

 OMNIBOT: Mobile Furniture
Baseline Development

BioRob & RRL student project
associated with CIS Research Pillar

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Recap: Motivation

Part of CIS Grant: Intelligent Assistive Robotics

Create smart assistive environments for persons with limited mobility
Contribute to rendering the **furniture** mobile



- Versatile in locomotion
- Modularity

Modular robotics (Roombots)



- Mechanical strength
 - Easy use/extend
 - Easy construct/repair
 - Inexpensive
- Potential to benefit more people**

Mobile robotics (Omnibot)

Outline

- **Mechanics**

Hardware adaptation

- **Electronics**

Teleoperation

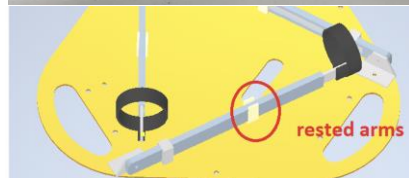
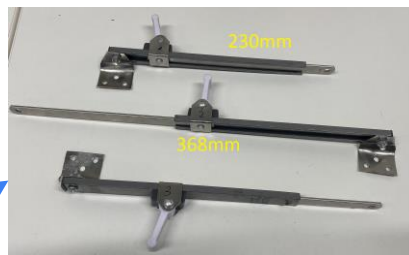
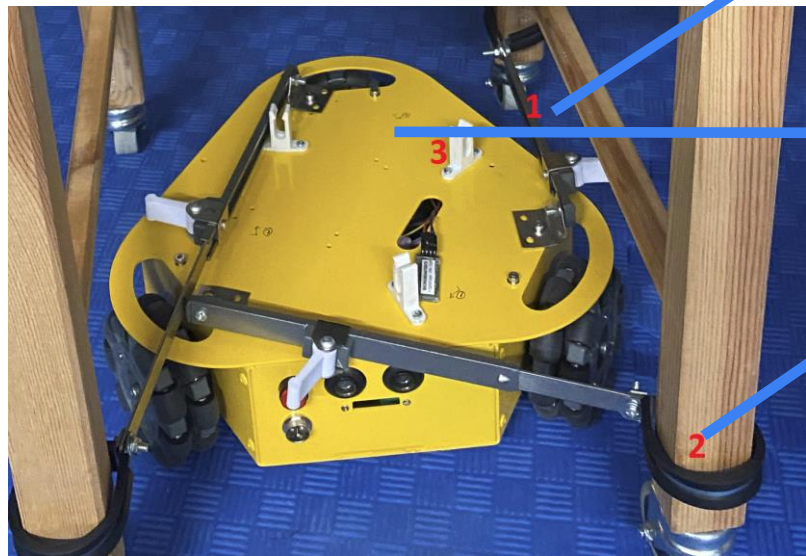
- **Algorithms**

Localization, navigation, interactive control

- **Conclusion**

Future extension on the baseline

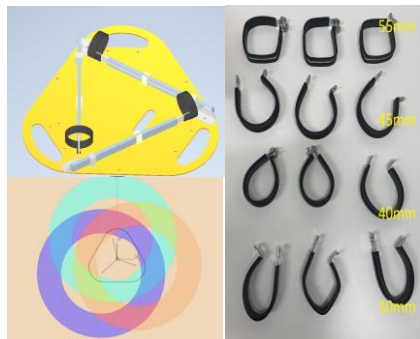
Mechanics: Attachment Design - Tripous



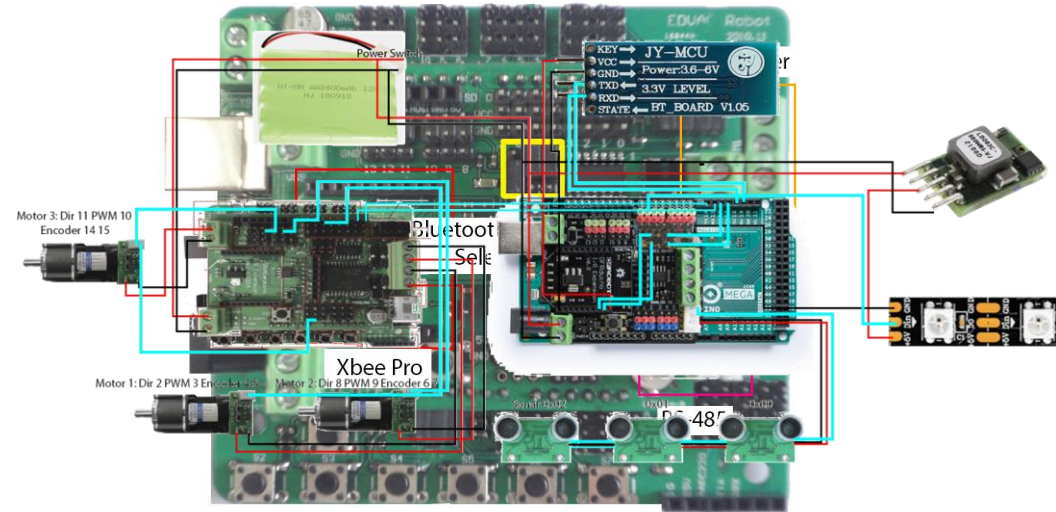
Mechanics: Highlights

- Interchangeability
- Economical
- Strong
- Future extendable with extra layer

2CHF per set
Telescopic arms: Window latch
Hands: Tube clamps



Electronics: Limitation



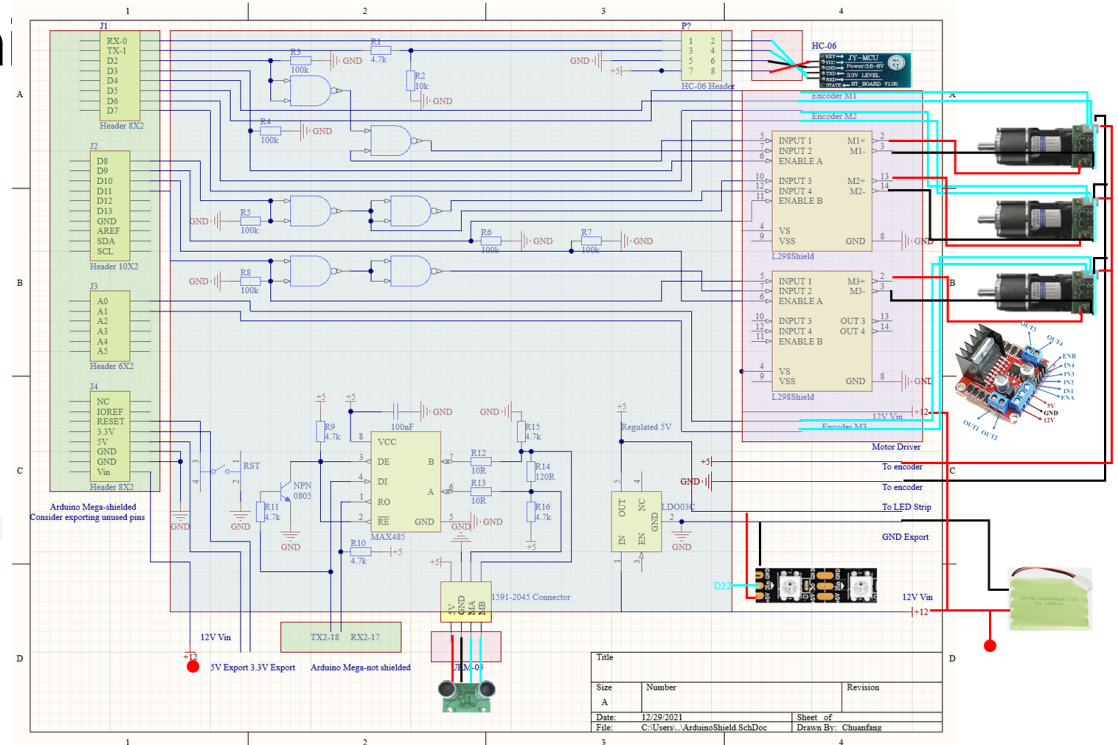
Nexus_duino (Atmega328P)

Resources	Old system	New system	
	AtMega-328	AtMega-328	Arduino Mega
Serials	Sonar	Mega	AtMega-328
	N/A	N/A	Sonar
	N/A	N/A	Bluetooth
	N/A	N/A	-
Timers	delay	delay	delay
	PWM pulses	PWM pulses	-
	PWM pulses	PWM pulses	-
	N/A	N/A	-
	N/A	N/A	-
Digital Pins	14/14	14/14	17/54
Analogue Pins	2/6	2/6	0/16
PWM	4/4	4/4	0/15

^a N/A: not existing ^b -: free for extension ^c a/b: used pins/all pins

TABLE 1: System resource comparison of old/new embedded systems

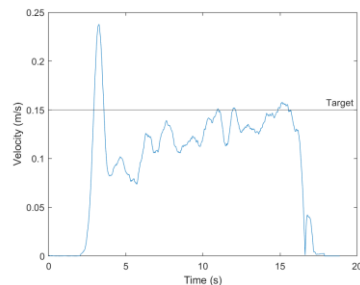
Electronics: Custom expansion sh



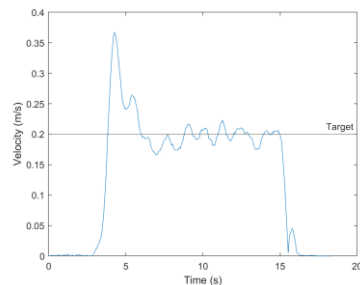
Electronics: Teleoperation

1. Communication with ROS master via Bluetooth 115,200 bps with **50Hz** control frequency
2. Motion commands are sent to the board and mapped to PID regulated current of for 3 motors controlling omni-directional wheels.
3. Sonar and temperature data are preprocessed and sent back
4. The LEDs on Omnibot indicate the motion/state.

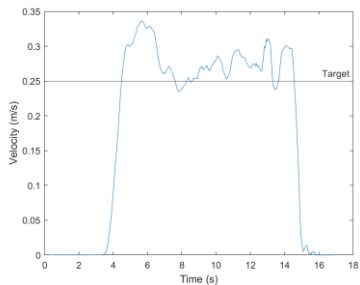
$v_{tar} = 0.15\text{m/s}$



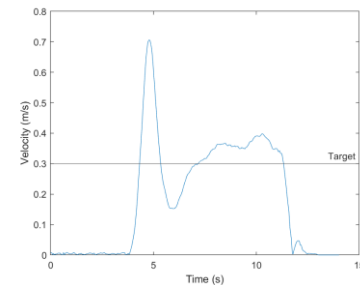
$v_{tar} = 0.20\text{m/s}$



$v_{tar} = 0.25\text{m/s}$

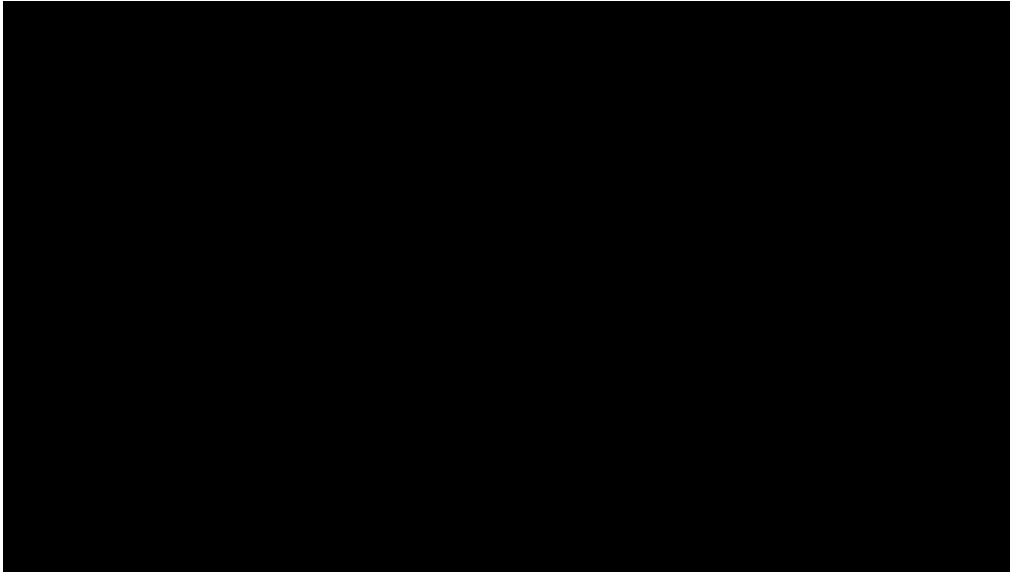


$v_{tar} = 0.30\text{m/s}$



Algorithms: Localization and Navigation

Scenario: Chair needs to go in front of patient while avoiding running into obstacle.



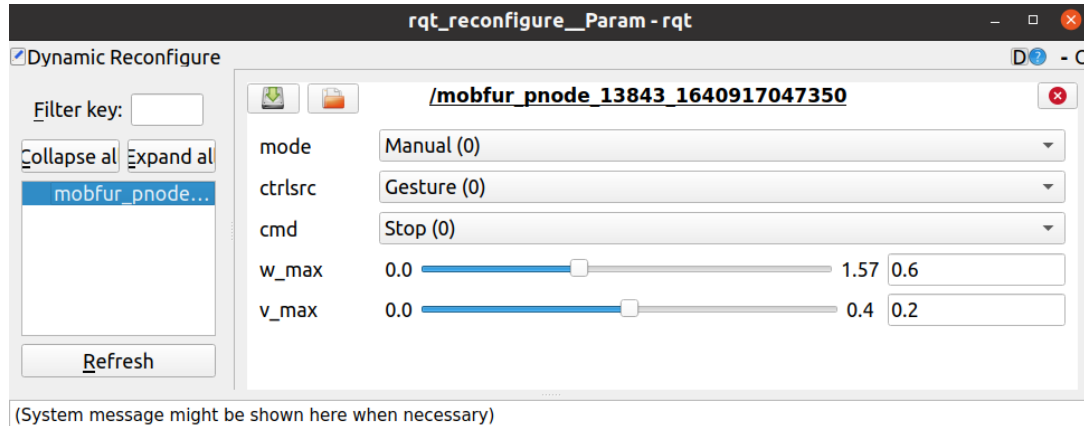
Algorithms:

Interactive control

- User interface control
- Voice control
- Gesture control
- Android application control

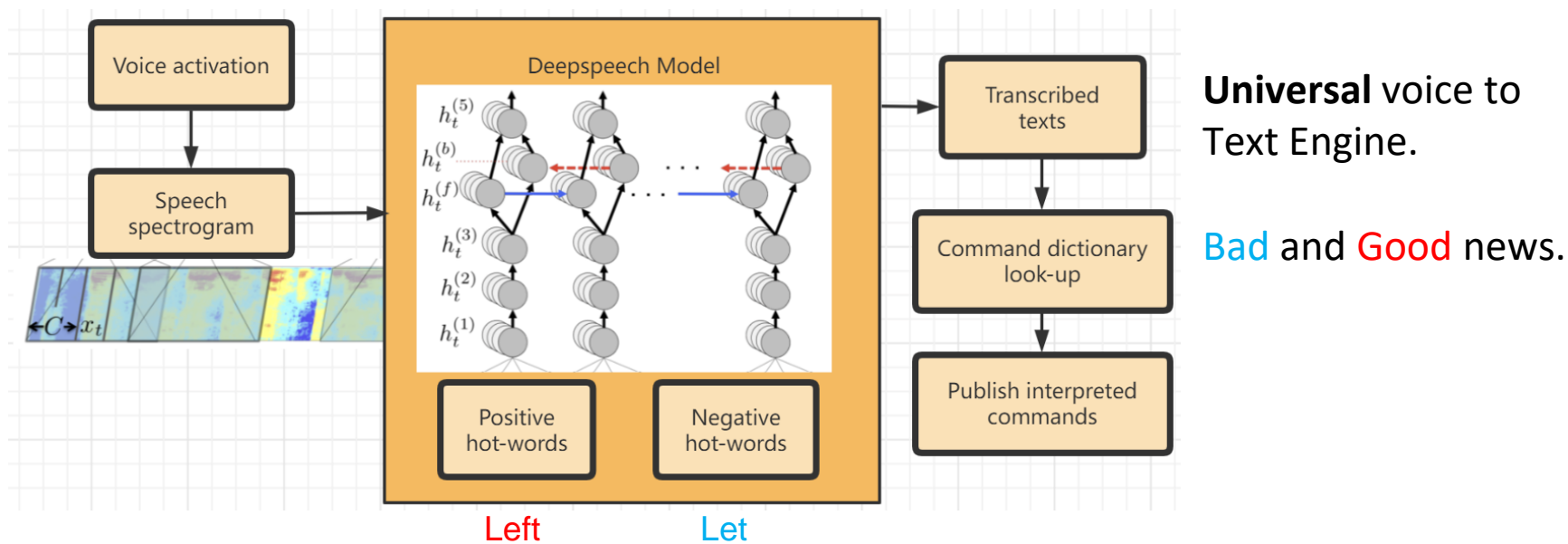
Various interactive control methods for different patients with different needs.

Algorithms: Interactive control

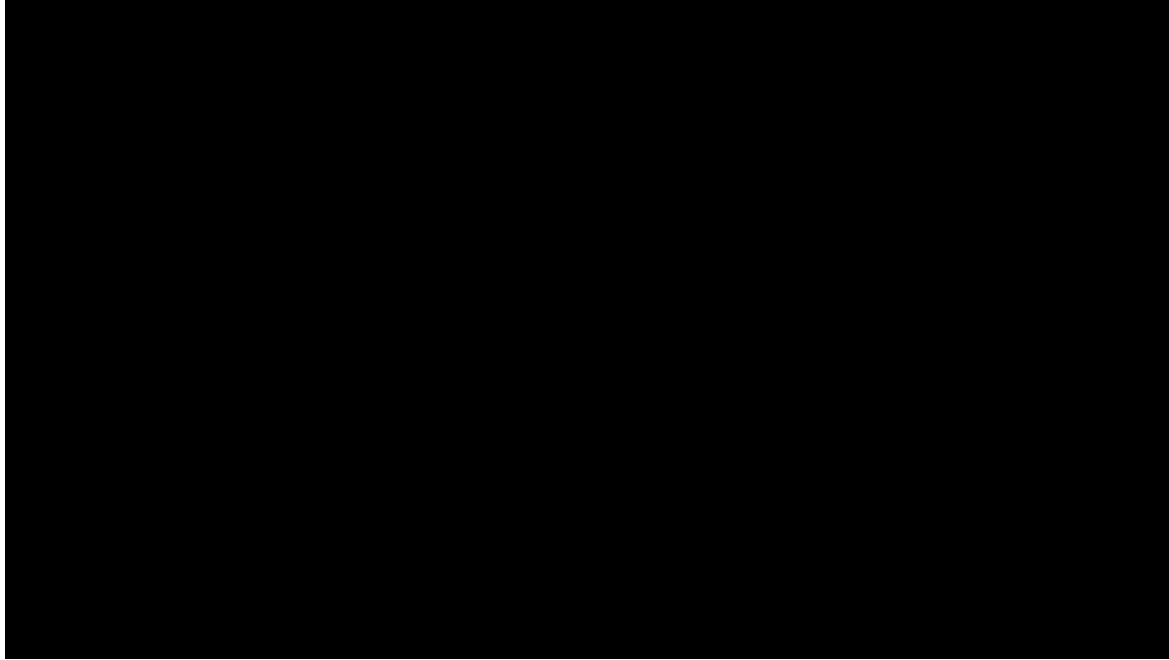


Manual/Auto
Gesture/Voice/Tablet
Stop/Forward/Backward/Left/Right
Rotation Velocity
Translation velocity

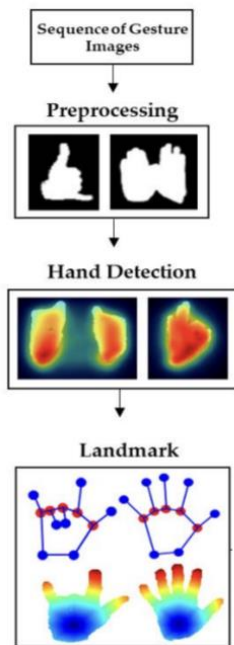
Algorithms: Voice control



Algorithms: Voice control



Algorithms: Gesture control

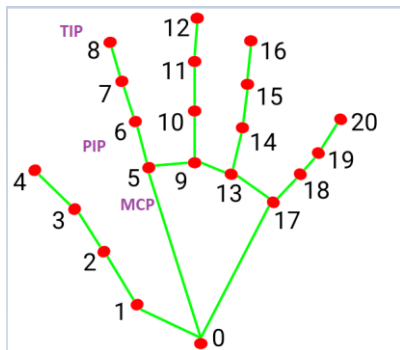








Palm Detection from raw image: Single shot multibox detector
Core: Feedforward CNN with non-maximum suppression

Hand Landmark from palm: Geodesic Distance



Algorithms: Gesture control



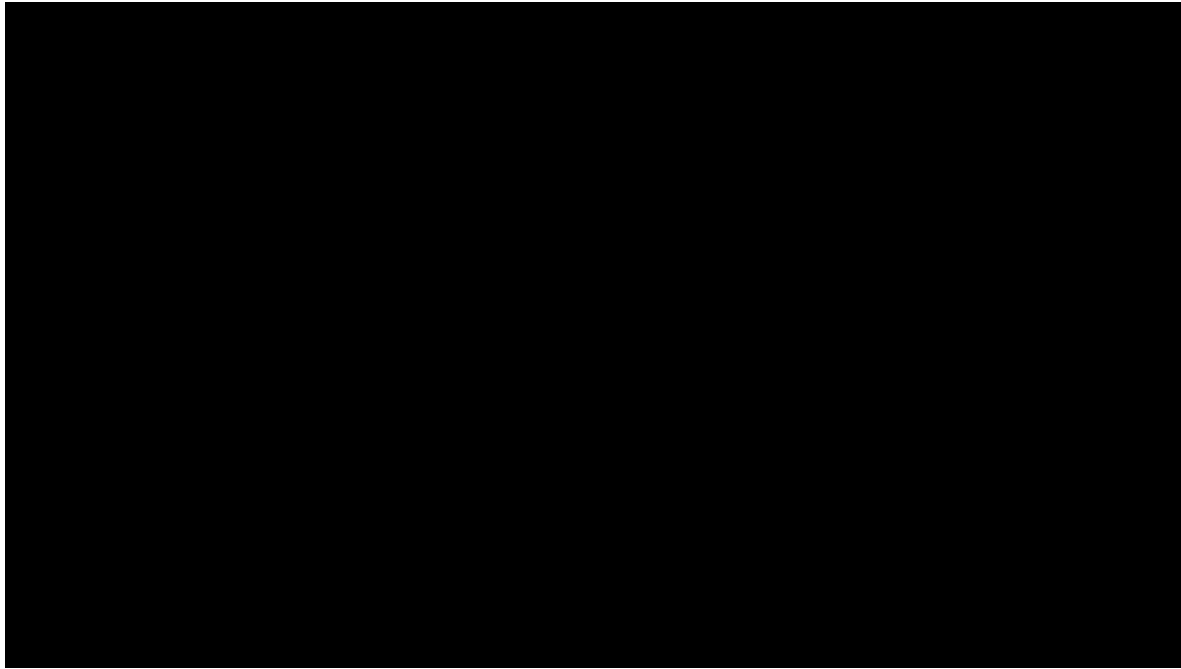
Gesture	Curved	Direction	Command
	None	Don't Care	Enter automatic mode
	All	Don't Care	Enter manual mode and stop
	Not index finger	Up	Move forward if in manual mode
	Not index finger	Down	Move backward if in manual mode
	Not index finger	Left	Move left if in manual mode
	Not index finger	Right	Move right if in manual mode

Curved: Detecting a finger is curved or not by comparing the vector direction of (MCP, PIP) and (PIP, TIP) .

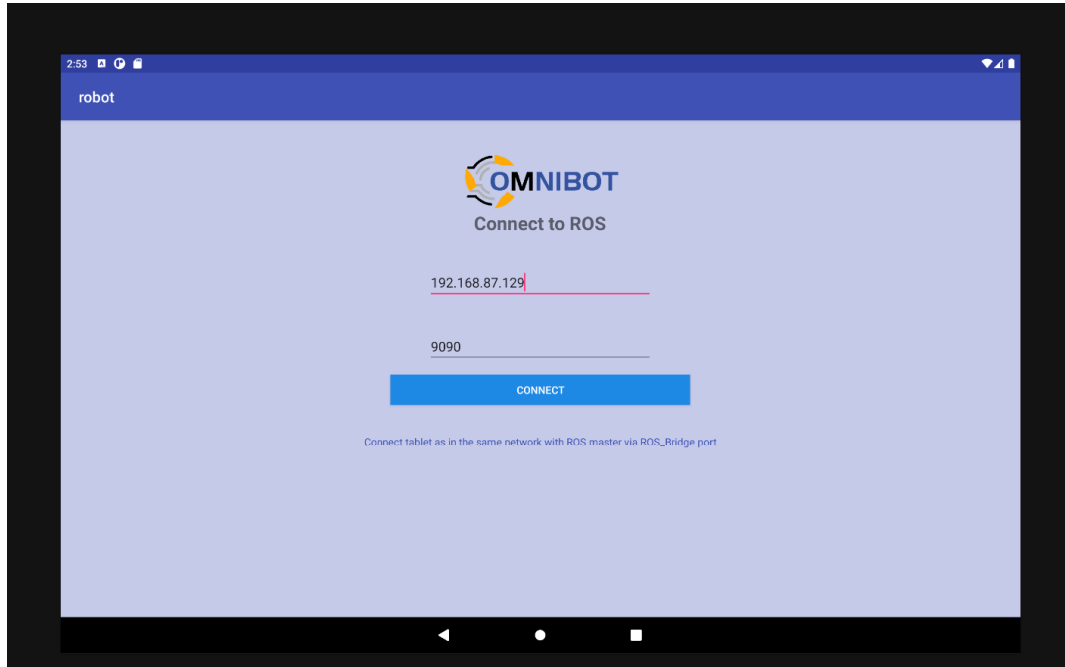
Direction: Detecting the finger direction by doing $\arctan2$ of vector (MCP, PIP) .

- Responsive control with 50Hz+ frequency
- Easily extended with Meshgrids

Algorithms: Gesture control



Algorithms: Tablet control



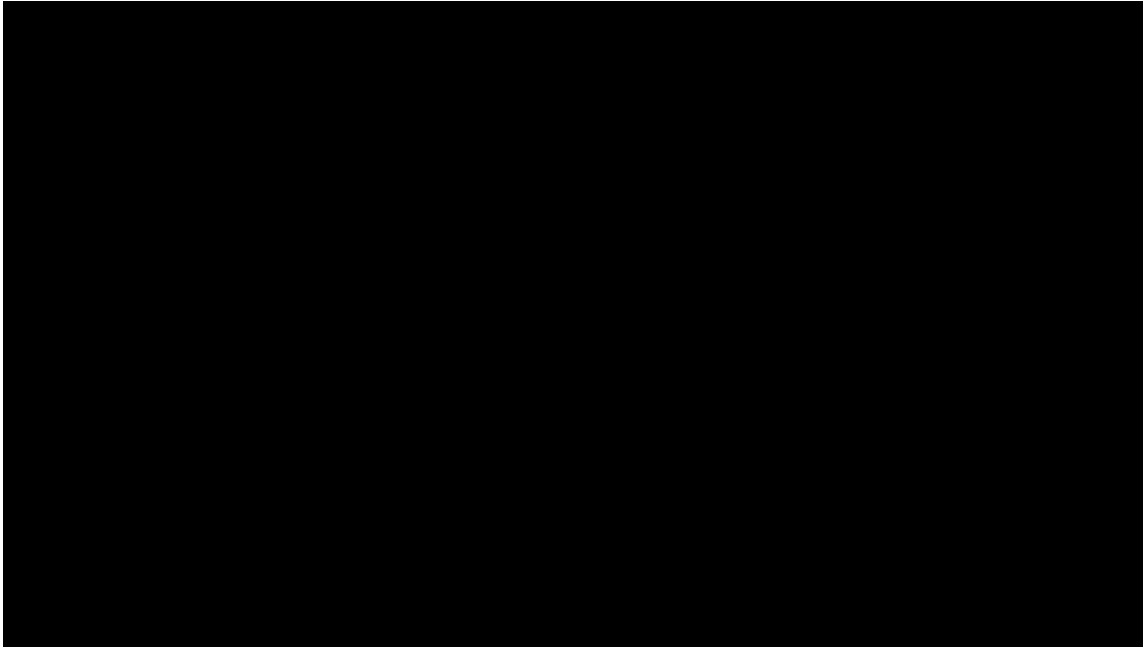
- Developed in Java with Android Studio
- Communication with ROS master over TCP/IP via *ros_bridge*
- Mobile device has to be in same network with ROS master

Algorithms: Tablet control

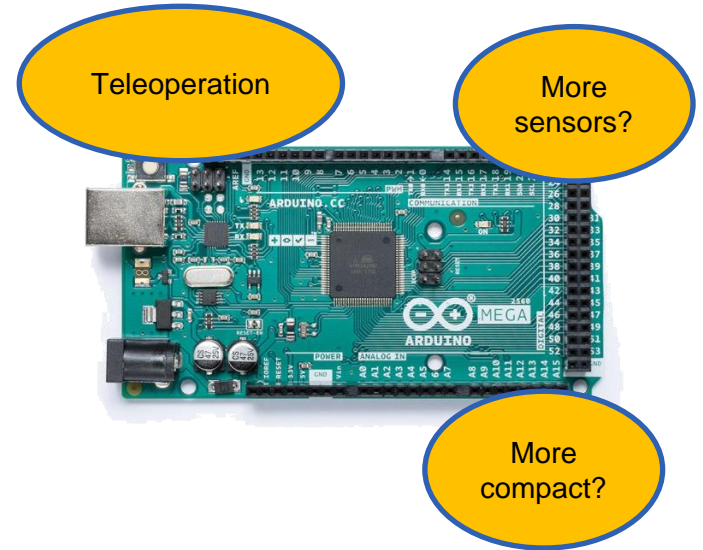
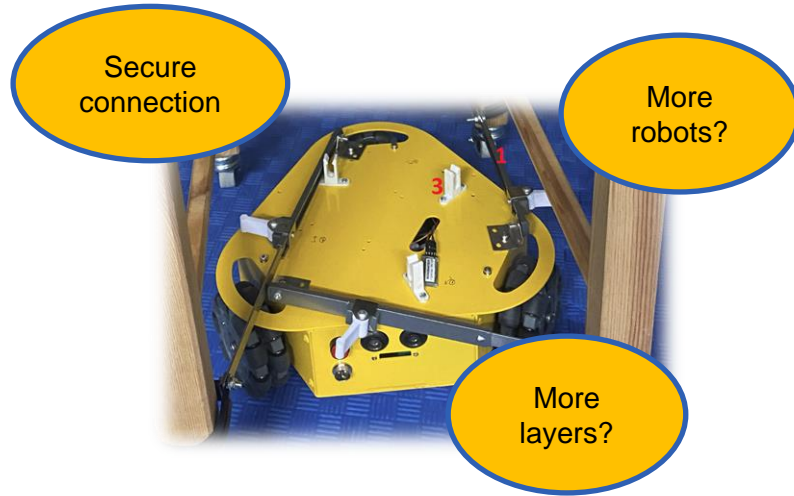


- Buttons for mode control
- Joystick and buttons for translational and rotational motion
- Display for message callback
- Secured design

Algorithms: Tablet control



Conclusion:



Conclusion:

