



Robots for disability

Prototype project

Fernando Okigami, Olzhas Nariman
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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



Leap Motion Controller, Gesture Motion Control for PC or MAC
by Leap Motion

\$61⁵⁴ 

Get it by **Tomorrow, Dec 14**

More Buying Choices
\$50.00 (19 used & new offers)

[See newer model of this item](#)

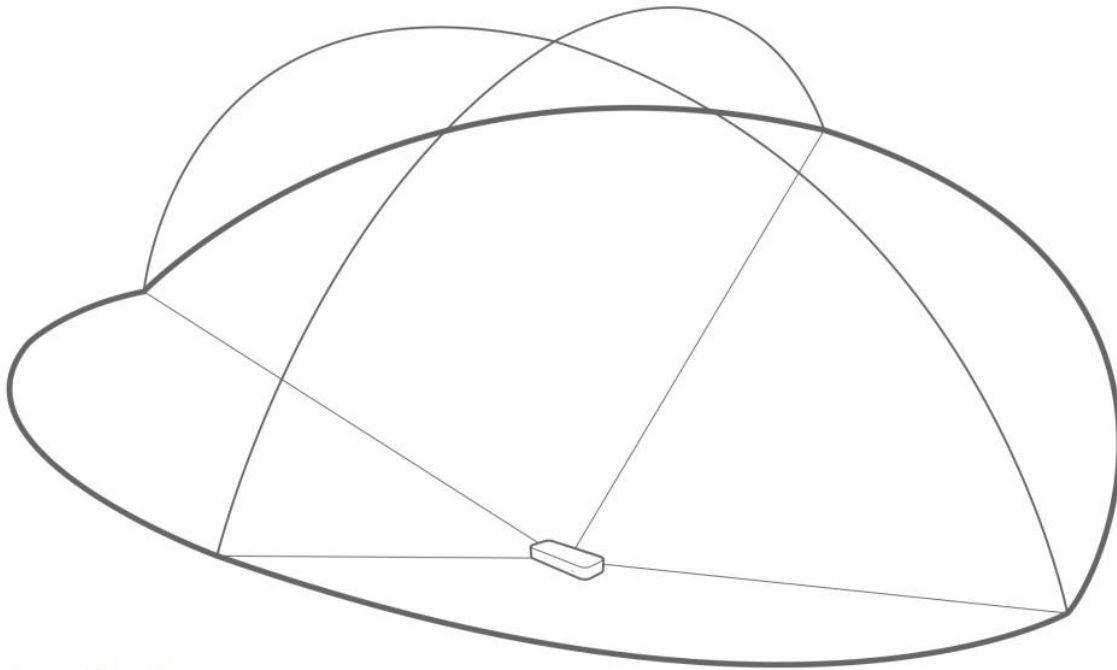
Hardware

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



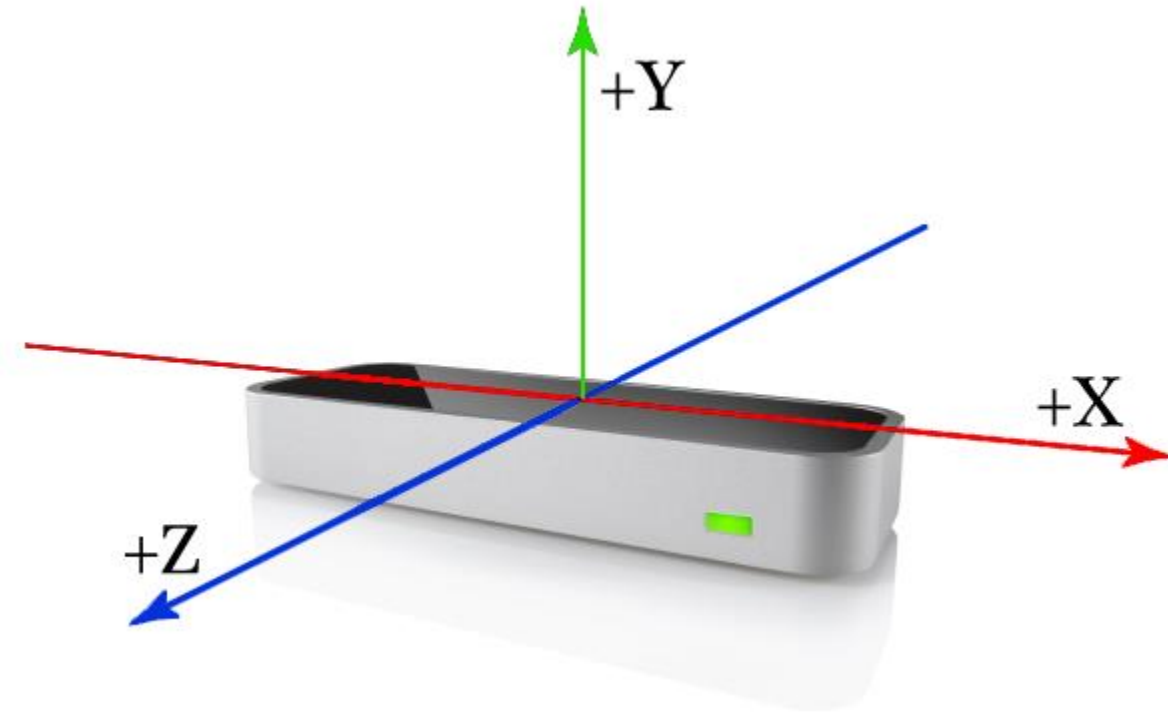
Interaction Area

$R = 2 \text{ ft}$ (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: $\text{std}x = 0.018$ mm, $\text{std}y = 0.016$ mm and $\text{std}z = 0.029$ 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:

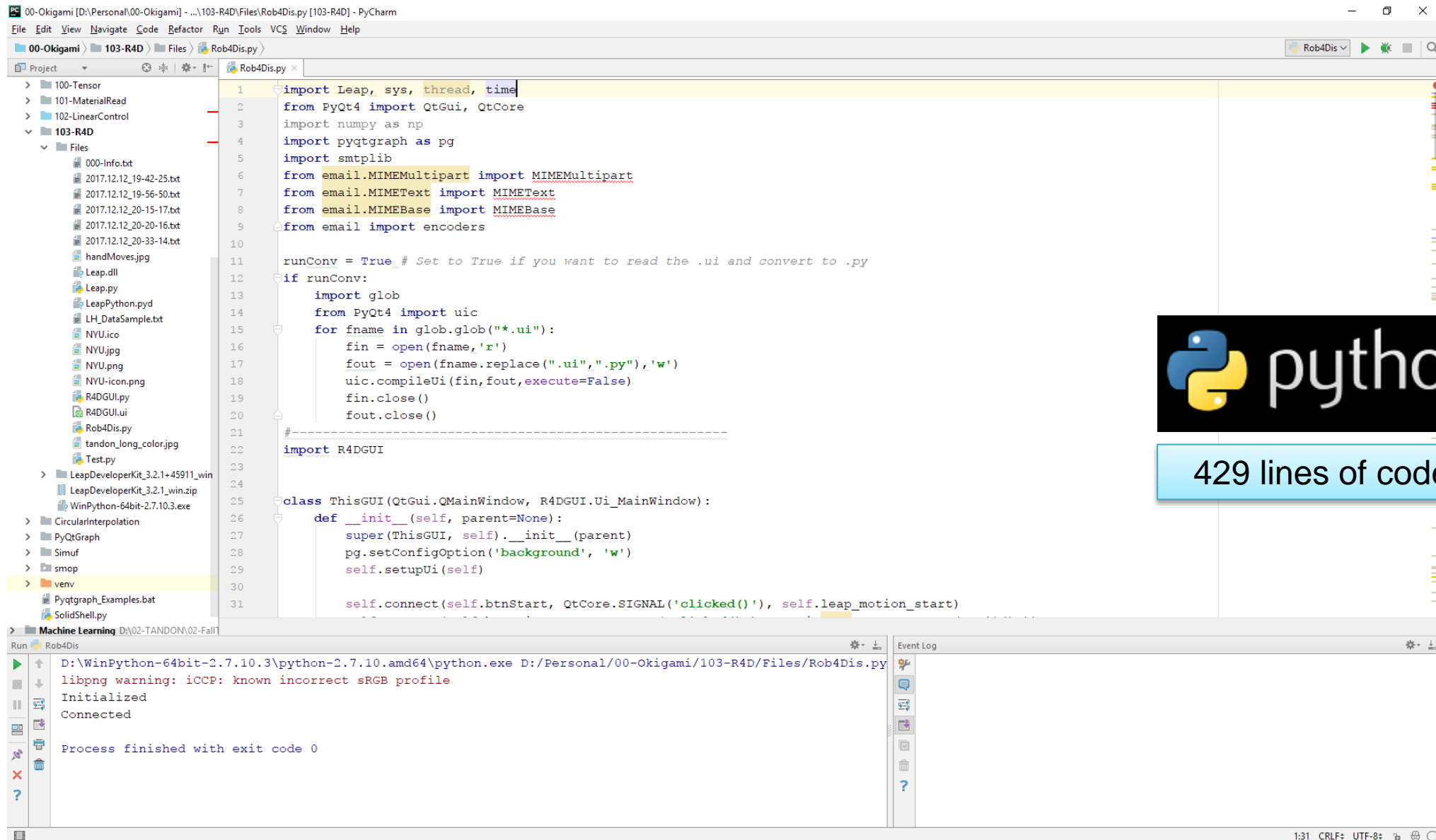
In the static scenario, the standard deviation was shown to be less than 0.5 mm at all times, in the best cases less than 0.01 mm. In addition, the high accuracy (below 0.2 mm) reported in [15] combines with our results to evaluate the controller as a reliable and accurate system for tracking static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

About precision and tracking: what literature says

Leap motion controller three dimensional verification and polynomial correction

[Yajaira-IlseCuriel-Razo^aOctaviolcasio-Hernández^{ab}GabrielSepúlveda-Cervantes^cJuan-BautistaHurtado-Ramos^aJosé-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.



429 lines of code only!

Qt Designer

File Edit Form View Settings Window Help

Widget Box

Filter

Layouts

- Vertical Layout
- Horizontal Layout
- Grid Layout
- Form Layout

Spacers

- Horizontal Spacer
- Vertical Spacer

Buttons

- OK Push Button
- Tool Button
- Radio Button
- Check Box
- Command Link Button
- Dialog Button Box

Item Views (Model-Based)

- List View
- Tree View
- Table View
- Column View

Item Widgets (Item-Based)

- List Widget
- Tree Widget
- Table Widget

Containers

- Group Box
- Scroll Area
- Tool Box
- Tab Widget
- Stacked Widget
- Frame
- Widget
- MDI Area
- Dock Widget

Input Widgets

- Combo Box
- Font Combo Box
- Line Edit
- Text Edit
- Plain Text Edit
- Spin Box

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Type Here

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Init and Status

Start

☐ Connected

Real-time detection

Hands: 0

Fingers: 0

Frame ID number

Hand tracking

General movement

Exercises

Lef 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

Righ 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

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Object Inspector

Object

- chkConnected
- groupBox_2
 - label_4
 - label_5
 - label_9
 - lblFrameID
 - spnFingers
 - spnHands
 - verticalSpacer
 - verticalLayout_6
 - tabWidget_2

Property Editor

Filter

tabWidget_2 : QTabWidget

Property	Value
tabletTracking	<input type="checkbox"/>
focusPolicy	TabFocus
contextMenuPolicy	DefaultContextMenu
acceptDrops	<input type="checkbox"/>
toolTip	
toolTipDuration	-1
statusTip	
whatsThis	
accessibleName	
accessibleDescription	
layoutDirection	LeftToRight
autoFillBackground	<input type="checkbox"/>
styleSheet	
locale	English, UnitedStates
inputMethodHints	ImhNone
QTabWidget	
tabPosition	North
tabShape	Rounded
currentIndex	0
iconSize	16 x 16
elideMode	ElideNone
usesScrollButtons	<input checked="" type="checkbox"/>
documentMode	<input type="checkbox"/>
tabsClosable	<input type="checkbox"/>
movable	<input type="checkbox"/>
tabBarAutoHide	<input type="checkbox"/>
currentTabText	Hand tracking
currentTabName	tabHand
currentTabIcon	
currentTabToolTip	
currentTabWhatsThis	

A diagram of a right hand with green spheres placed on various bones to indicate motion capture points. The spheres are located on the thumb, index, middle, ring, and pinky fingers (distal, intermediate, proximal), on the metacarpals, and on the wrist. Labels with arrows point to these positions: 'Tip Position' points to the distal sphere of the index finger; 'Palm Position' points to a sphere on the central metacarpal; 'Wrist Position' points to a sphere at the wrist; 'Arm' points to the forearm; 'Thumb', 'Index', 'Middle', 'Ring', and 'Pinky' label the respective fingers. A box labeled 'Bones' contains labels for 'Distal', 'Intermediate', 'Proximal', and 'Metacarpal', each with an arrow pointing to a corresponding sphere on the right hand.

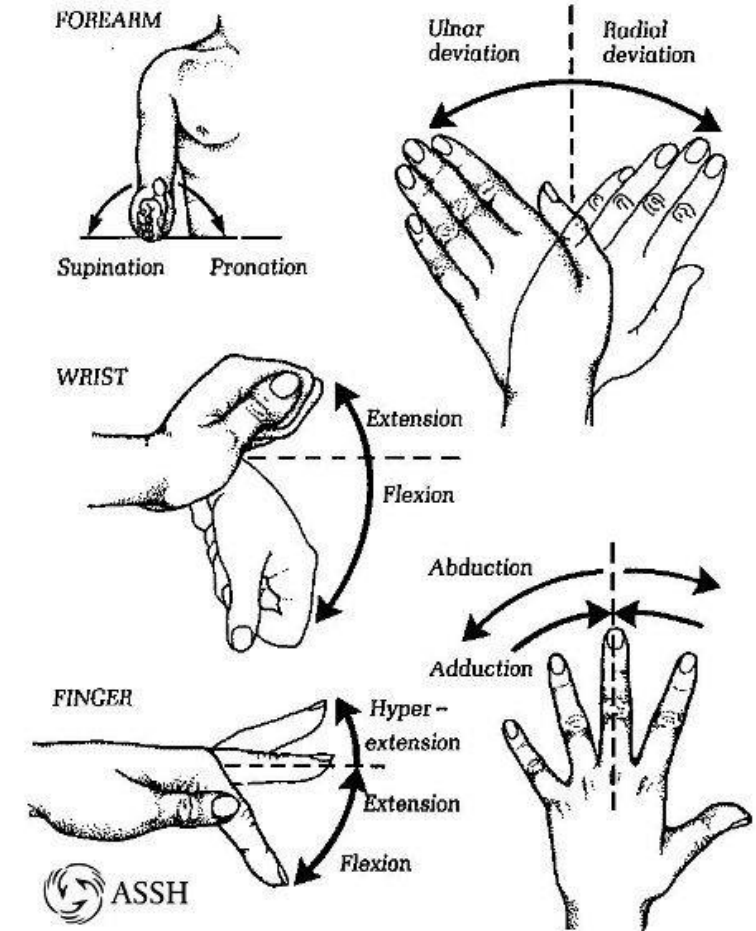
- **Through a user-friendly interface:**

- 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

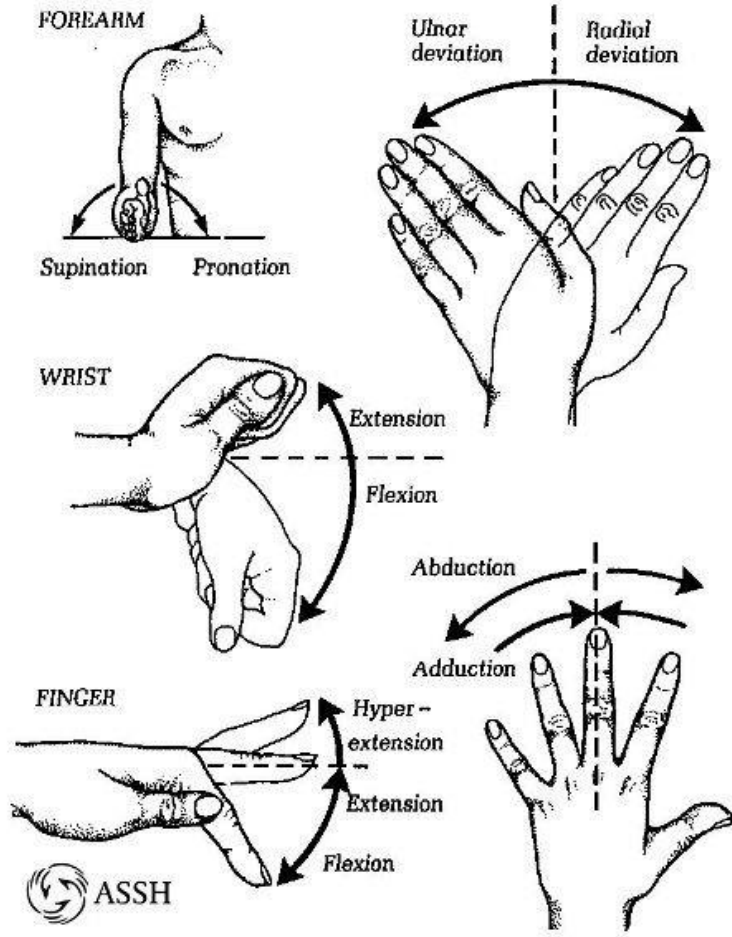
- **We can assess:**

- 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*



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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

Yaw

Pitch

Roll

100%

Quit

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There's room to do much more!

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NYU

TANDON SCHOOL OF ENGINEERING

Init and Status

Start

☐ Connected

Real-time detection

Hands

0

Fingers

0

Frame ID number

Hand tracking

General movement

Exercises

Tab 1

Tab 2

LEVEL 2

☐ Palm Up Down

☐ Wrist Curl

LEVEL 3

☐ Grip Release

☐ Coin Drop

☐ After exercises

angle between fingers [bar charts]

☐ Wrist Bend Movement

Do you want to finish Exercises?

☐ Progress chart

☐ Wrist Side Movement

LEVEL 1

☐ Finger Curl

☐ Pen Spin

→ Start Managing Graphs

☐ Before

☐ Rolling Movement

OK

Cancel

Plot the graphs

→ Start the Exercises

GroupBox

Info

Bones

Quit

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Proposed exercises to be done in the platform

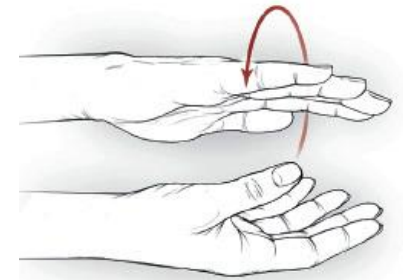
1. Wrist extension and flexion

- 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.



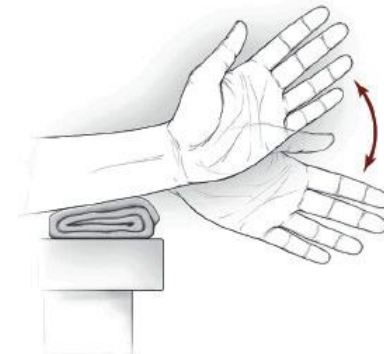
2. Wrist supination/pronation

- 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