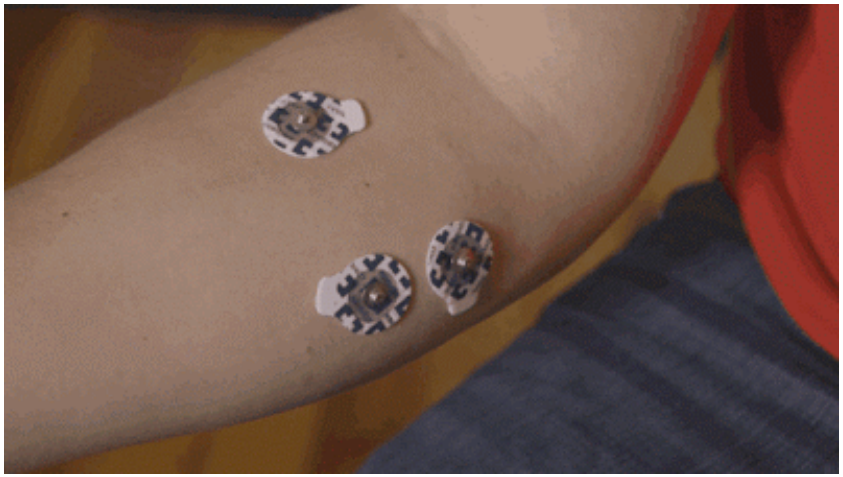


Figure: Electronic board for the EMG acquisition.

- INA121 - Amplifier capable of high gains;
- UFA42 - High pass filter (20Hz);
- Low pass filter (500Hz);
- Notch filter 60Hz.

Controller
MyoWare Muscle Sensor

- Single-supply voltage of +3.1V to +5V;
- Indicador LEDs;
- Two Output modes: EMG Envelope and Raw EMG;
- Adjustable Gain;
- Electrodes snap directly to MyoWare.



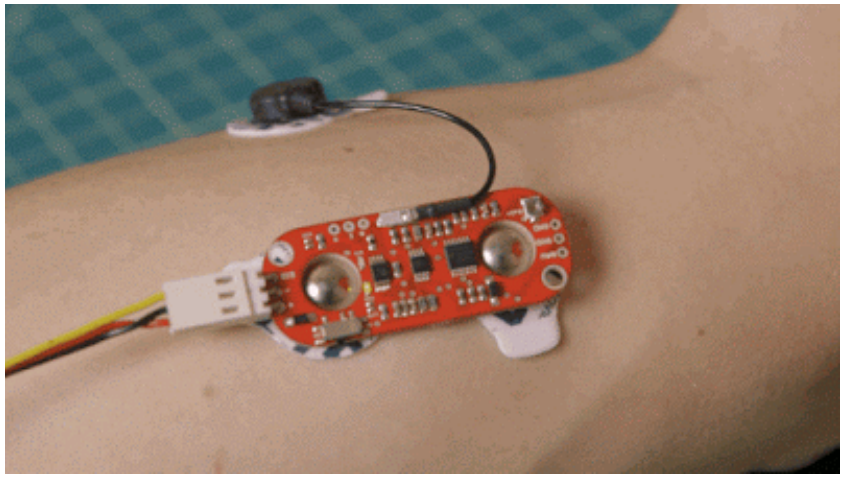


Figure: Setup EMG sensors

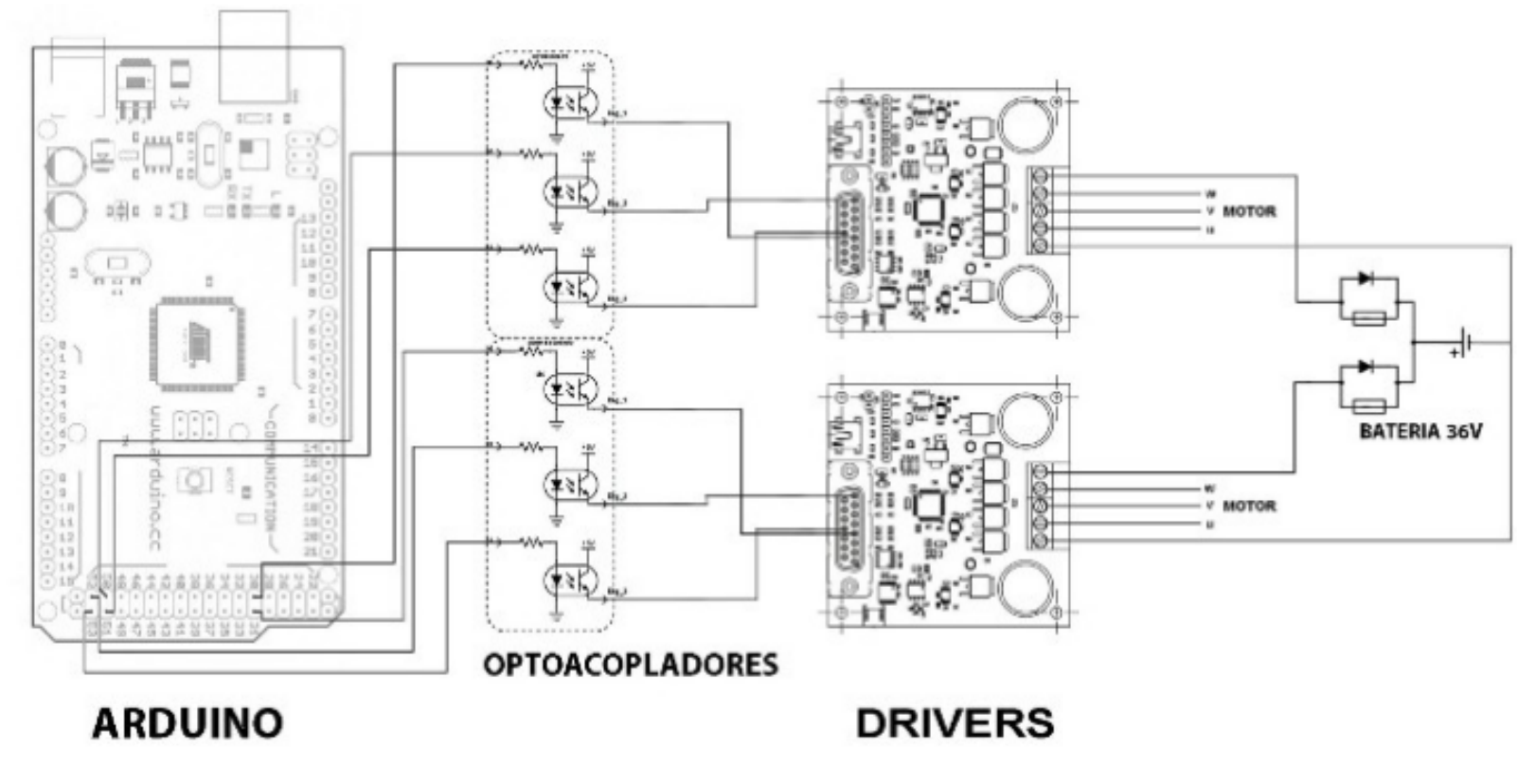


Figure: Power and Control Circuit

Driven Wheelchair
Video

Repository and Informations

https://eriveltongualter.github.io/

https://eriveltongualter.github.io/wheelchair.html

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Automation and Control Engineer

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- **Overview**
- **Extra Projects**
- **Undergraduate Projects**
  - Power-Assisted Wheelchair
  - Hand Press Machine
  - Load Cell
  - Coffee Machine
  - Tutoring Classes
  - VEX Robotics
- **Business Projects**
- **Undergraduated Class List**
- **Resume**
- **Fun Time**

Power-Assisted Wheelchair

When I went back to Brazil from Western Michigan University – USA, I joined a research with Professor Marko Ackermann. The main goal of the research is to model and simulate a power-assisted wheelchair to accomplish the maneuver called wheelie, where the wheelchair employed is to overcome obstacles and descend ramps.

For this task, I conducted several experiments to estimate the real parameters of the system. The controller of the wheelchair was designed in the Matlab and was inspired the control law. The next step is to manufacture a power-assisted wheelchair.

Thank you