



Robots for disability

Prototype project

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Aim: Assessment and Rehabilitation tool

- ❖ Millions of people survived after stroke attack
- ❖ 9 out of 10 require rehabilitation courses
- ❖ *Multiple Sclerosis, Parkinson's Disease, Brain Injury, etc.*



PROTOTYPE

- ❖ Measurement system for upper limbs performance
- ❖ Leap Motion Controller + Python + QtDesigner + Medical inputs (Prof. Raghavan)





Advantages

- ❖ Low-cost: only \$60
- ❖ Recording performance: 110 frames per second
- ❖ High accuracy



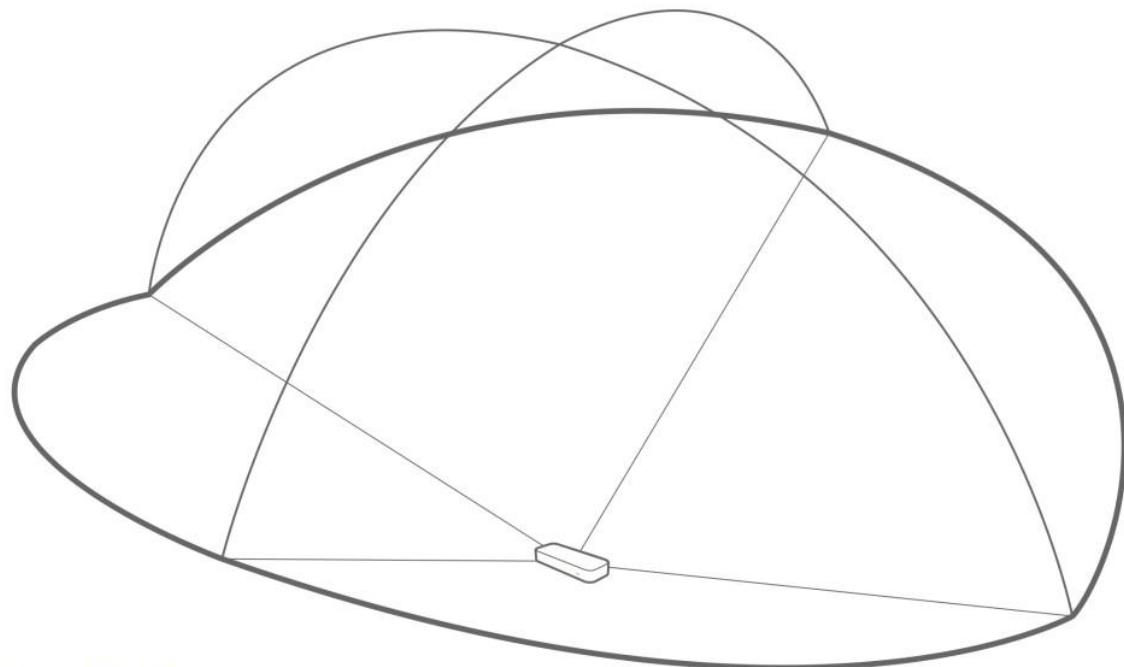
Hardware

- ❖ 2 cameras
- ❖ 3 infrared LEDs
- ❖ 850 nanometers wavelength



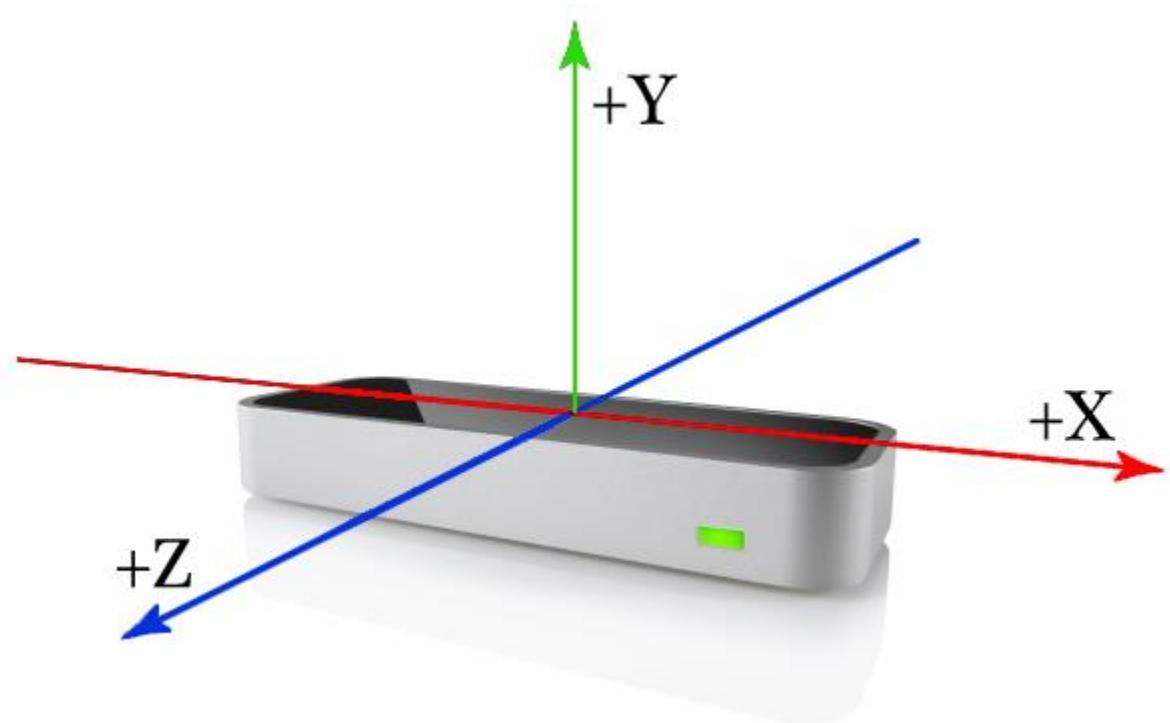
Interaction Area

$R = 2 \text{ ft}$ (almost hemisphere)



Interaction Area

2 feet above the controller, by 2 feet wide on each side
(150° angle), by 2 feet deep on each side (120° angle)



About precision and tracking: what literature says

An Analysis of the Precision and Reliability of the Leap Motion Sensor and Its Suitability for Static and Dynamic Tracking

[Jože Guna](#), [*Grega Jakus](#), [Matevž Pogačnik](#), [Sašo Tomažič](#), and [Jaka Sodnik](#)

1. In the static scenario, the standard deviation was less than 0.5 mm.
2. The results of the dynamic scenario revealed the inconsistent performance of the controller, with a significant drop in accuracy for samples taken more than 250 mm above the controller's surface.
3. The results show a deviation between the desired 3D position and the average measured positions below 0.2 mm for static setups and of 1.2 mm for dynamic setups.
4. The standard deviation of the noise for the static marker was measured for each individual coordinate: $stdx = 0.018$ mm, $stdy = 0.016$ mm and $stdz = 0.029$ mm.
5. The lowest standard deviation (0.0081 mm) was measured on the x axis 30 cm above the controller, while the highest standard deviation (0.49 mm) was measured on the y axis at the leftmost and topmost positions. (STATIC)
6. The mean sampling frequency was 39.0 Hz. The standard deviation was 12.8 Hz.
7. this paper also shows: Distance deviation distributions in x - z plane at (a) $y = 150$ mm; and (b) $y = 250$ mm. (DYNAMIC)

Conclusion:

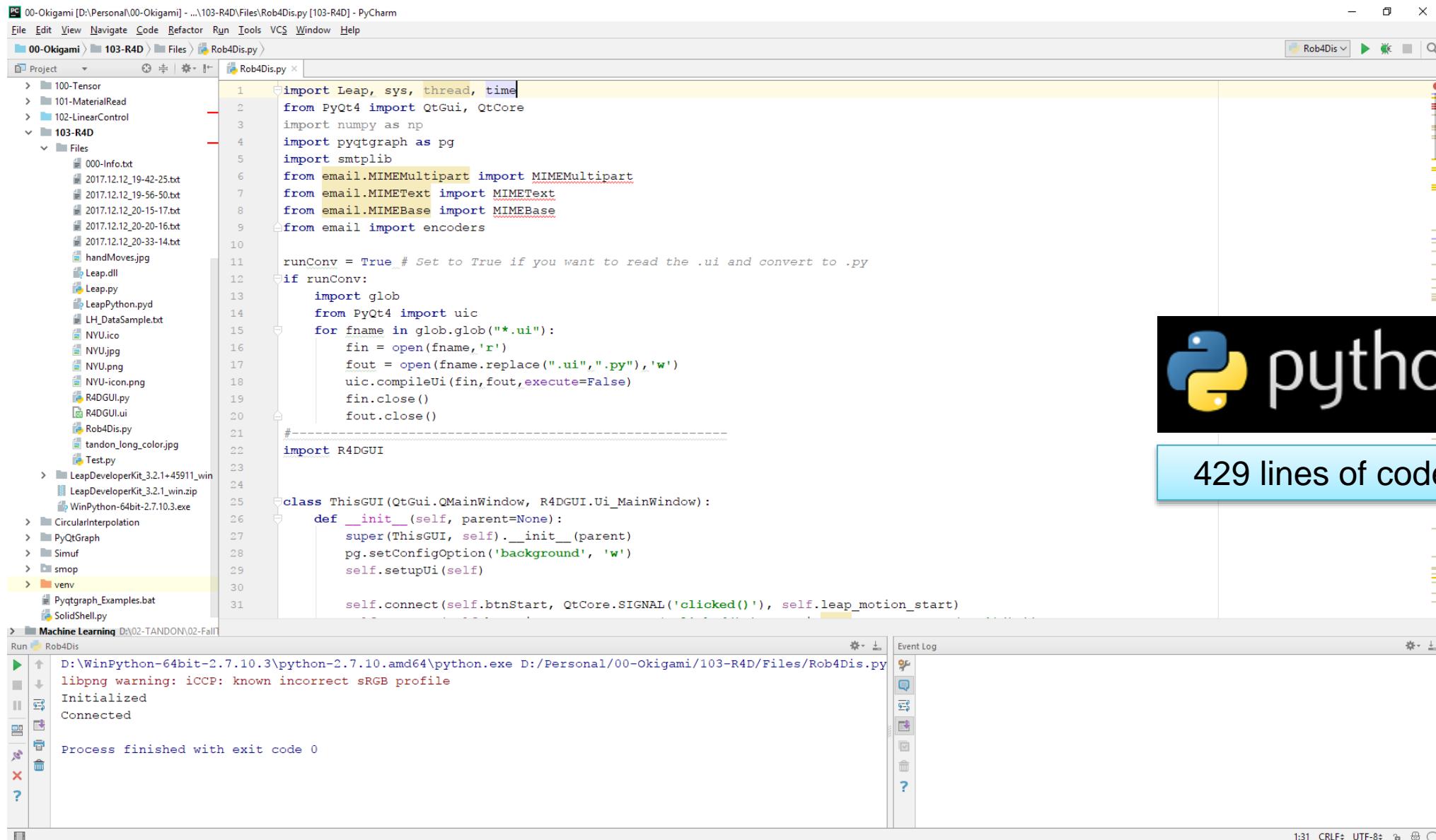
In the static scenario, the standard deviation was shown to be less than 0.5 mm at all times, in the best cases less than 0.01 mm. In addition, the high accuracy (below 0.2 mm) reported in [15] combines with our results to evaluate the controller as a reliable and accurate system for tracking static points.

About precision and tracking: what literature says

Leap motion controller three dimensional verification and polynomial correction

[Yajaira-IlseCuriel-Razo^a](#)[OctavioLcasio-Hernández^{ab}](#)[GabrielSepúlveda-Cervantes^c](#)[Juan-BautistaHurtado-Ramos^a](#)[José-JoelGonzález-Barbosa^a](#)

1. The results demonstrated an axis-independent deviation for static setups between the desired 3D position and the measured position of less than 0.2 mm. For dynamic situations, independent from the plane, the accuracy was less than 2.5 mm. Repeatability averaged less than 0.17 mm. They concluded it was not possible to achieve the theoretical accuracy of 0.01 mm under real conditions but it did provide high precision (0.7 mm).
2. For static measurements, a plastic arm model simulating a human arm was used, and showed a **standard deviation less than 0.5 mm**.
3. However, while the palm was properly recognized within 300 mm of the LMC, palm coordinates were very unstable during the process when **the palm touched the surface**.
4. These errors are the deviation of LMC tracked data from a desired 3D position **measured by the CMM**. The mean error of the four trajectories was 9.550 mm, significantly larger than the quoted manufacturing accuracy, 0.01 mm [\[13\]](#). The uncertainties also exceed 0.01 mm, the smallest being 0.136 mm in the first trajectory. Other researchers [\[14,16\]](#) have commented previously regarding the manufacturing accuracy. When [\[14\]](#) moved a sharp pen mounted on the robotic arm over discrete positions on a path, the standard deviation was slightly less than 0.7 mm per axis, implying it was not possible to achieve the nominal manufacturing accuracy of 0.01 mm under real conditions.



PyCharm IDE screenshot showing the Rob4Dis.py file with 429 lines of code. The code is a Python script that converts UI files to Python code using the PyQt4 and uic modules. It includes imports for Leap, sys, thread, time, PyQt4, QtCore, numpy, pyqtgraph, smtplib, and email modules. The script uses glob to find .ui files, opens them, and uses uic.compileUi to convert them to .py files. It then imports R4DGUI and defines a class ThisGUI that inherits from QMainWindow and Ui_MainWindow. The __init__ method sets the background to white and connects the btnStart button to the leap_motion_start slot.

```
import Leap, sys, thread, time
from PyQt4 import QtGui, QtCore
import numpy as np
import pyqtgraph as pg
import smtplib
from email.MIMEMultipart import MIMEMultipart
from email.MIMEText import MIMEText
from email.MIMEBase import MIMEBase
from email import encoders

runConv = True # Set to True if you want to read the .ui and convert to .py
if runConv:
    import glob
    from PyQt4 import uic
    for fname in glob.glob("*.ui"):
        fin = open(fname, 'r')
        fout = open(fname.replace(".ui", ".py"), 'w')
        uic.compileUi(fin, fout, execute=False)
        fin.close()
        fout.close()

import R4DGUI

class ThisGUI(QtGui.QMainWindow, R4DGUI.Ui_MainWindow):
    def __init__(self, parent=None):
        super(ThisGUI, self).__init__(parent)
        pg.setConfigOption('background', 'w')
        self.setupUi(self)

        self.connect(self.btnExit, QtCore.SIGNAL('clicked()'), self.leap_motion_start)
```

Machine Learning DA02-TANDON\02-Fall

Run Rob4Dis

```
D:\WinPython-64bit-2.7.10.3\python-2.7.10.amd64\python.exe D:/Personal/00-Okigami/103-R4D/Files/Rob4Dis.py
libpng warning: iCCP: known incorrect sRGB profile
Initialized
Connected

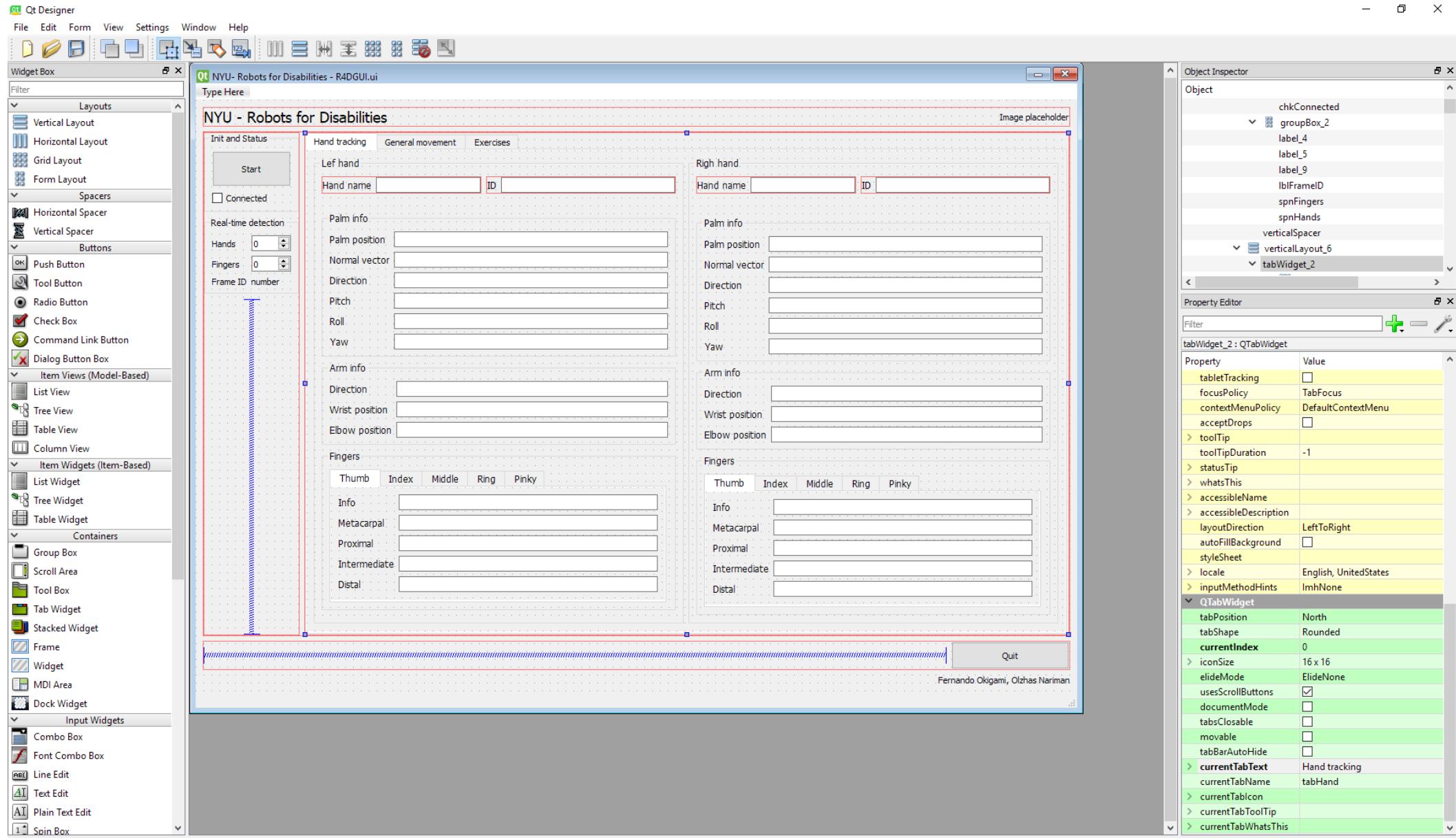
Process finished with exit code 0
```

Event Log

1:31 CRLF UTF-8



429 lines of code only!



NYU- Robots for Disabilities

NYU - Robots for Disabilities

Init and Status

Hand tracking General movement Exercises

Left hand

Hand name ID

Palm info

Palm position

Normal vector

Direction

Pitch

Roll

Yaw

Arm info

Direction

Wrist position

Elbow position

Fingers

Thumb Index Middle Ring Pinky

Info

Metacarpal

Proximal

Intermediate

Distal

Right hand

Hand name ID

Palm info

Palm position

Normal vector

Direction

Pitch

Roll

Yaw

Arm info

Direction

Wrist position

Elbow position

Fingers

Thumb Index Middle Ring Pinky

Info

Metacarpal

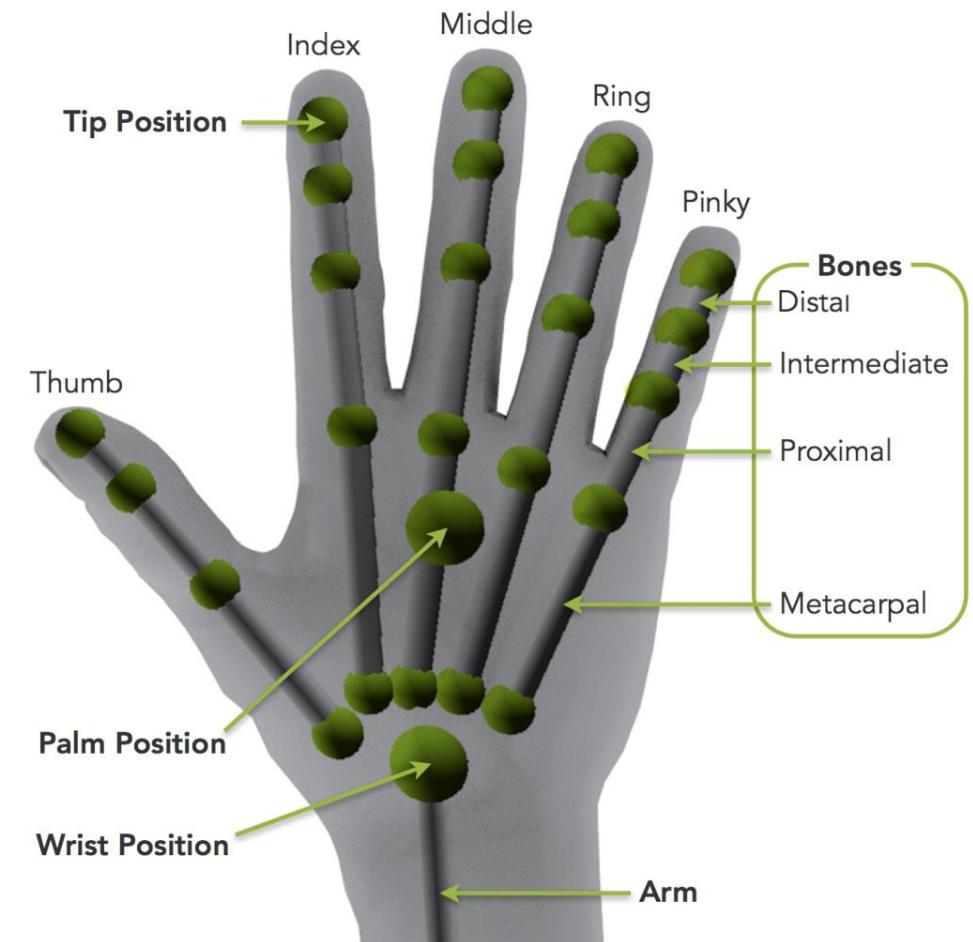
Proximal

Intermediate

Distal

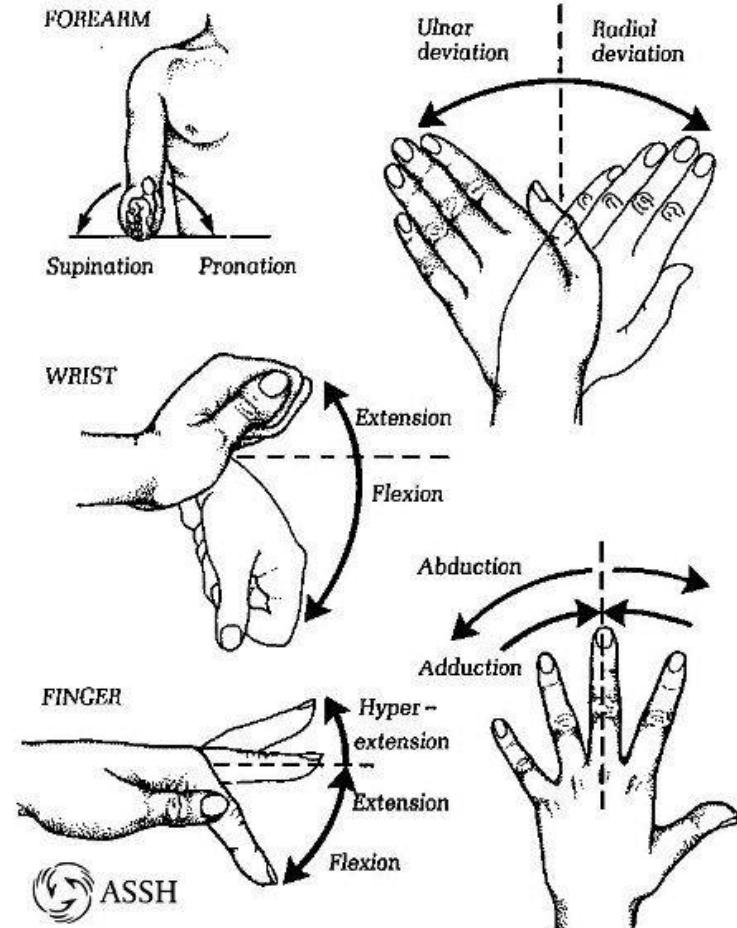
Quit

Fernando Okigami, Olzhas Nariman

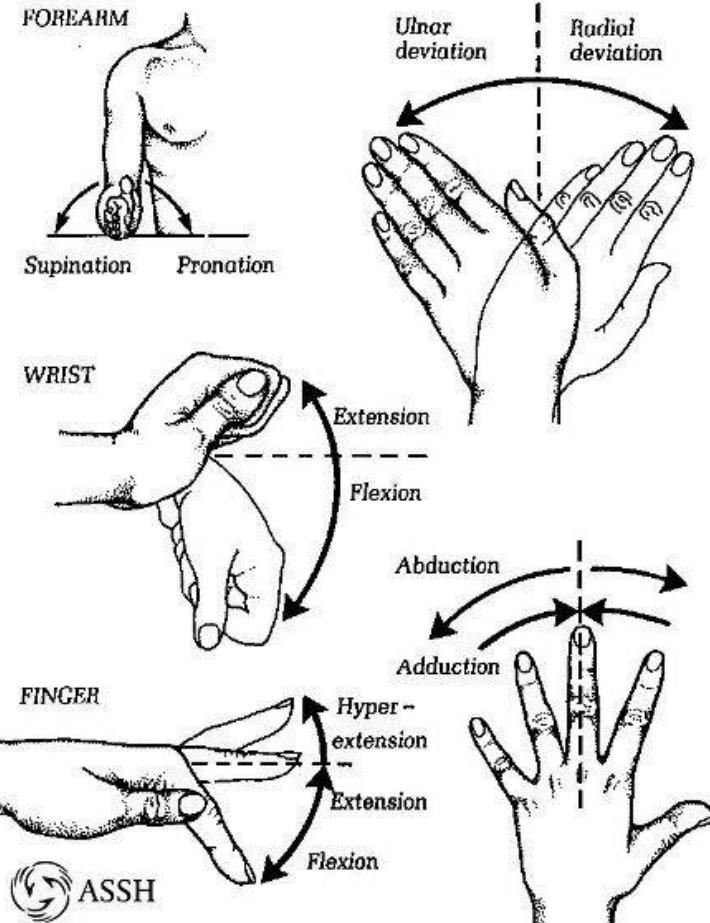


- **Through a user-friendly interface:**
 - Accurately track movements
 - Measure travel distance
 - Count number of cycles for exercises
 - Determine session times
 - Exchange data with doctors
 - Traceability of patients' data
 - Analyze hidden trends in sub-movements
- **We can assess:**
 - Range of motion
 - Smoothness of movement
 - Frequency of tremors

This way we can reveal early symptoms



"you can't manage what you can't measure."
Peter Drucker



NYU- Robots for Disabilities

NYU - Robots for Disabilities

Init and Status

Start

Connected

Real-time detection

Hands 0

Fingers 0

Frame ID number

Hand tracking General movement Exercises

Select hand

Left hand

Right hand

Duration and repetitions

5 Seconds

1 Repetitions

Control session

Start

Pause

Stop and send report

Yaw Pitch Roll

100

80

60

40

20

0

-20

-40

-60

-80

-100

0 1

YAW

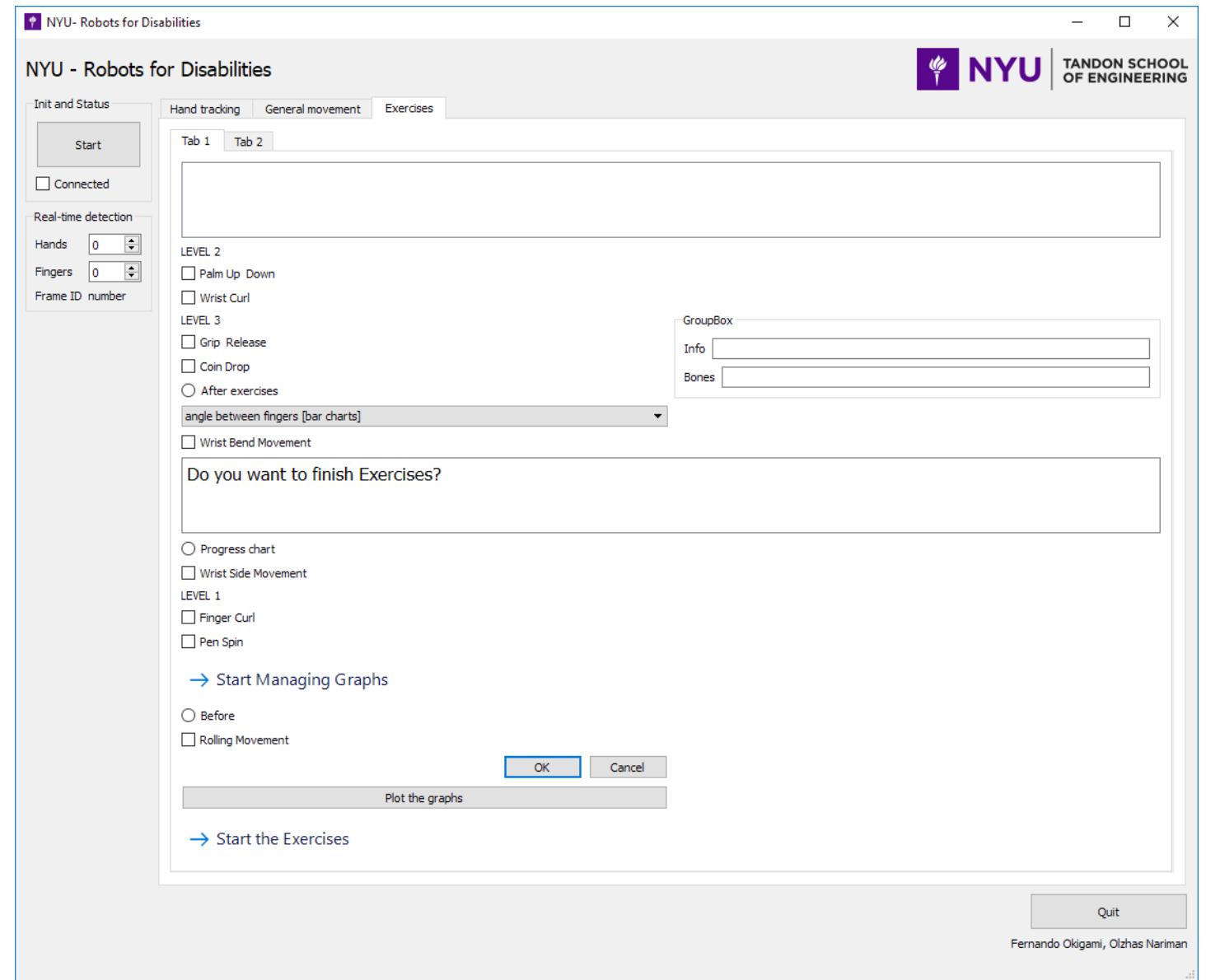
ROLL

PITCH

100%

Quit

NYU TANDON SCHOOL OF ENGINEERING

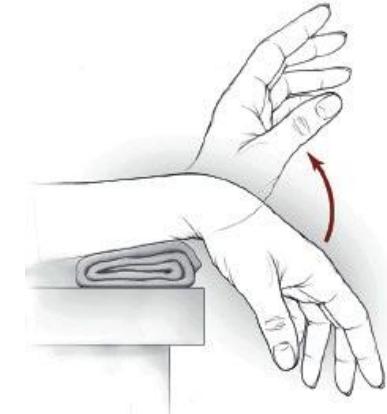


There's room to do much more!

Proposed exercises to be done in the platform

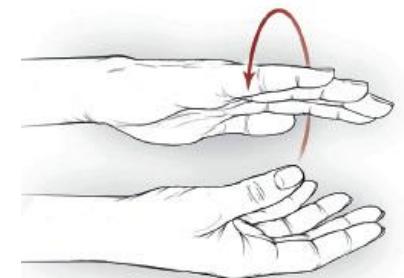
1. Wrist extension and flexion

- Place your forearm on a table on a rolled-up towel for padding with your hand hanging off the edge of the table, palm down.
- Move the hand upward until you feel a gentle stretch.
- Return to the starting position.
- Repeat the same motions with the elbow bent at your side, palm facing up.



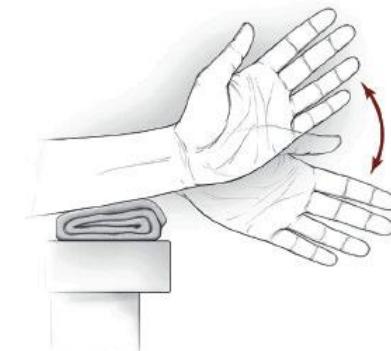
2. Wrist supination/pronation

- Stand or sit with your arm at your side with the elbow bent to 90 degrees, palm facing down.
- Rotate your forearm, so that your palm faces up and then down.



3. Wrist ulnar/radial deviation

- Support your forearm on a table on a rolled-up towel for padding or on your knee, thumb upward.
- Move the wrist up and down through its full range of motion.



LIVE DEMO