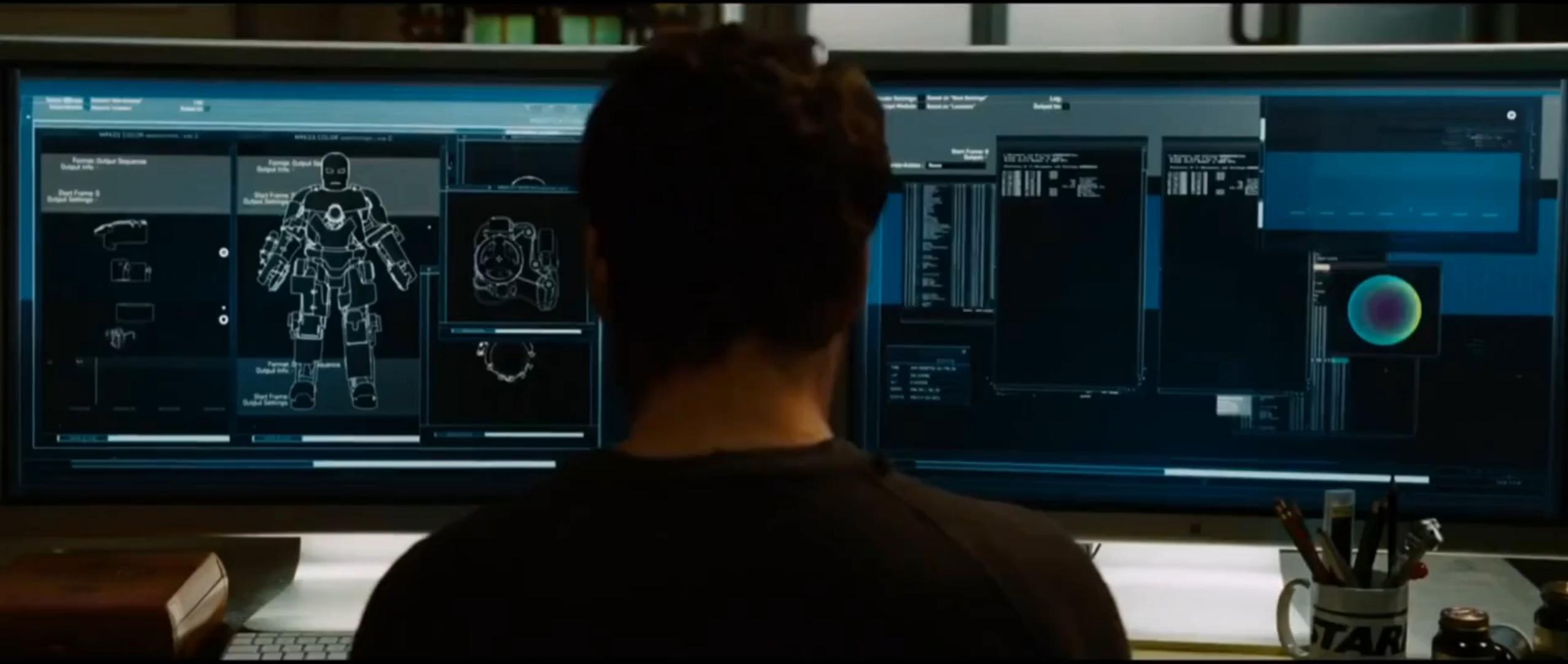


**K.R.I.S.**

A NEW DEVICE FOR KINESTHETIC  
ROBOT INTERACTION



# ROBOTS TODAY...



# HOW IT COULD BE...



# CONTENTS

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**Part 1:** Why teaching is better than telling.

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**Part 2:** Designing the Kinesthetic Robotic Interaction System (K.R.I.S. )

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**Part 3:** Experimentation and results

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**Part 4:** Demonstration and final thoughts

# PART 1

WHY TEACHING IS BETTER THAN TELLING.

# THE TYPES OF INTERACTIONS

- Pushing a robot out of the way
- Letting a robot go around an obstacle
- Assisting in a task like holding or manipulating some object
- Adjusting a robot's trajectory

**"BECAUSE PHRI IS  
INTENTIONAL, IT IS ALSO  
INFORMATIVE"**

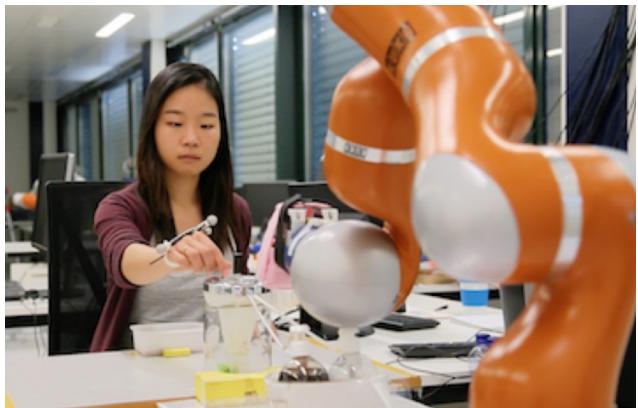
ANDREA BAJCSY, DYLAN P. LOSEY, MARCIA K. O'MALLY ANCA  
D. DRAGAN (2017)

# HOW HUMANS TEACH MOTION



# TYPICAL LFD MODALITIES

Observation



Teleoperation



Kinesthetic

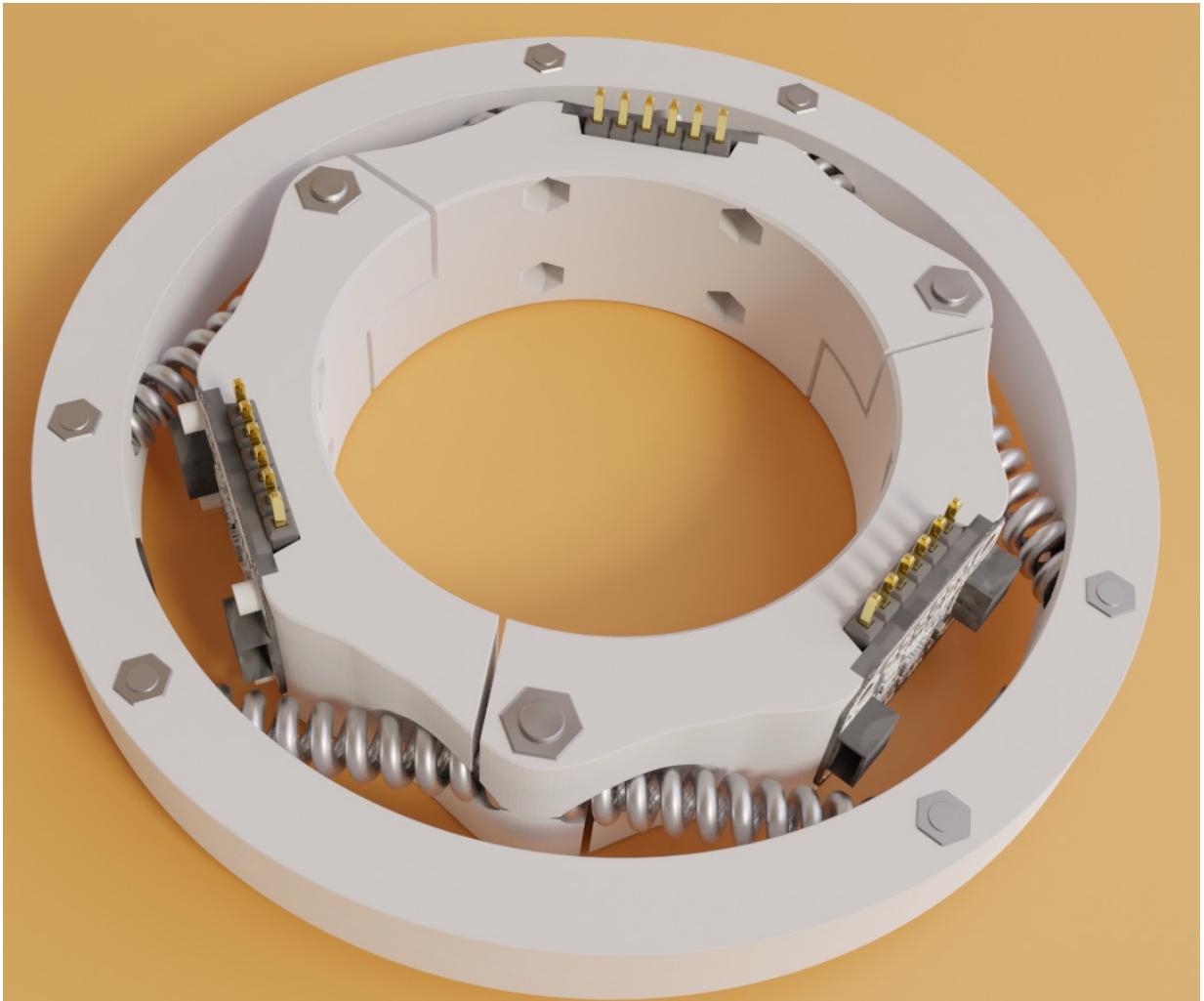


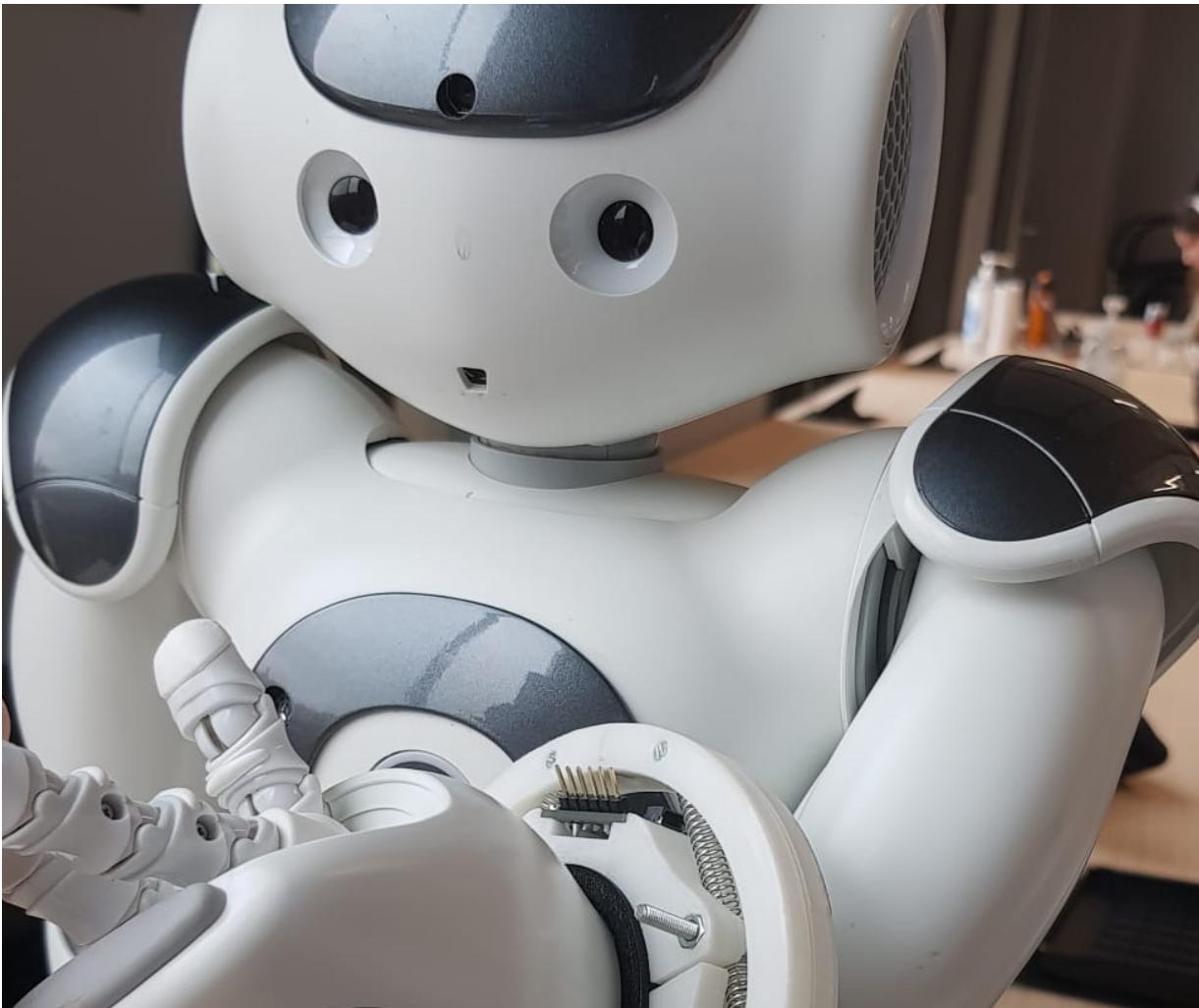
# PART 2

DESIGNING THE KINESTHETIC ROBOTIC  
INTERACTION SYSTEM (K.R.I.S.)

# HIGH LEVEL DESIGN

- Analog in six degrees
- Independent movement
- On or near end-effector





## SUCCESS METRICS

- Usable during operation
- Intuitiveness
- Precision
- Low-mental load

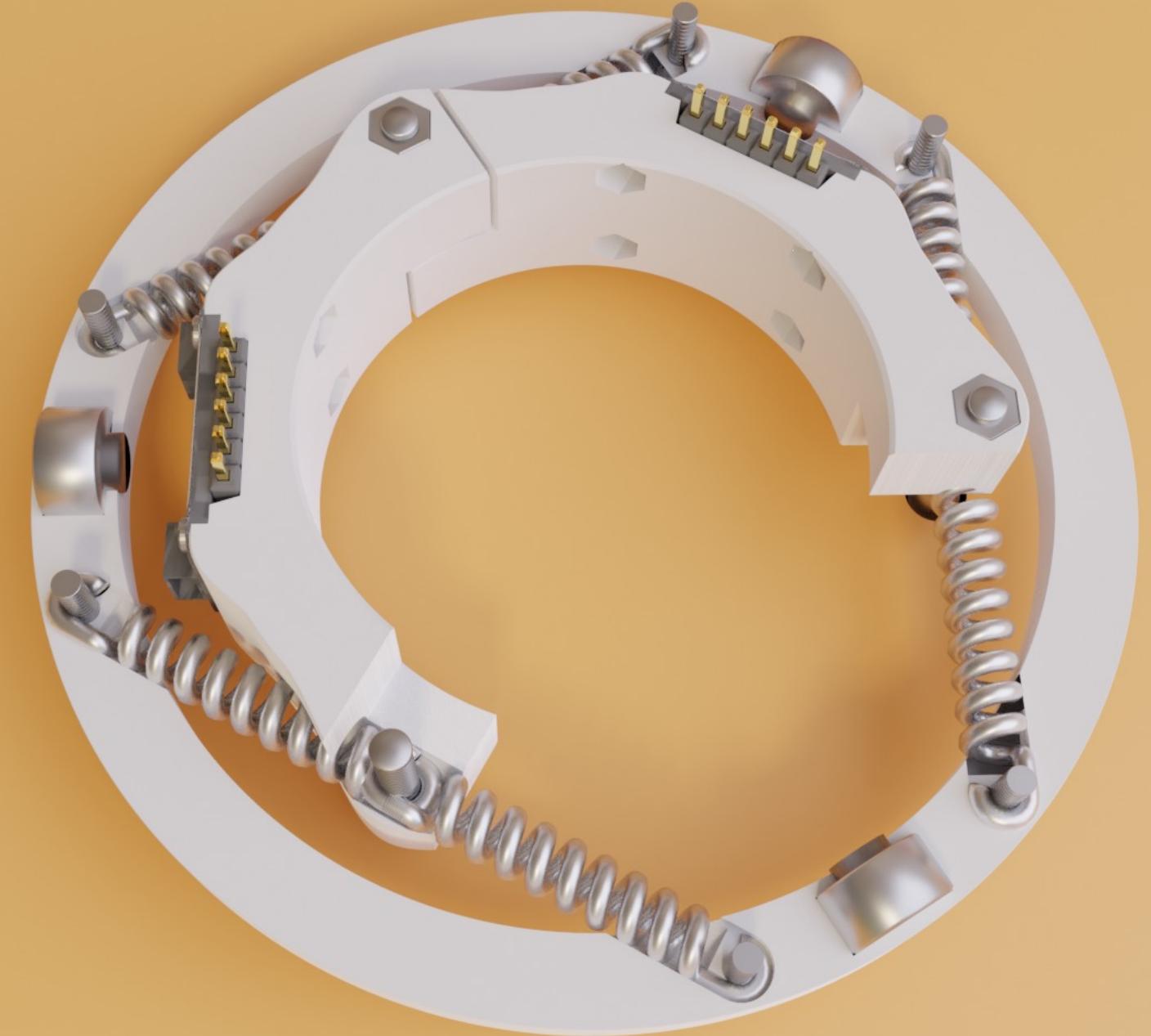
## Outer ring

## Inner ring

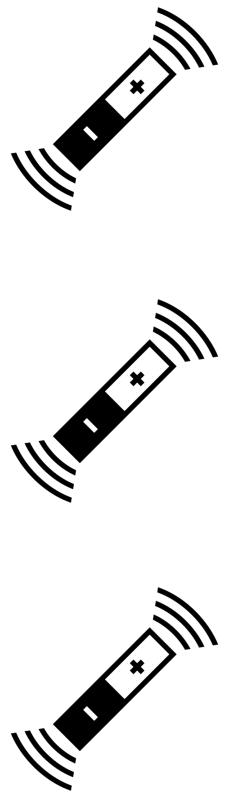
Sensors

# Magnets

# Springs



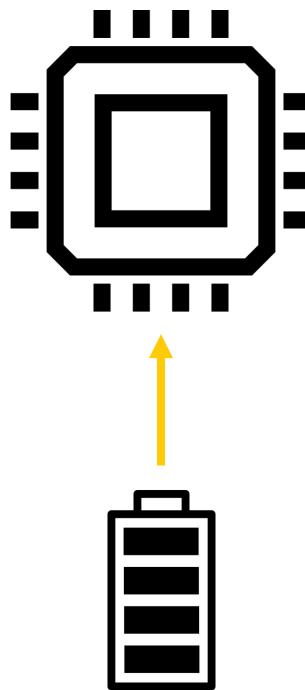
3x magnet



3 x sensor



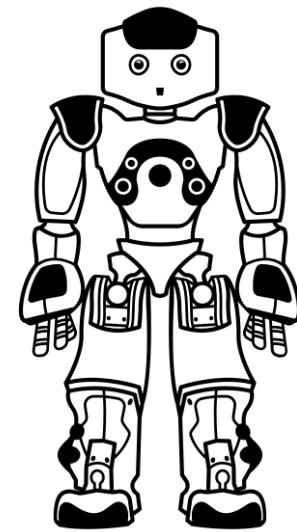
Microcontroller



Laptop



NAO



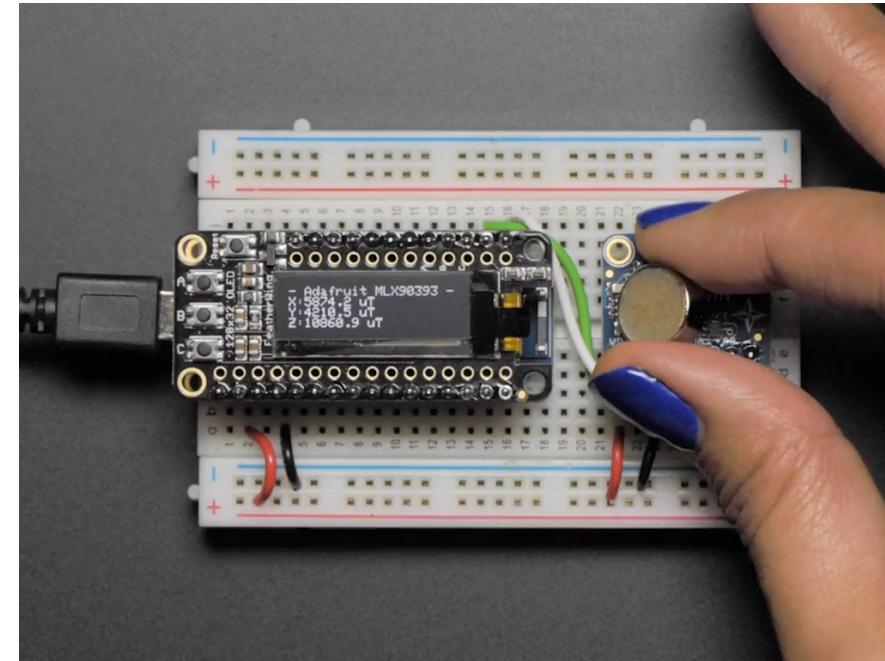
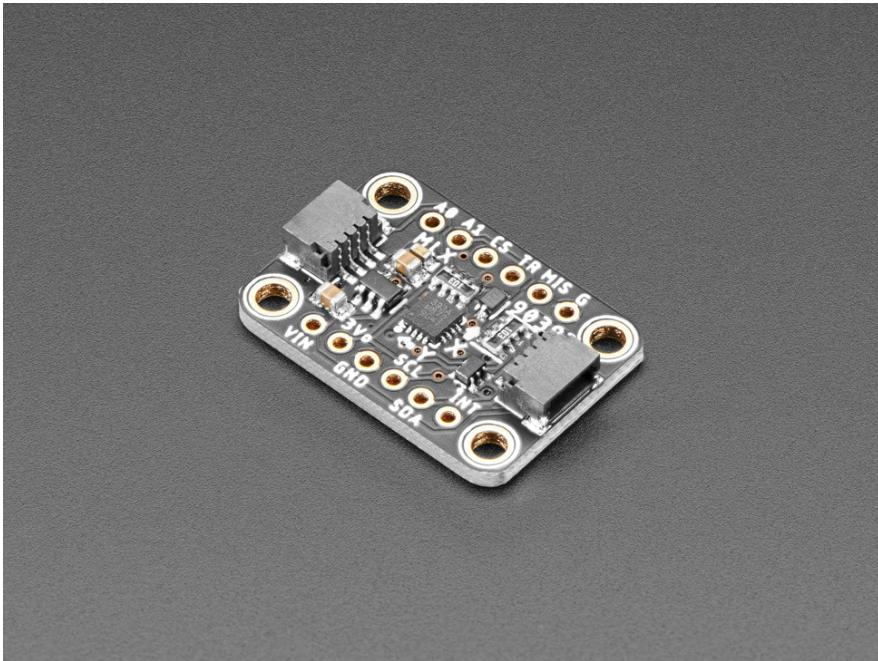
Battery

# TYPE OF SENSOR:

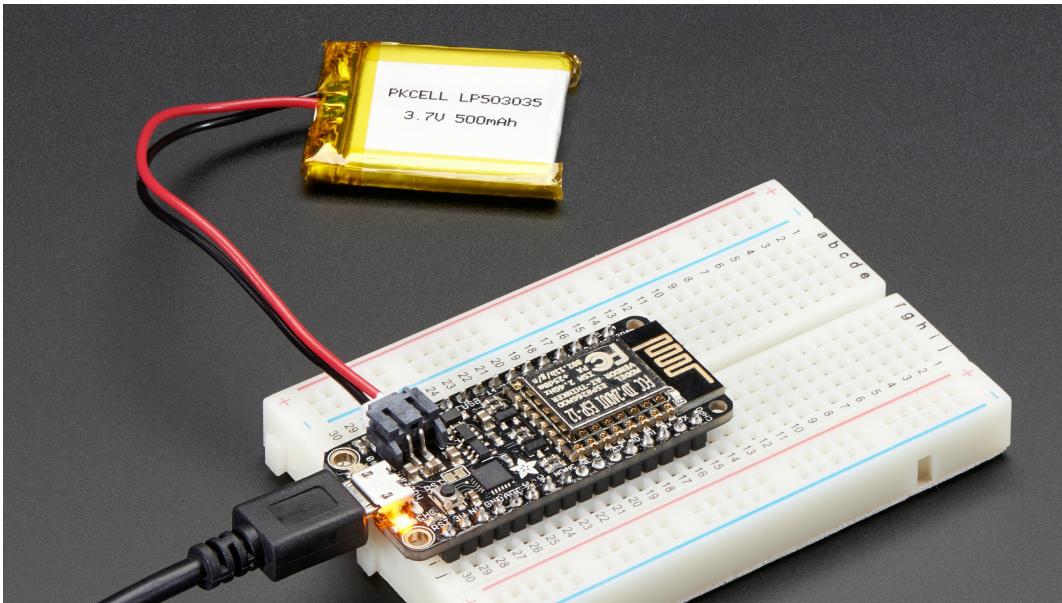
## ADAFRUIT

## MLX90393

### 3 AXIS MAGNETOMETER



# TYPE OF MICROCONTROLLER: ADAFRUIT FEATHER HUZZAH ESP8266



# TRANSFORMATION SOLVER

Sensor input:

X1: ....  
Y1: ....  
Z1: ....  
X2: ....  
Y2: ....  
Z2: ....  
X3: ....  
Y3: ....  
Z3: ....

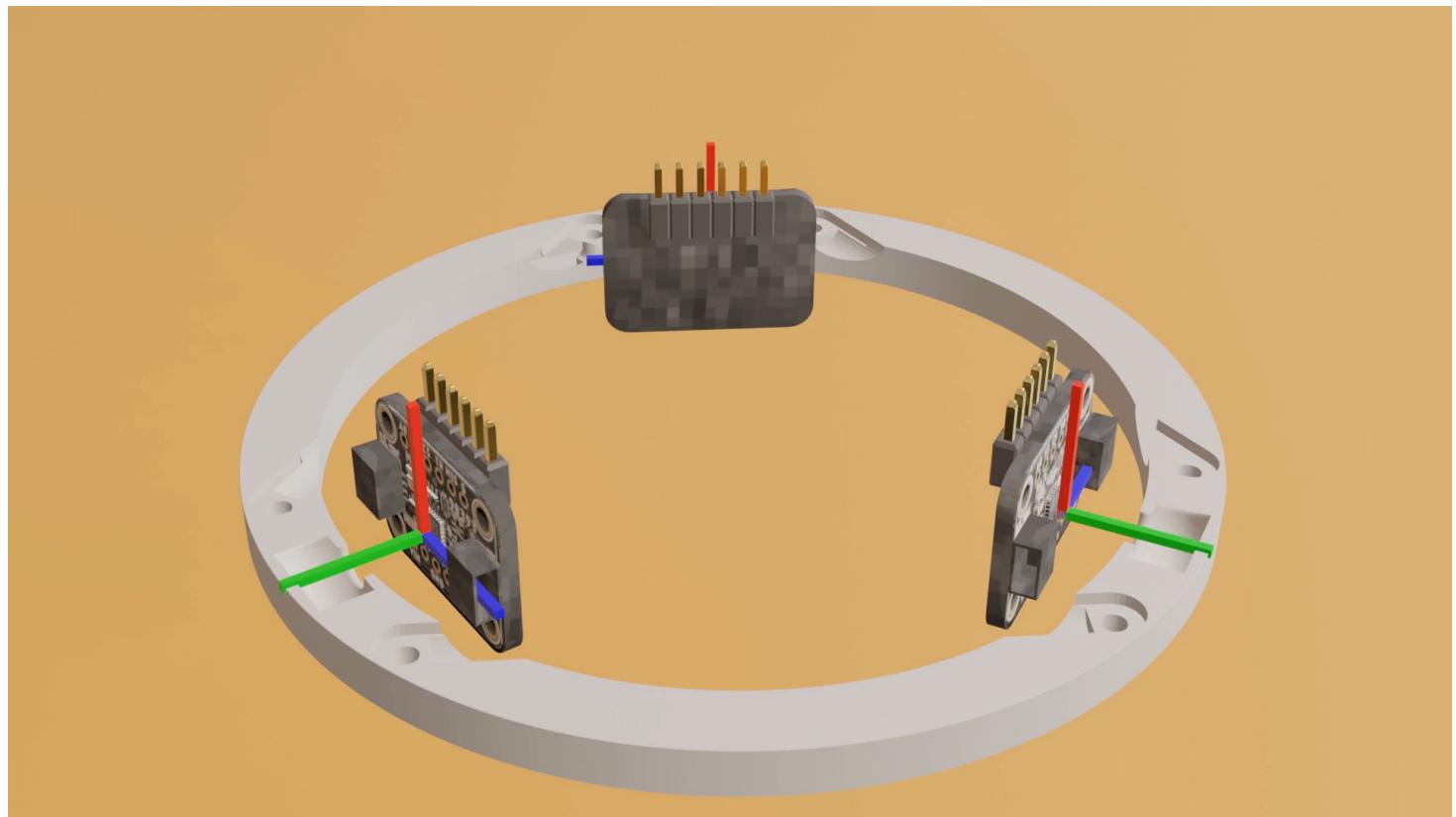


Transformation output:

X: ....  
Y: ....  
Z: ....  
Rx: ....  
Ry: ....  
Rz: ....

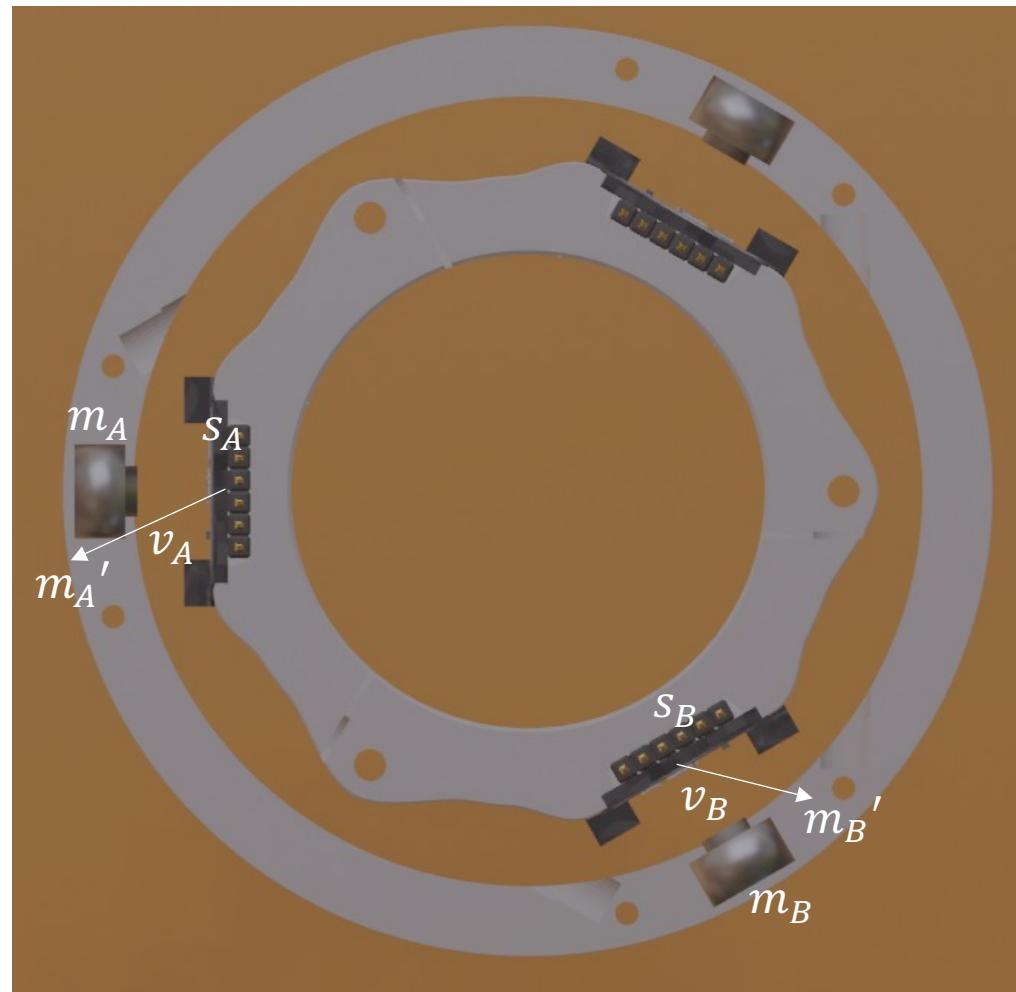
# TRANSFORMATION SOLVER

- Step 1: Aligning to a singular reference frame



# TRANSFORMATION SOLVER

- Step 1: Aligning to a singular reference frame
- Step 2: Find scale factor



$$m'_A = s_A + v_A \cdot sf$$

$$m'_B = s_B + v_B \cdot sf$$

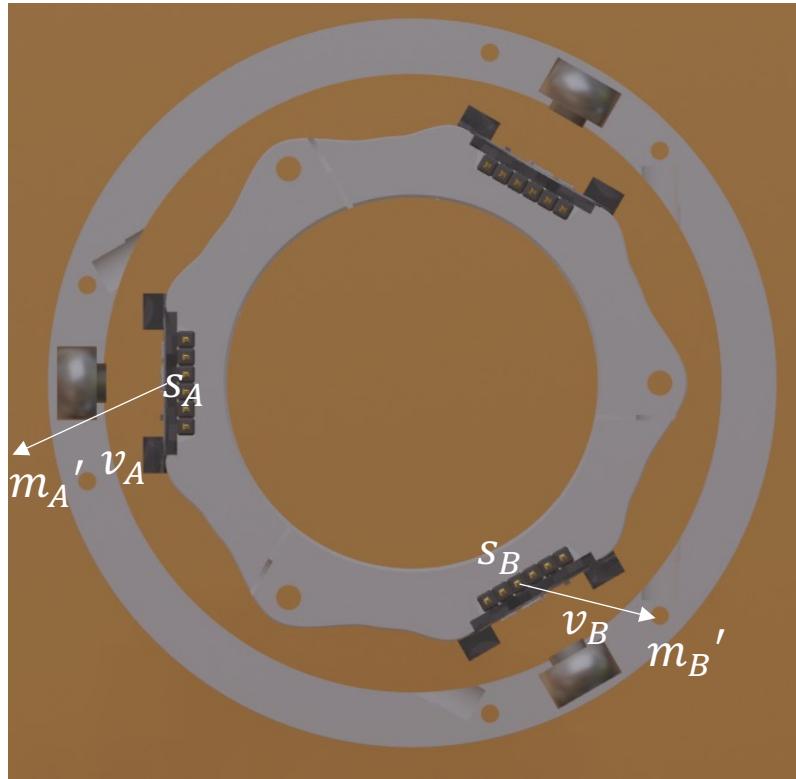
$$|m'_B - m'_A| = |m_B - m_A|$$

$$|m'_A| + |m'_B - m'_A| = |m'_B|$$

$$sf = \frac{| -s_A - v_{m_A}^{m_B} + s_B |}{|v_B - v_A|}$$

# TRANSFORMATION SOLVER

- Step 1: Aligning to a singular reference frame
- Step 2: Find scale
- Step 3: Project magnet positions



$$m'_A = s_A + v_A \cdot sf$$

$$m'_B = s_B + v_B \cdot sf$$

# TRANSFORMATION SOLVER

- Step 1: Aligning to a singular reference frame
- Step 2: Find scale
- Step 3: Project magnet positions
- Step 4: Apply the Kabsch algorithm

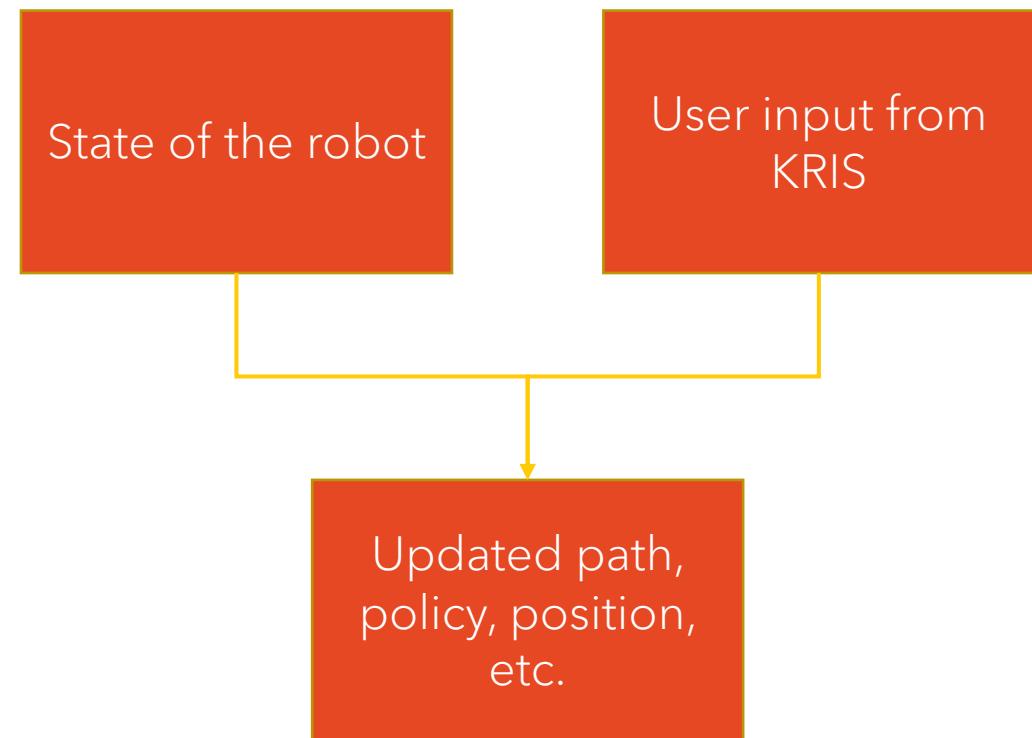
Input:

Newly found coordinates  
Coordinates in base position

Output:

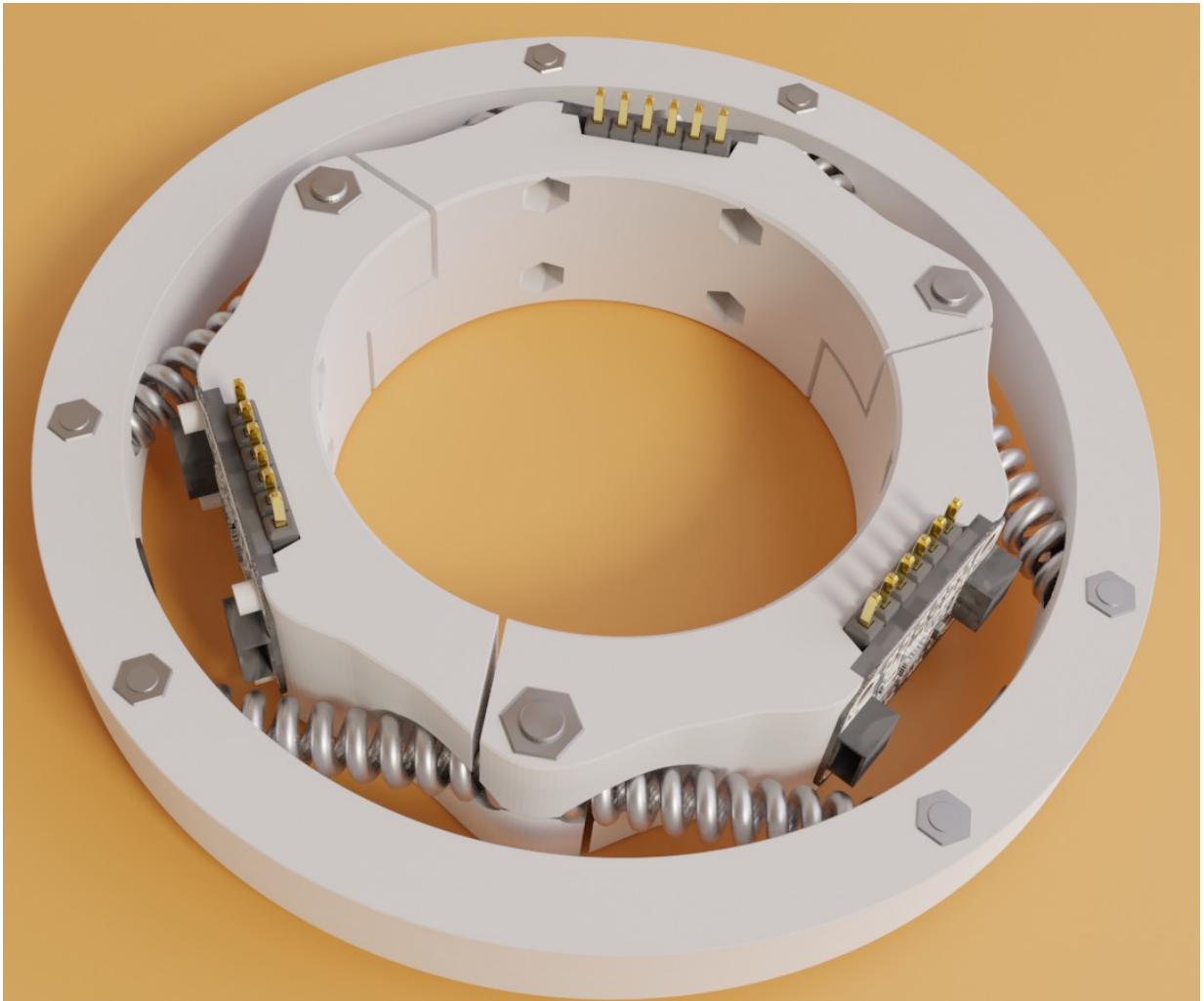
Rotation and translation of closest  
approximation

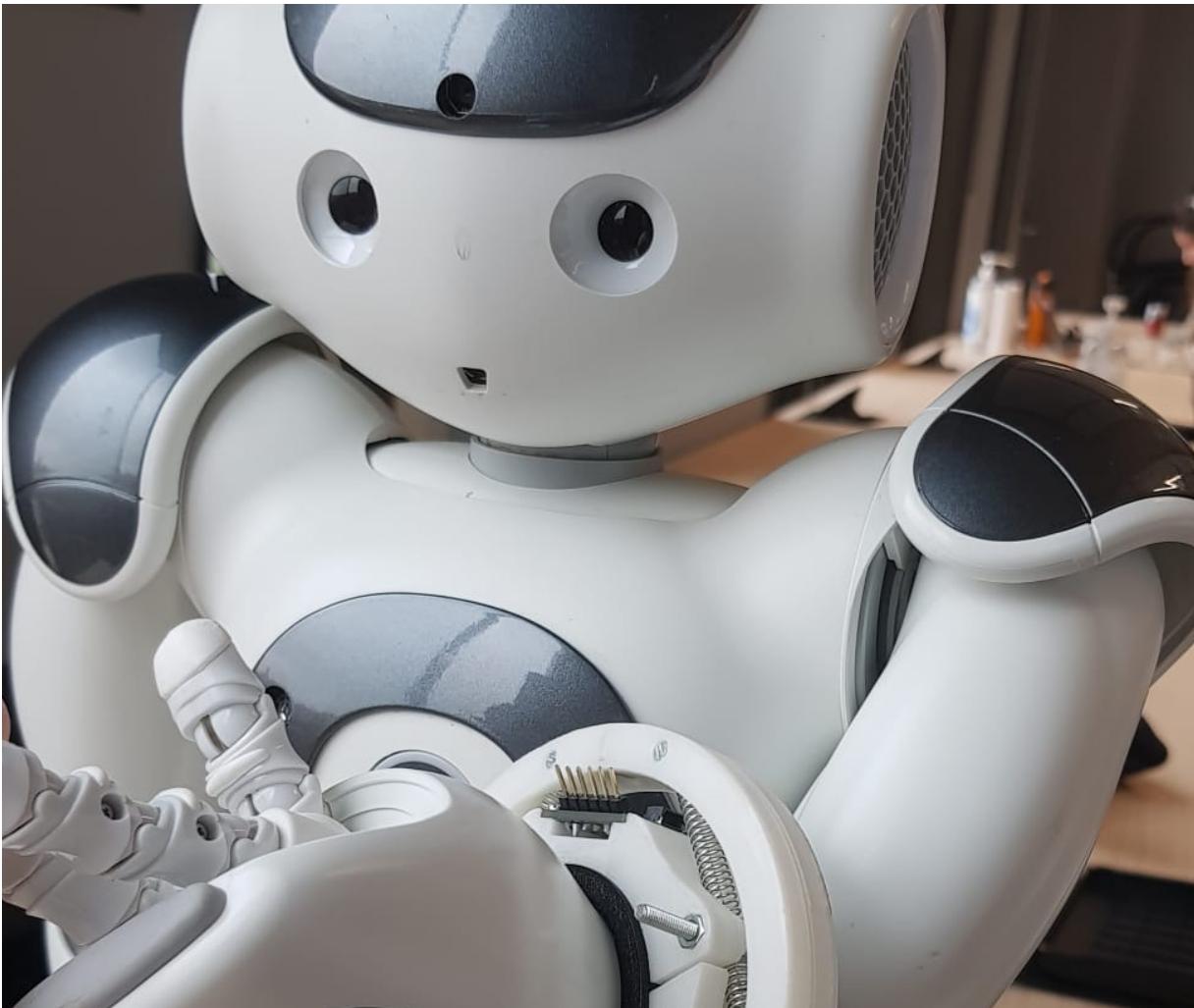
# HOW WE USE THIS INFORMATION



# HIGH LEVEL DESIGN

- Analog in six degrees
- Independent movement
- On or near end-effector





## SUCCESS METRICS

- Usable during operation
- Intuitiveness
- Precision
- Low-mental load

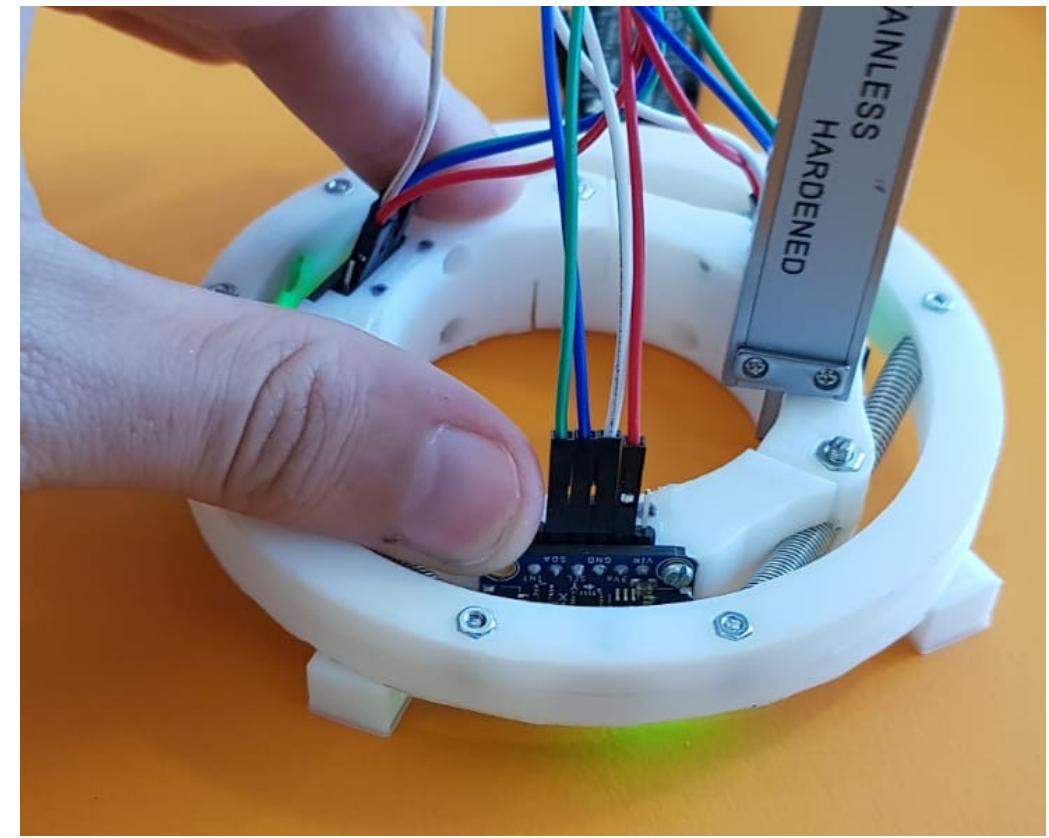
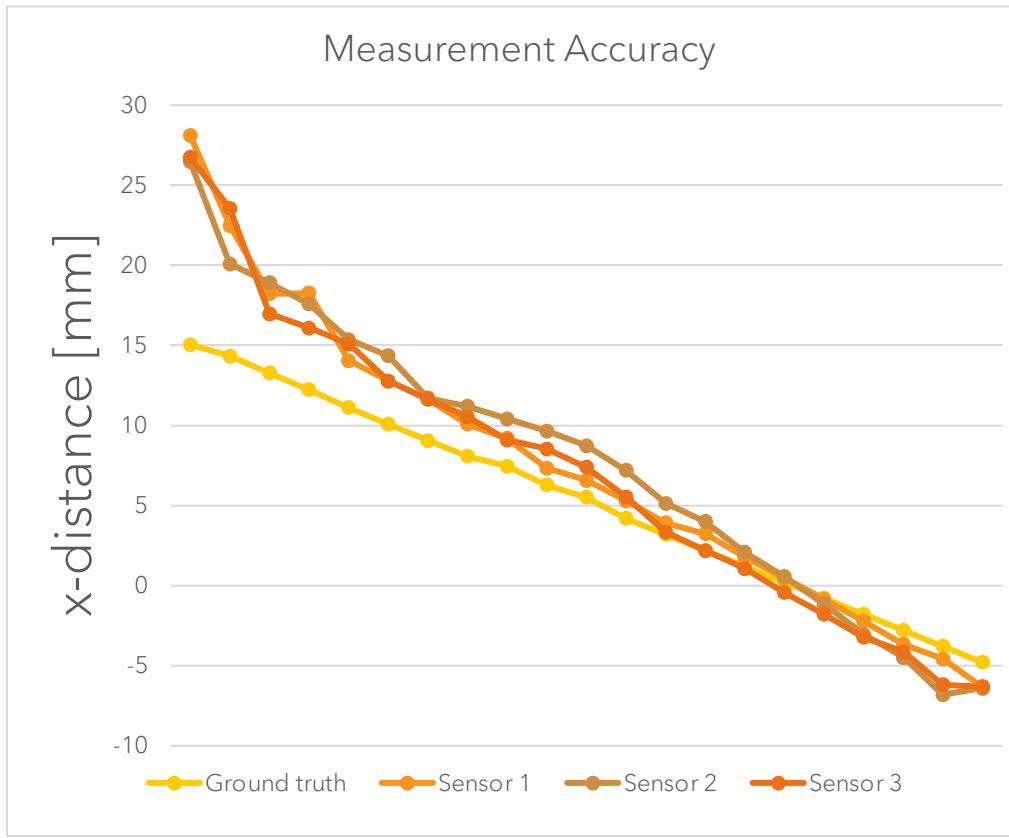
# PART 3

EXPERIMENTATION AND RESULTS

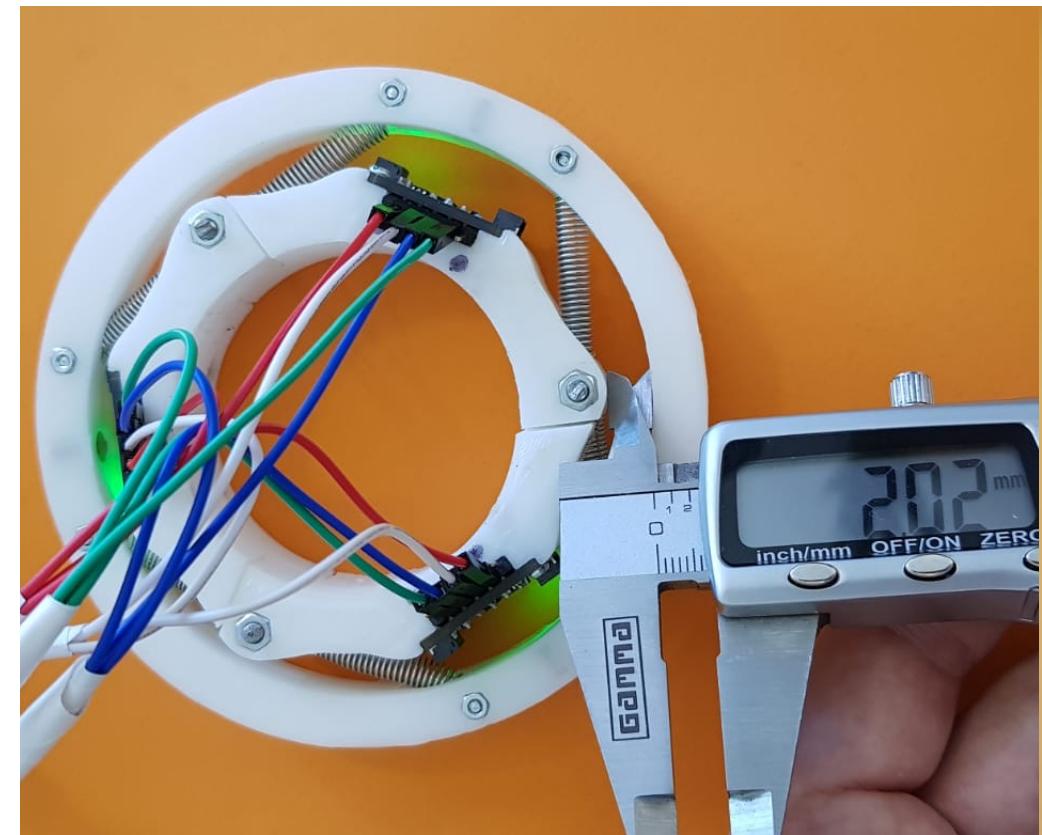
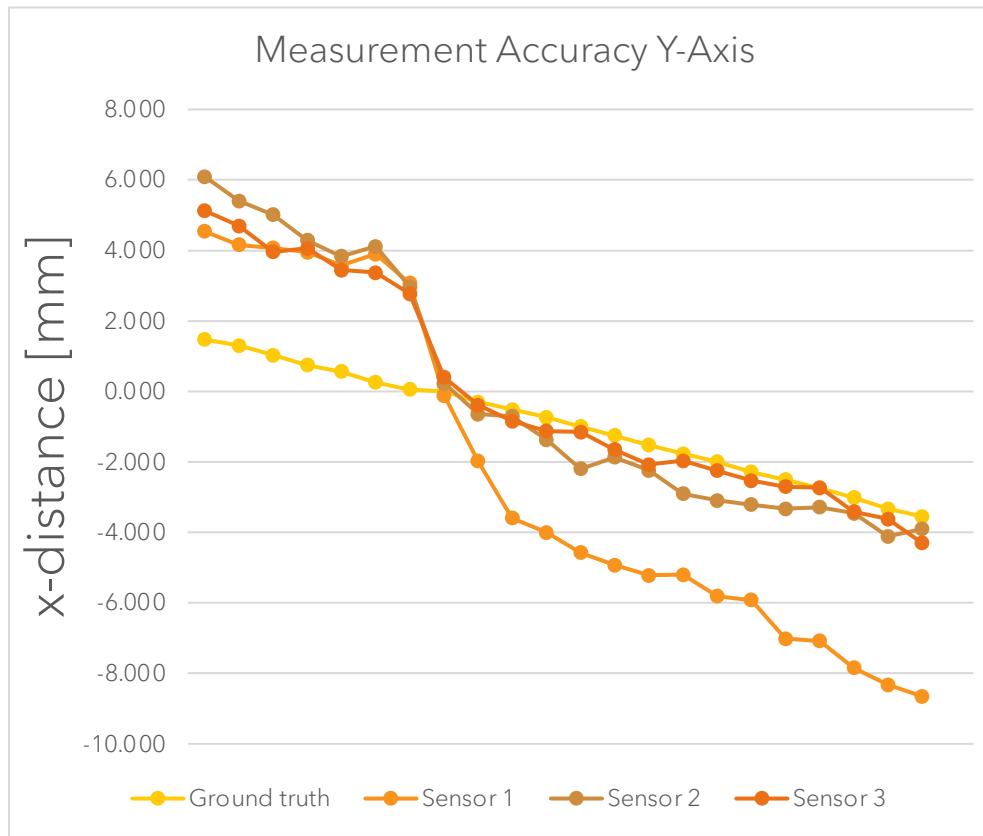
# **PRECISION EXPERIMENTS**

HOW PRECISE IS K.R.I.S.

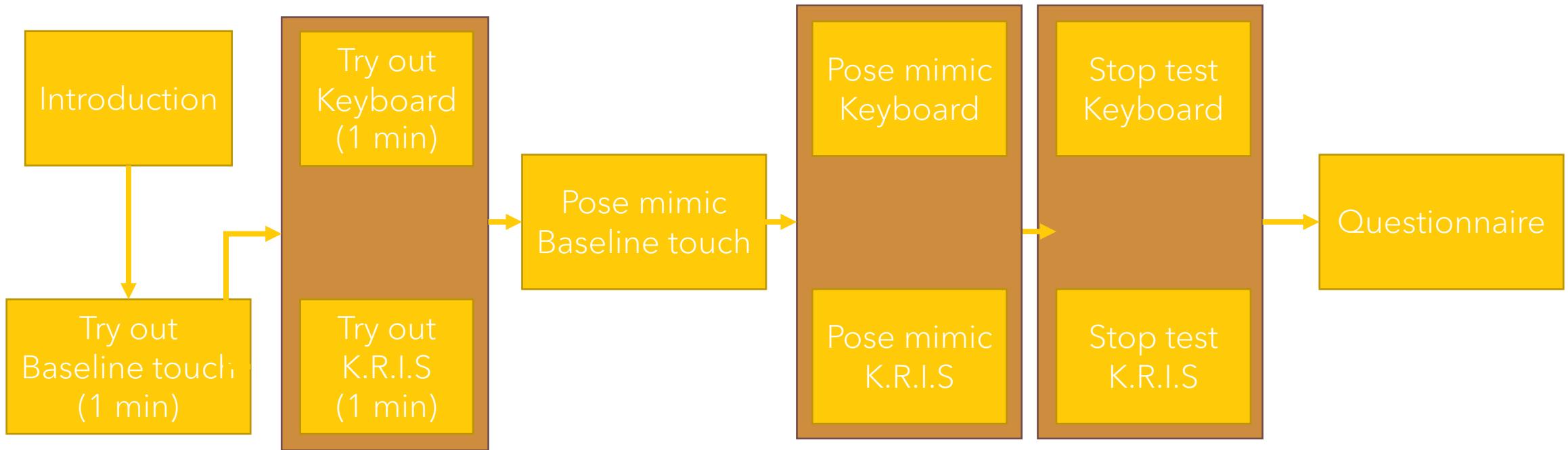
# PRECISION IN AXIS DIRECTION



# PRECISION IN COUNTER AXIS DIRECTION



# USER STUDY



# **POSE MIMICKING EXPERIMENTS**

HOW INTUITIVE, USABLE AND COGNITIVELY DEMANDING IS  
KRIS COMPARED TO A COMPARABLE BASELINE

# POSE MIMICKING



# **POSE MIMICKING**

- Is K.R.I.S intuitive enough to be taught quickly
  - User gets only 1 minute to learn the methods for controlling the robot
- How well is a user able to control the robot
  - Is the user getting close to their desired path
- How does the user rate the experience of using K.R.I.S. compared to the baseline
  - SUS score
- How mentally demanding is the task
  - TLX score

# **BASELINES**

## **Touch**

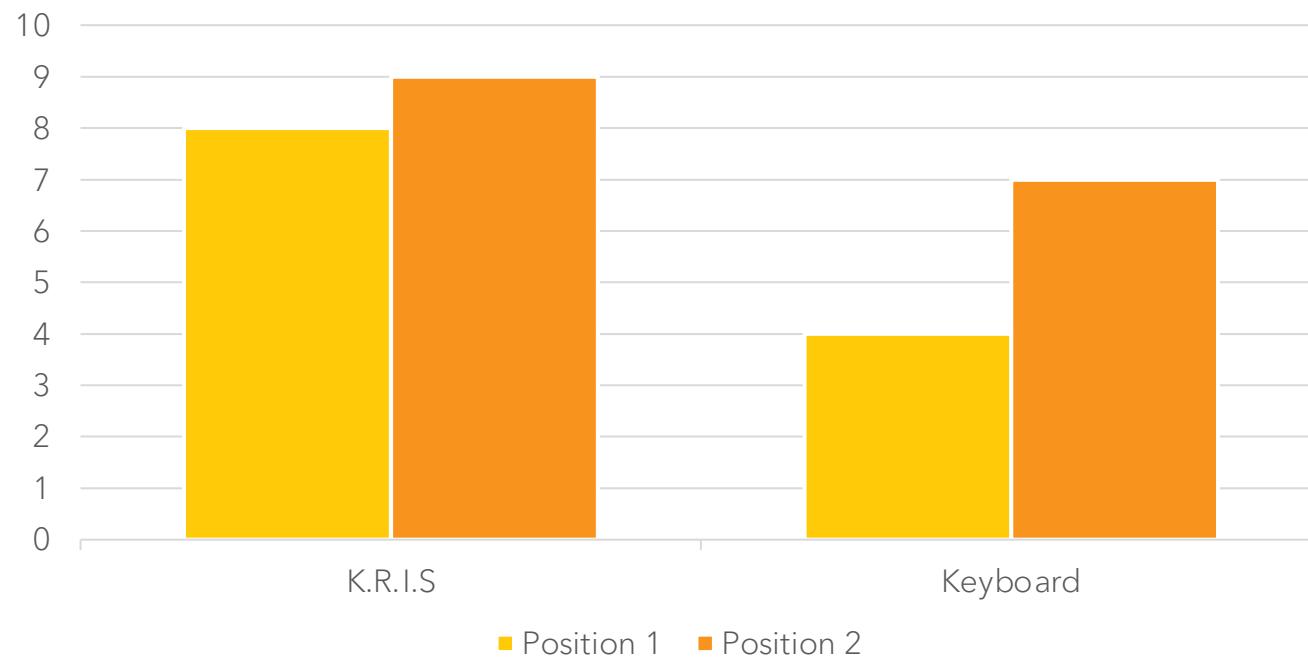
- physically moving the robots arm
- Naturally very intuitive method
- Used as a reference for ideal path

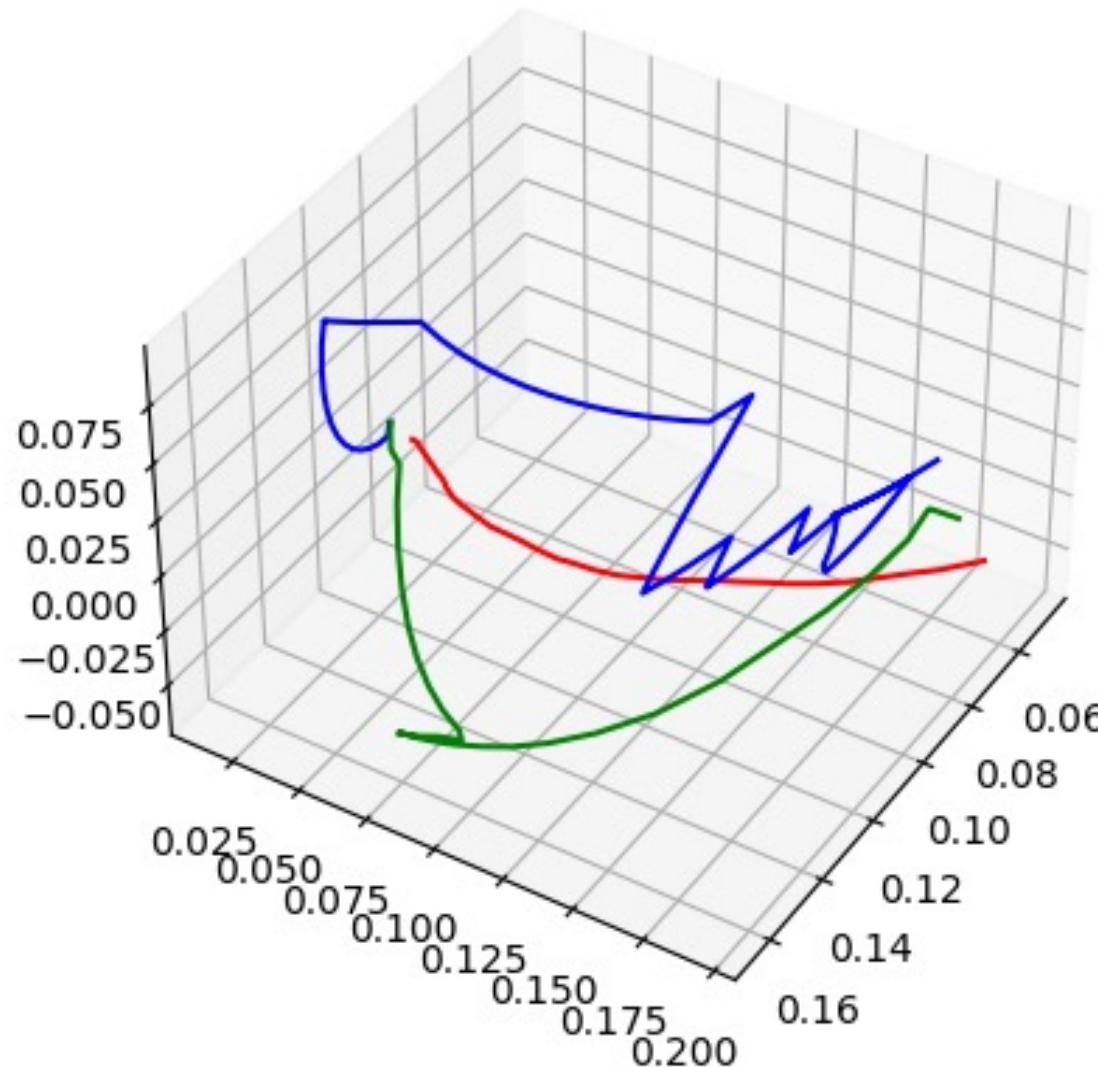
## **Keyboard**

- using buttons to control the position and rotation of the robot
- Meant to be quite unintuitive

# COMPLETION

Successful completions





## TYPICAL PATH

- Touching seems to be the most direct, without any stops or big changes in direction
- K.R.I.S seems to need one or a couple of course corrections
- Keyboard is very jagged in its path

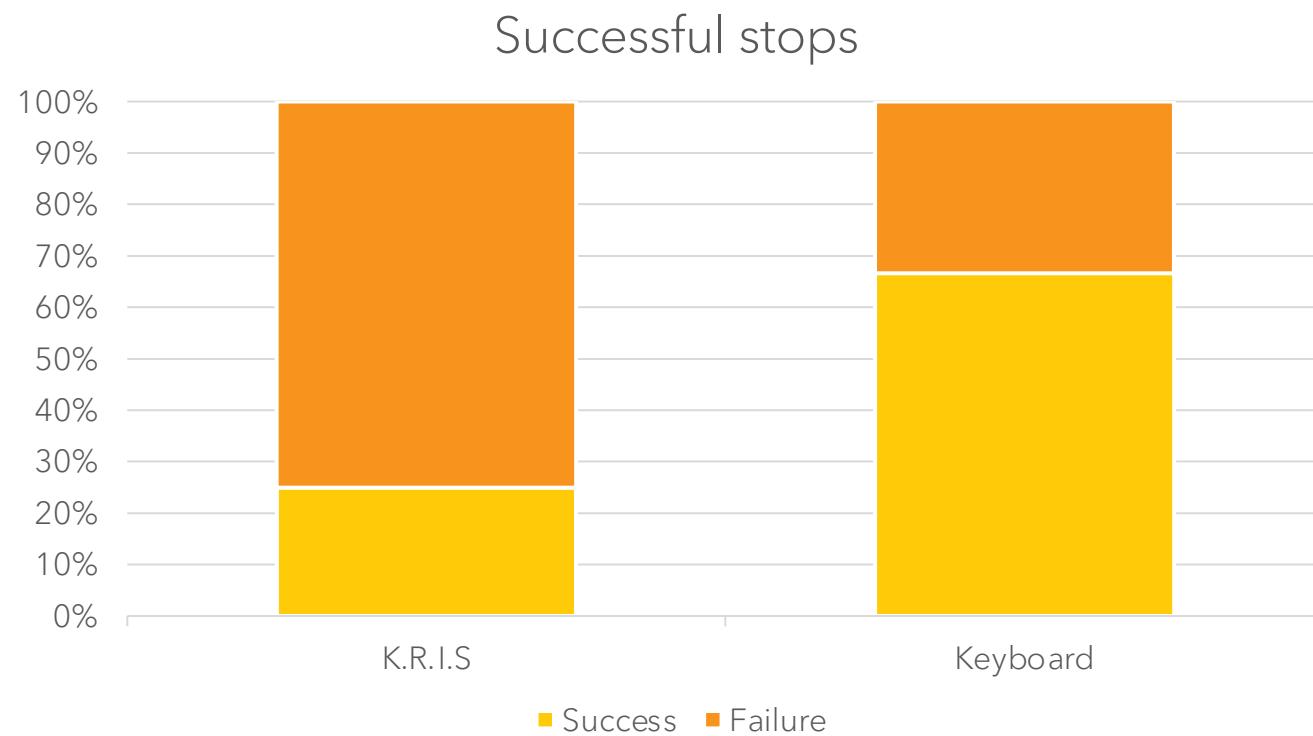
# **PATH STOP EXPERIMENTS**

USING K.R.I.S. DURING OPERATION, IS A USER ABLE TO GIVE PRECISE ADJUSTMENTS WHILE THE ROBOT IS MOVING

# **STOP THE ROBOT'S PATH**

- The robot has a set path
- Input in the direction will slow down or speed up the robot
- Comparing to the keyboard baseline

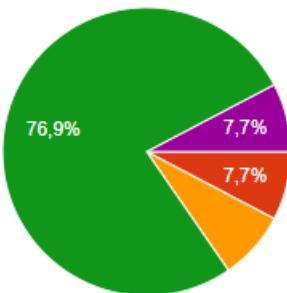
# STOP THE ROBOT'S PATH



# RESULTS TO THE QUESTIONNAIRE

(KRIS) I thought this product was easy to use

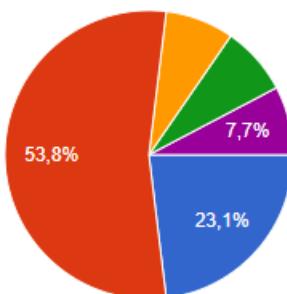
13 antwoorden



- Completely disagree
- Disagree
- Neutral
- Agree
- Completely agree

(Keyboard) I thought this product was easy to use

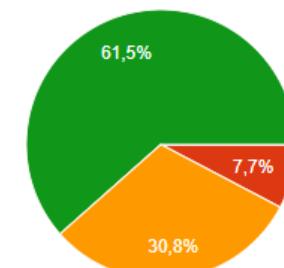
13 antwoorden



- Completely disagree
- Disagree
- Neutral
- Agree
- Completely agree

(KRIS) I would imagine that most people would learn to use this product very quickly

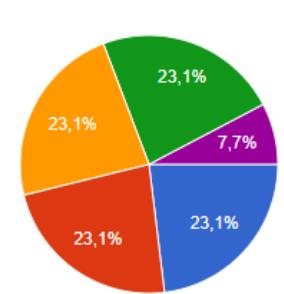
13 antwoorden



- Completely disagree
- Disagree
- Neutral
- Agree
- Completely agree

(Keyboard) I would imagine that most people would learn to use this product very quickly

13 antwoorden

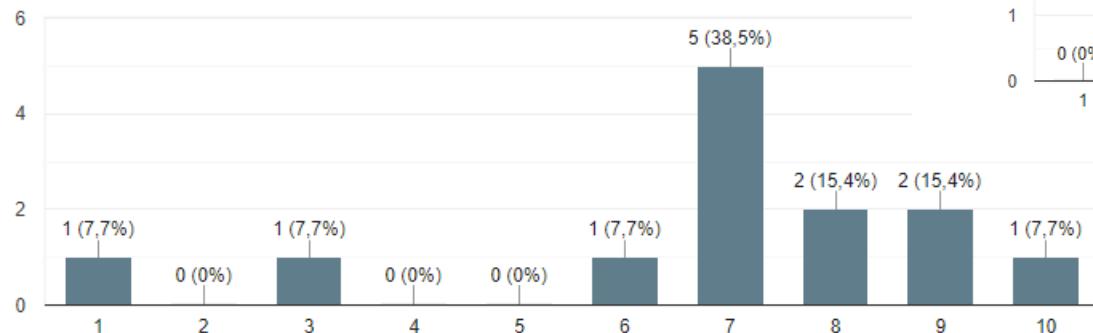


- Completely disagree
- Disagree
- Neutral
- Agree
- Completely agree

# RESULTS TO THE QUESTIONNAIRE

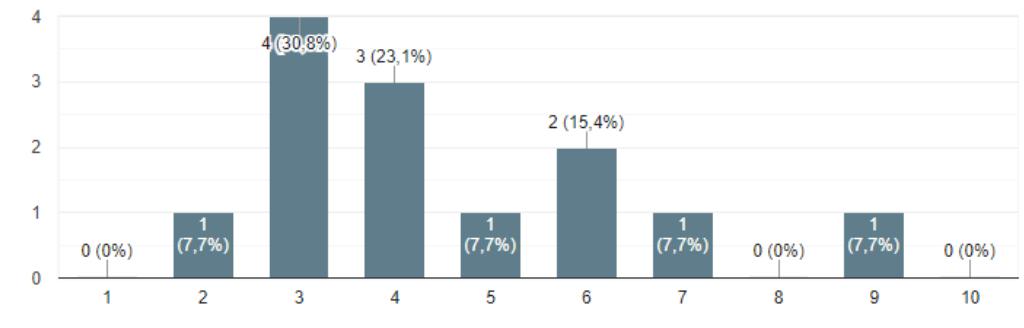
(Keyboard) How mentally demanding was the task?

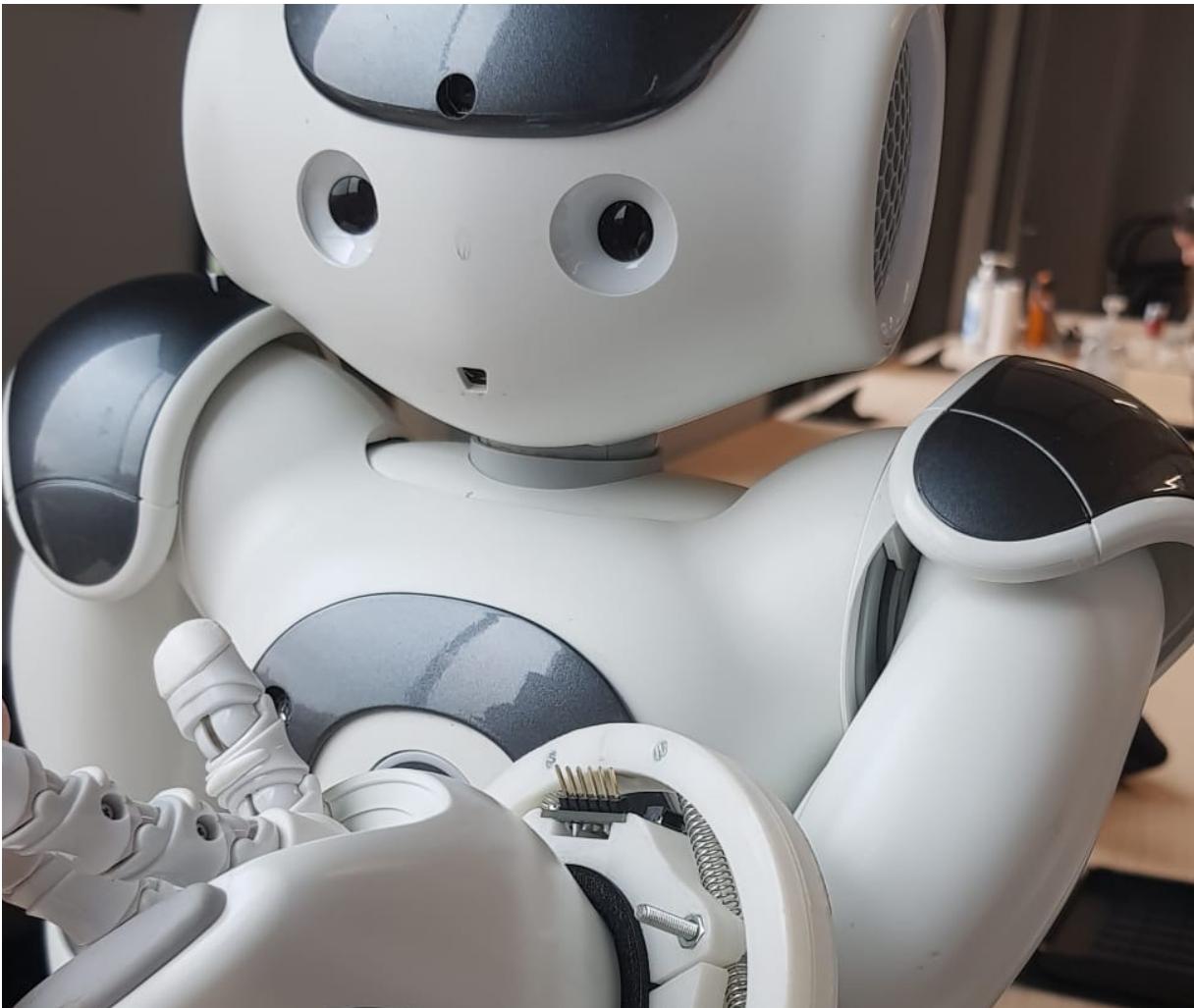
13 antwoorden



(KRIS) How mentally demanding was the task?

13 antwoorden





## SUCCESS METRICS

- Usable during operation
- Intuitiveness
- Precision
- Low-mental load

# PART 4

DEMONSTRATION AND FINAL THOUGHTS



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ROBOT INTERACTION