Workshop Unit 8
Teleoperation and Data Collection

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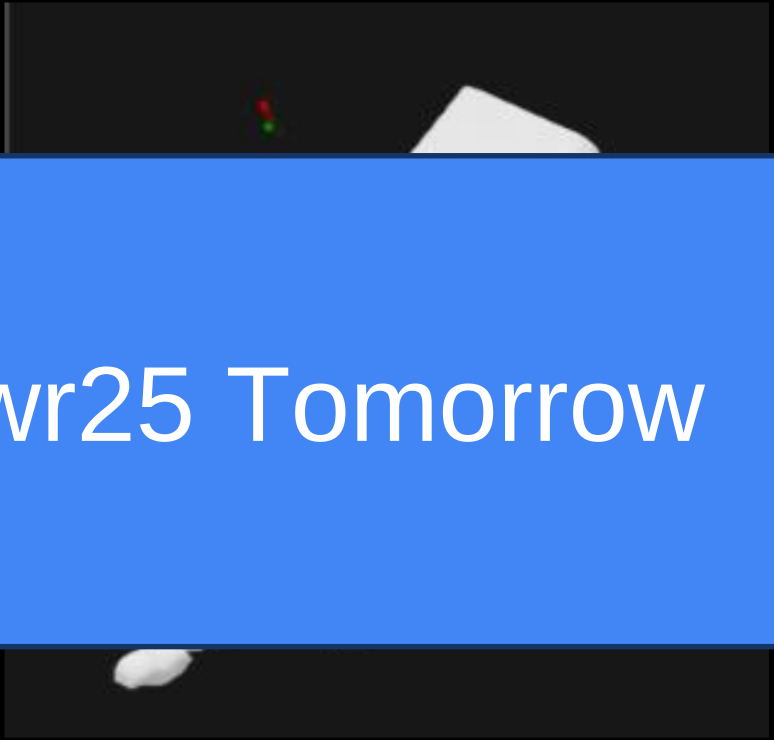
3 November 2024

Well done on Task 1!

- Regarding the command
  - The current code flips the command every five seconds. You can give the command however you like.



Updates to the faive_system/rwr25 Tomorrow

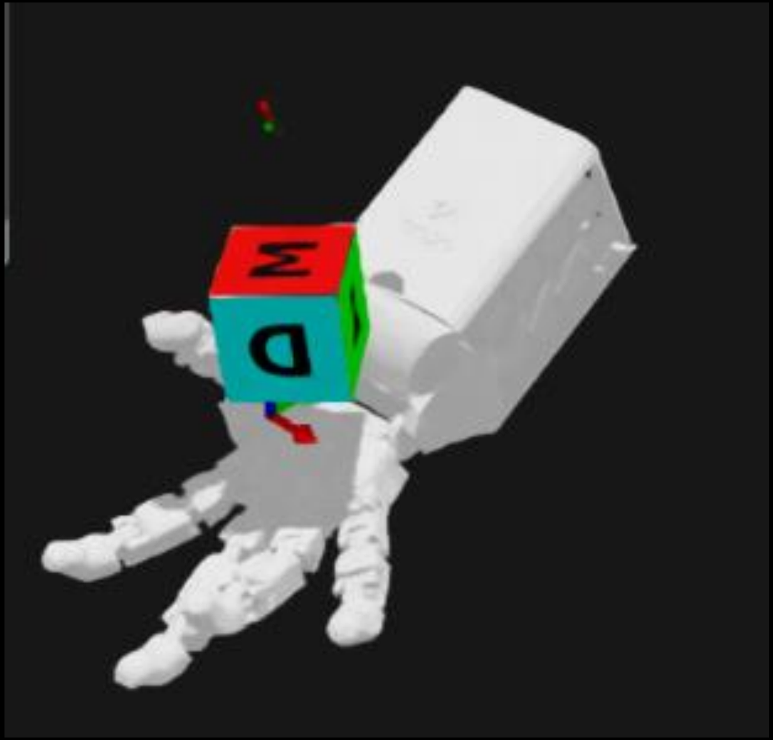
Task 1 show case day

- Each team make a short presentation
- Subtask 1:
  - 3 min slides
  - 5 runs x 1 min.
- Subtask 2:
  - 3 min slides
  - 5 runs x 1 min.

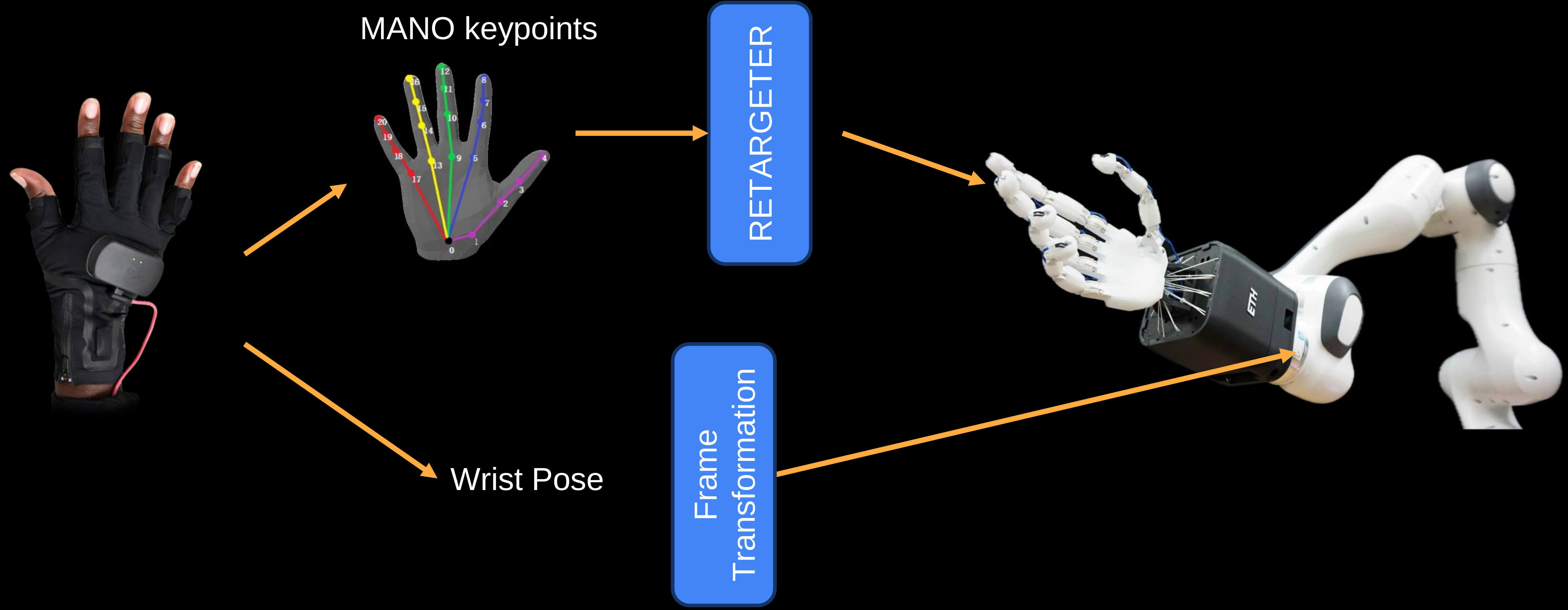
- Videos are recorded and post processed for grading.
- Timer doesn’t stop when cube is dropped.

- The orders of 6 teams will be randomized at the day.

- When one team is presenting, the other team setup the hand



Overview



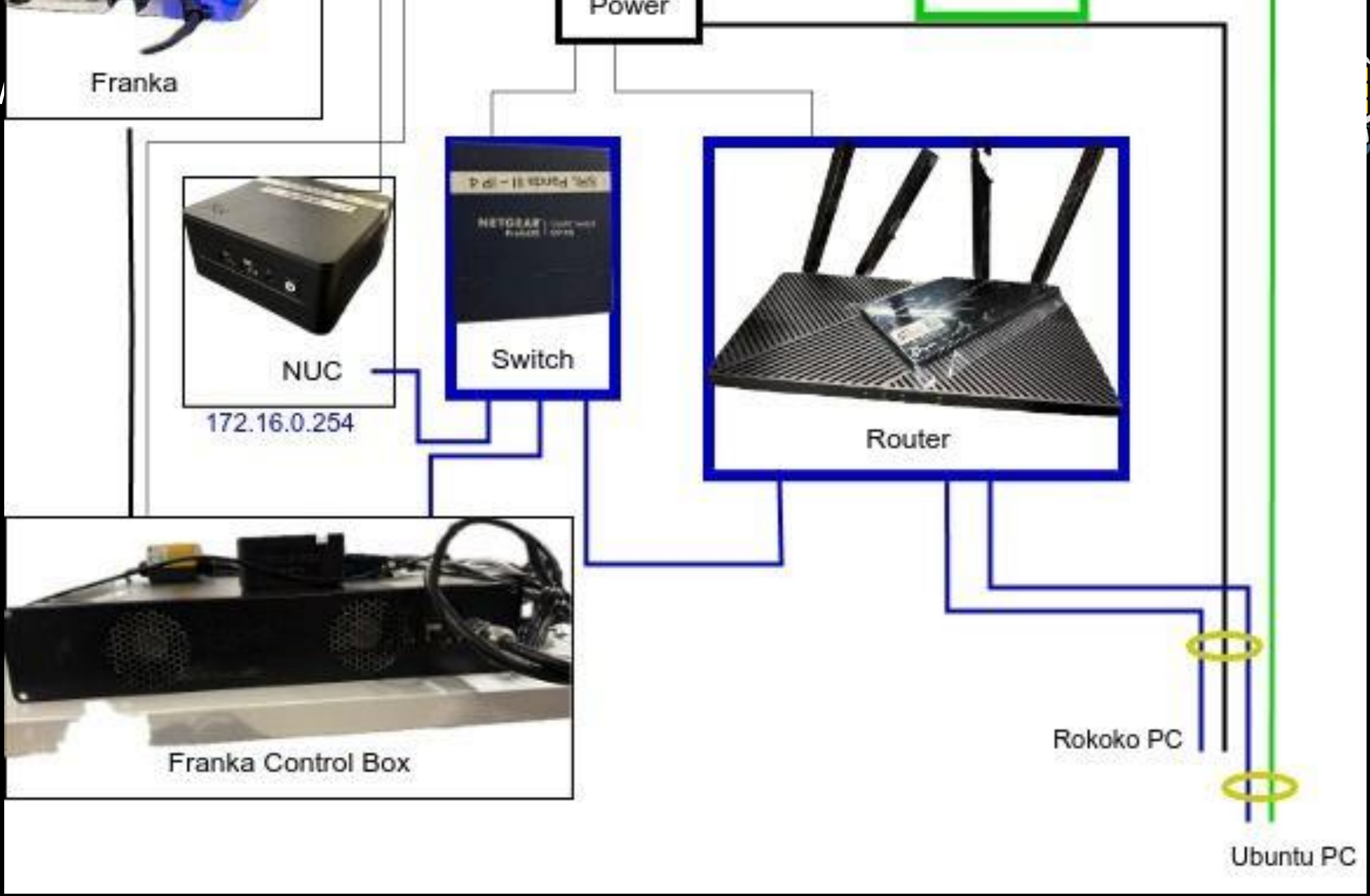
MANO keypoints

RETARGETER

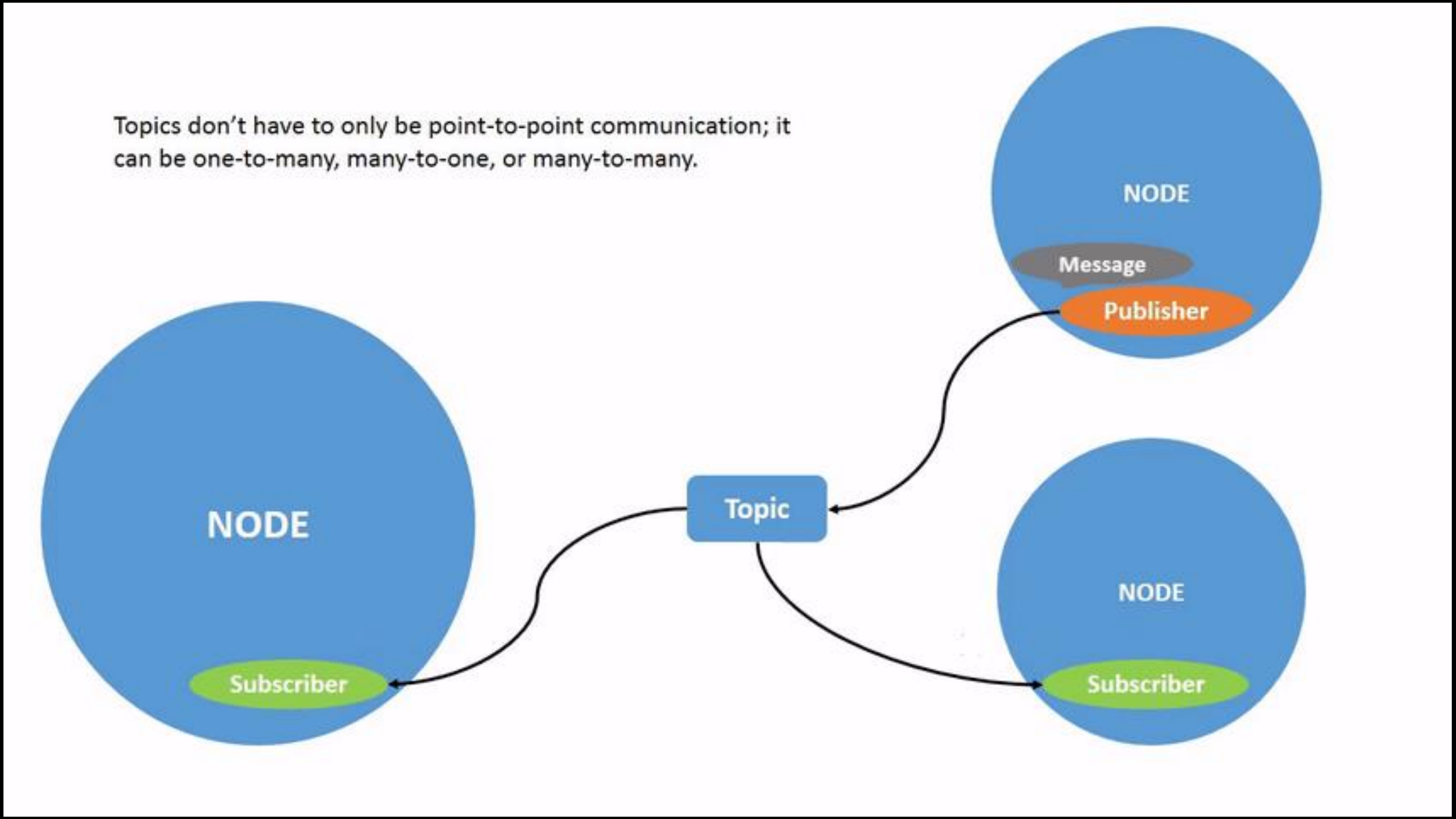
Wrist Pose

Frame Transformation

Hardware of the rw



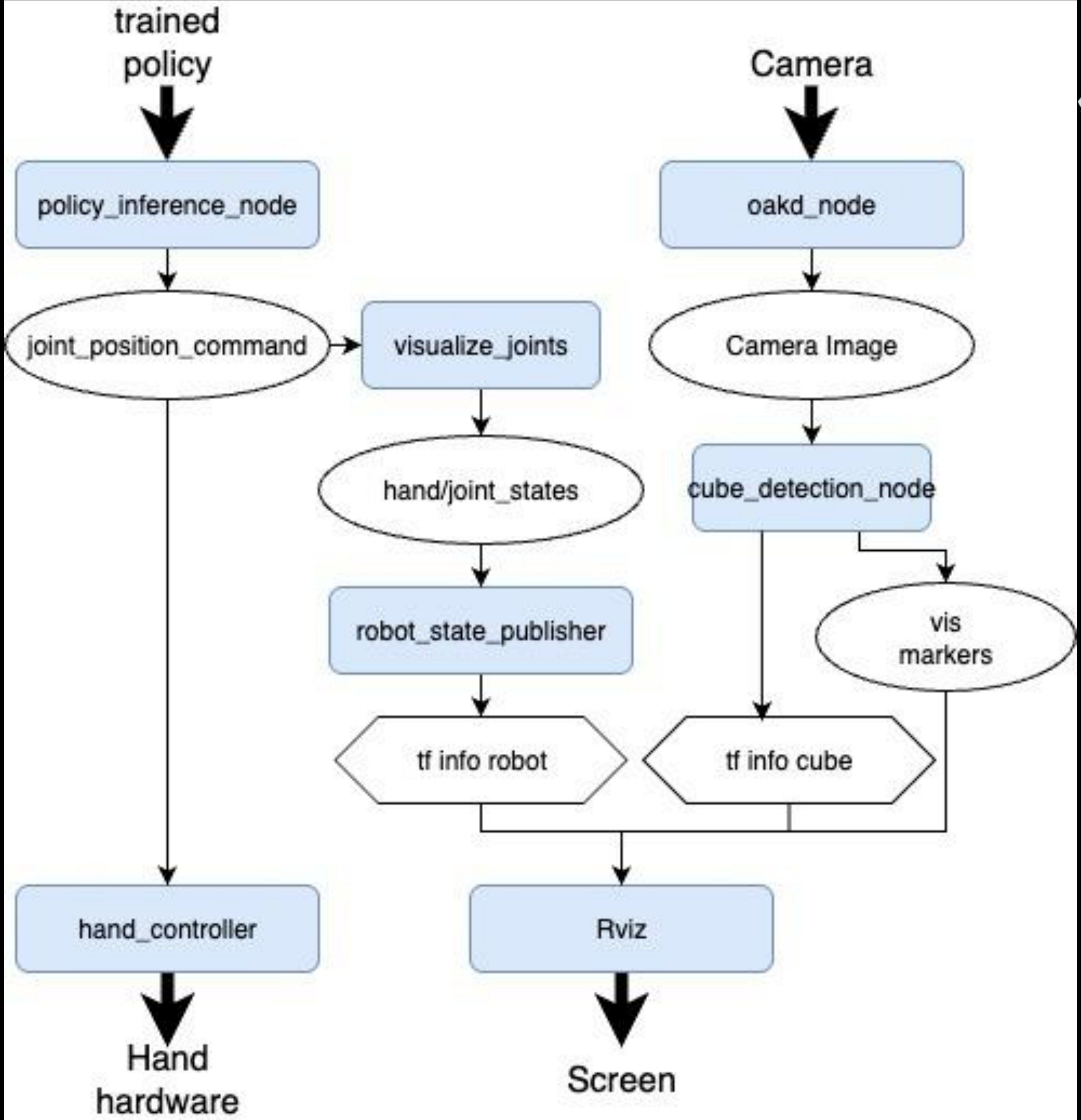
Teleoperation : ROS



Topics don’t have to only be point-to-point communication; it can be one-to-many, many-to-one, or many-to-many.

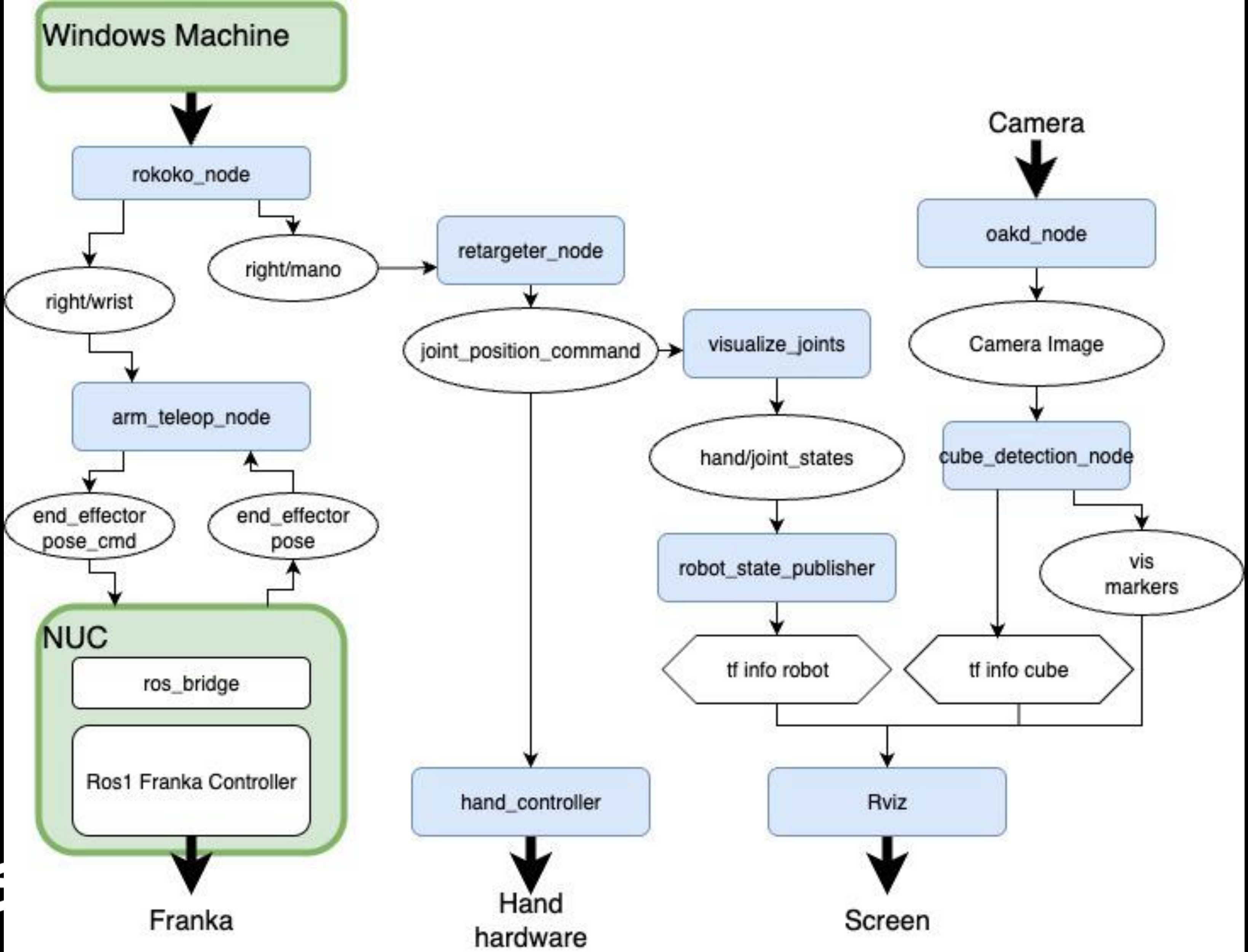
Software of rwr system

The stack when we run task 1



Software of rwr system

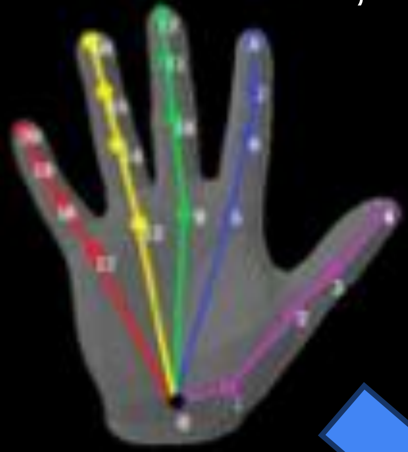
Task2 Teleop



Demo 1 : Streaming Data with the Rokoko Glove + Coil

Retargeting

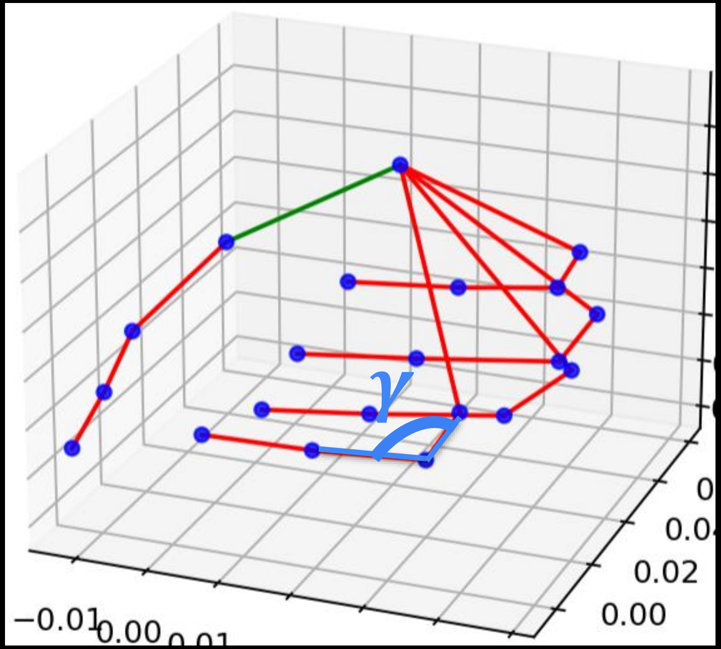
Dimension : 21,



Dimension : ??

Option 1 : “The Naiive”

- Directly take the joint angles from the 3D keypoints
- Transfer 1-to-1 to the robot hand



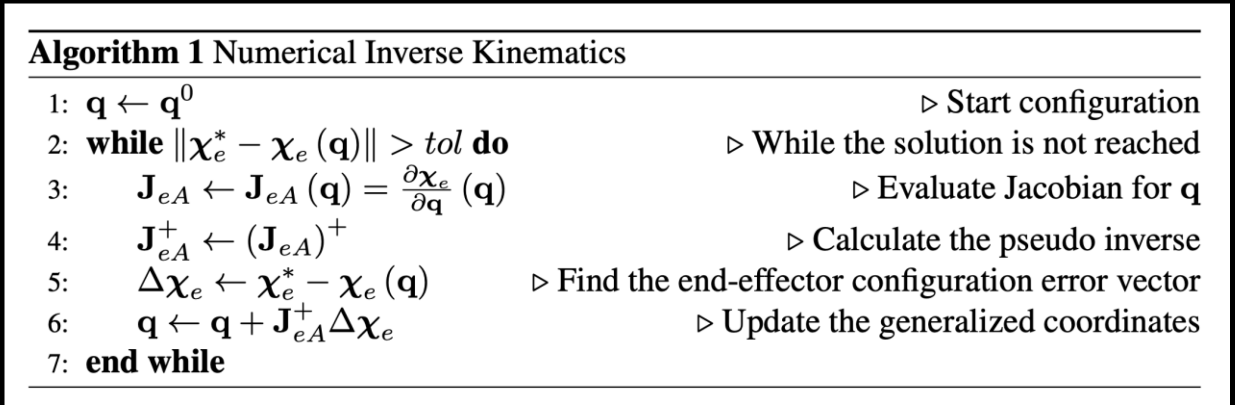
PRO

- Easy and straightforward
- Can be useful to quickly test the rom of the joints

CONS

- Not applicable for non-human robot hands
- Fingertips will most likely be not in the wanted spot

Option 2 : “The Roboticist”



```
Algorithm 1 Numerical Inverse Kinematics
q ← $\mathbf{q}^0$                                              ▷ Start configuration
while $\|\chi_e^* - \chi_e(\mathbf{q})\| > tol$ do              ▷ While the solution is not reached
    $\mathbf{J}_{eA} \leftarrow \mathbf{J}_{eA}(\mathbf{q}) = \frac{\partial \chi_e}{\partial \mathbf{q}}(\mathbf{q})$    ▷ Evaluate Jacobian for q
    $\mathbf{J}_{eA}^+ \leftarrow (\mathbf{J}_{eA})^+$          ▷ Calculate the pseudo inverse
    $\Delta\chi_e \leftarrow \chi_e^* - \chi_e(\mathbf{q})$     ▷ Find the end-effector configuration error vector
    $\mathbf{q} \leftarrow \mathbf{q} + \mathbf{J}_{eA}^+ \Delta\chi_e$    ▷ Update the generalized coordinates
end while
```

From Robot Dynamics Lectures link to notes

PRO

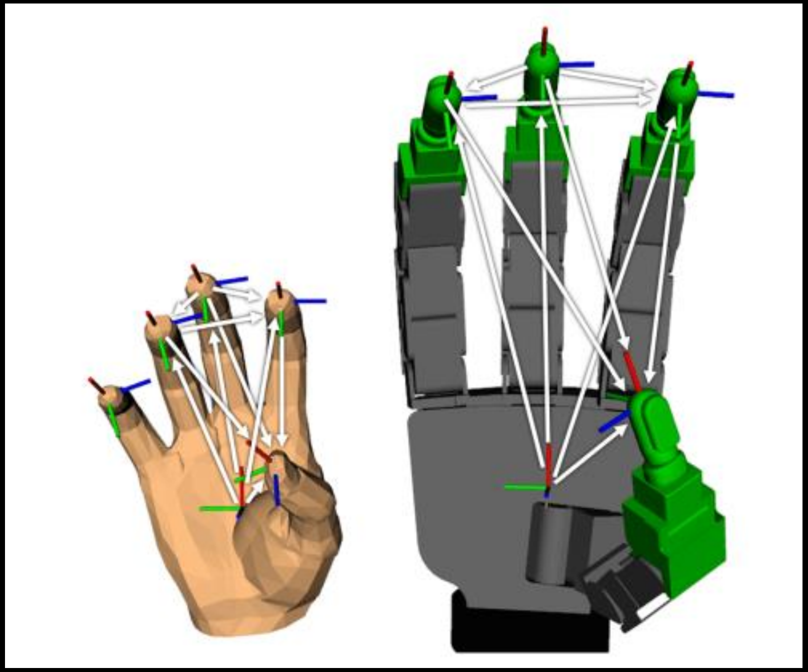
- Can be very fast (up to 80Hz)
- Accurate fingertip tracking

Set target pose to fingertip position, then solve numerically with Jacobian pseudo-inverse method

CONS

- Can fall into numerical instability quite easily

Option 3 : “The ML guy”



Robotic Telekinesis: Learning a Robotic Hand Imitator by Watching Humans on Youtube, 2022
arxive

- Define keyvectors on the robot and the human hand
- Define Loss function

Scaling coefficient

$$L(q) = \sum_{i=1}^{N} \left\| v_i^h - (c_i \cdot v_i^r) \right\|_2^2$$

Robot joint angles

Hand keyvector

Robot keyvector

- Minimize with gradient descent

PRO

- Can adapt to non-human designs
- Pretty stable

CONS

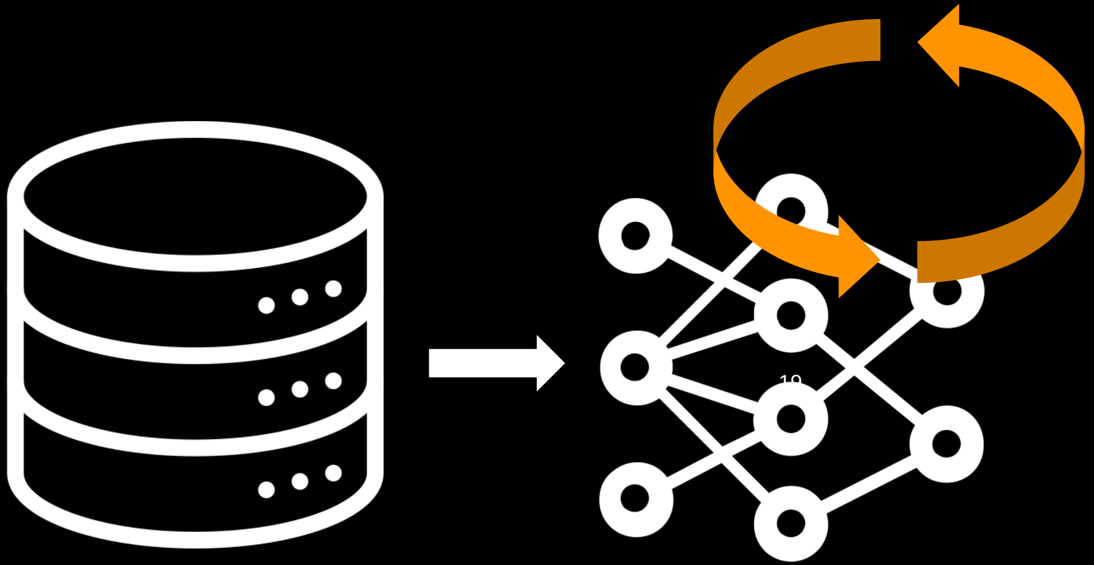
- Can be slow if not optimized
- Need tuning

Demo 2 : Retargeting

Data Collection

Imitation Learning

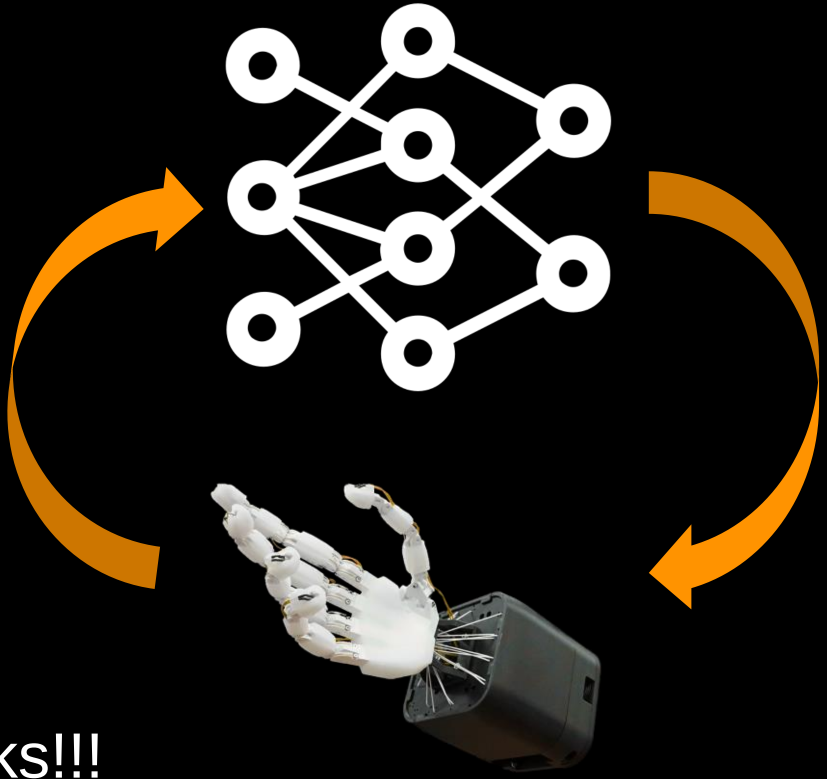
Learn from **expert demonstrations**



Dataset of demonstrations

Train Policy

Deploy on the robot hand



Dedicated workshops and lectures in the next 2 weeks!!!

Data Collection

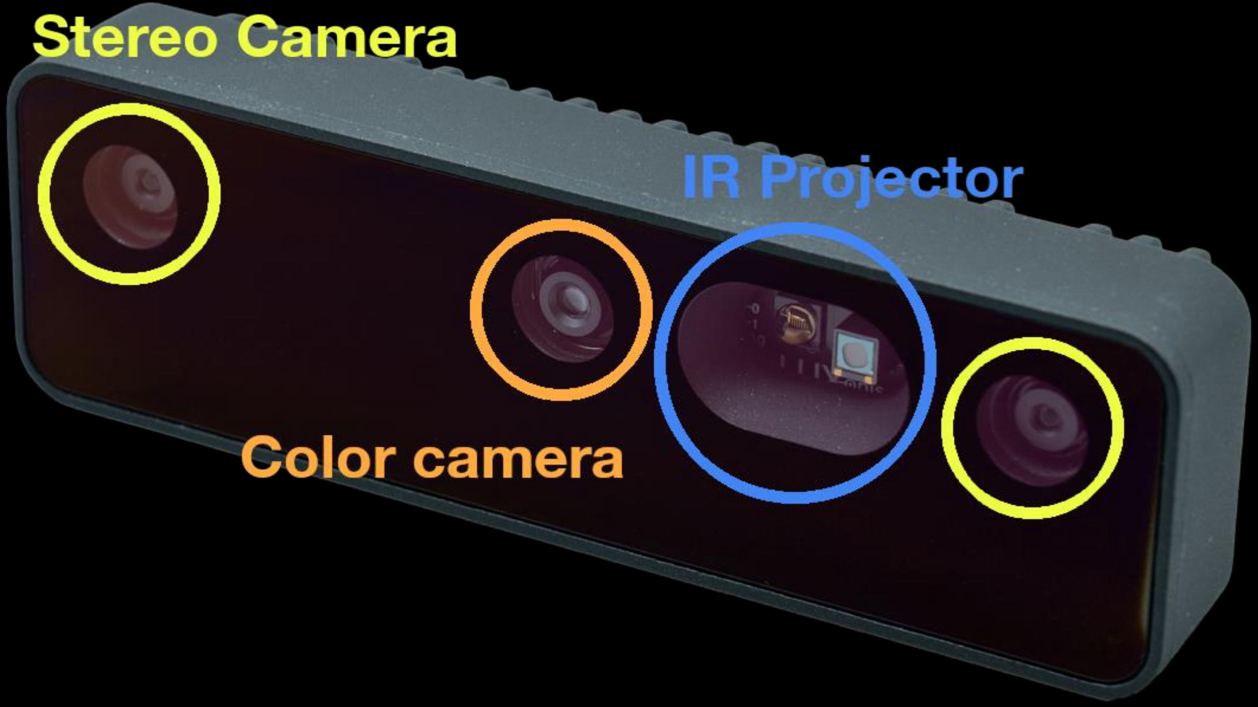
What do we need to record during a demonstration?

- RGB images (Egocentric (wirst), Exocentric (front, side))
- End Effector Pose
- Joint Commands

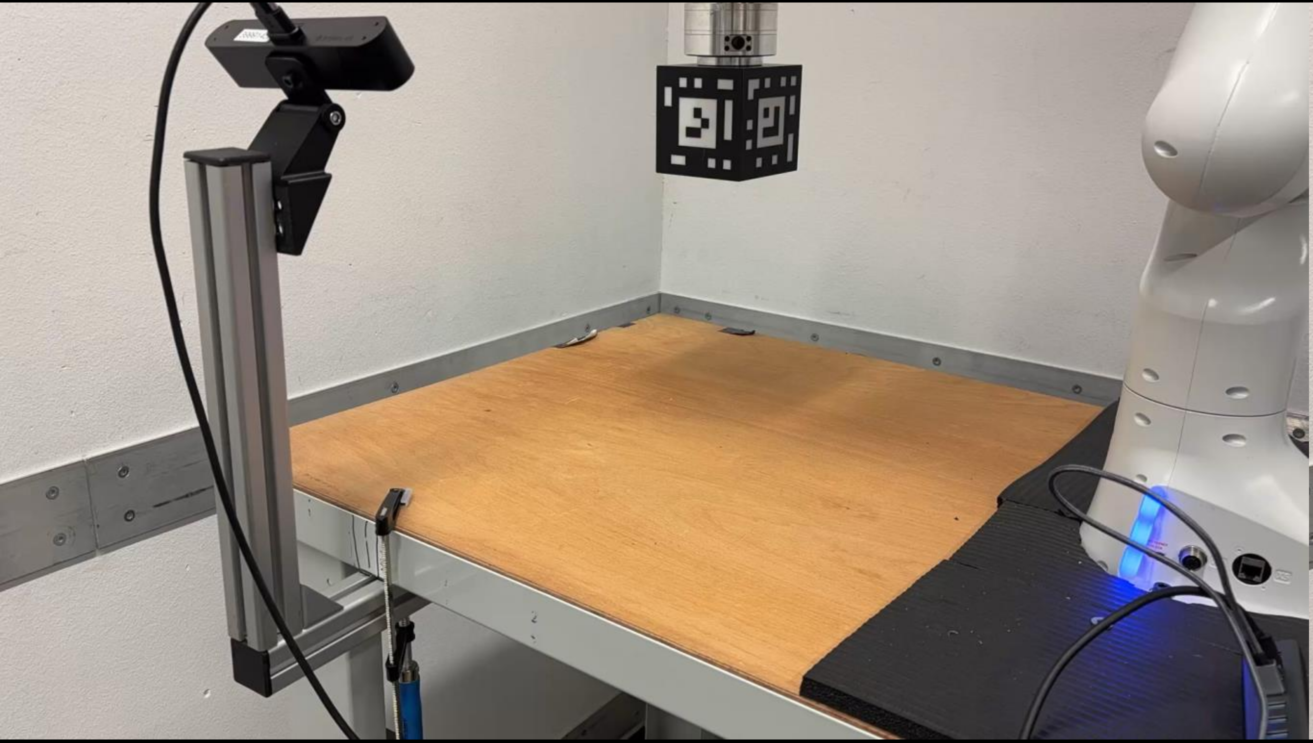
- ??? (Sensor inputs, pointclouds, explicit object tracking, depth, language commands, event annotations, ecc..)

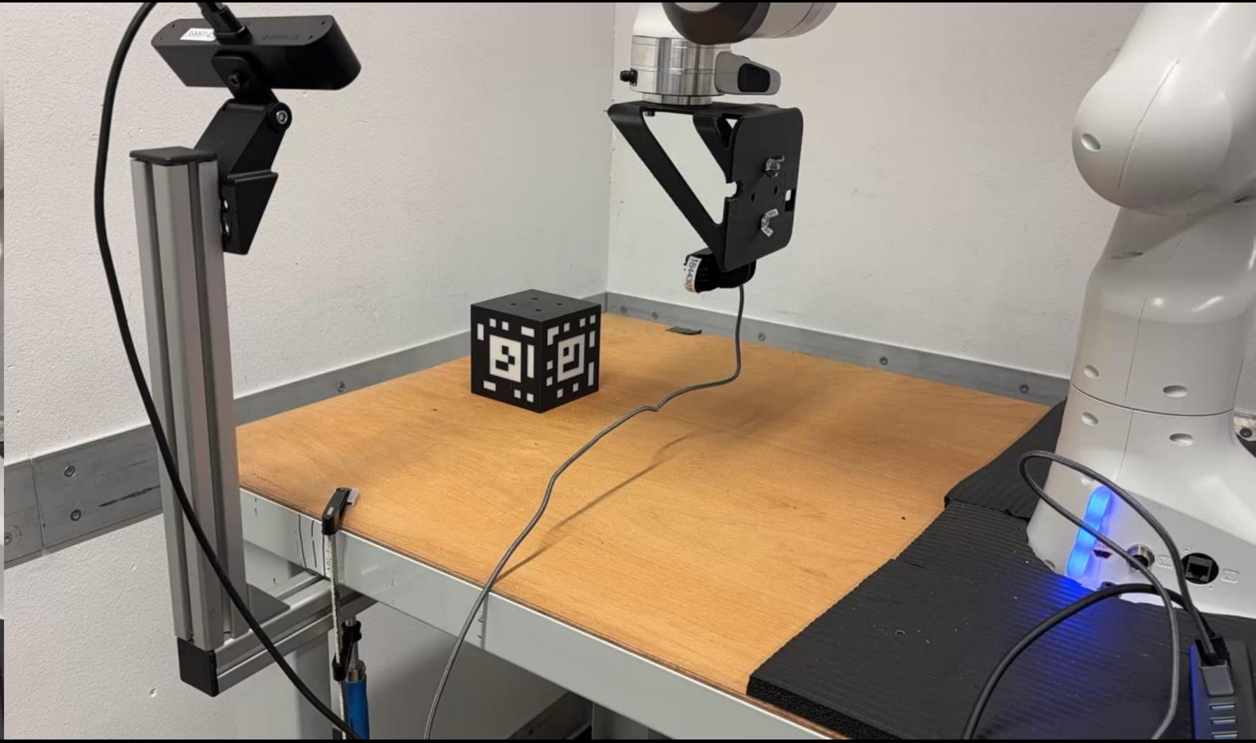
Data Collection

We will use OAKD cameras : Depth, RGB, Stereo



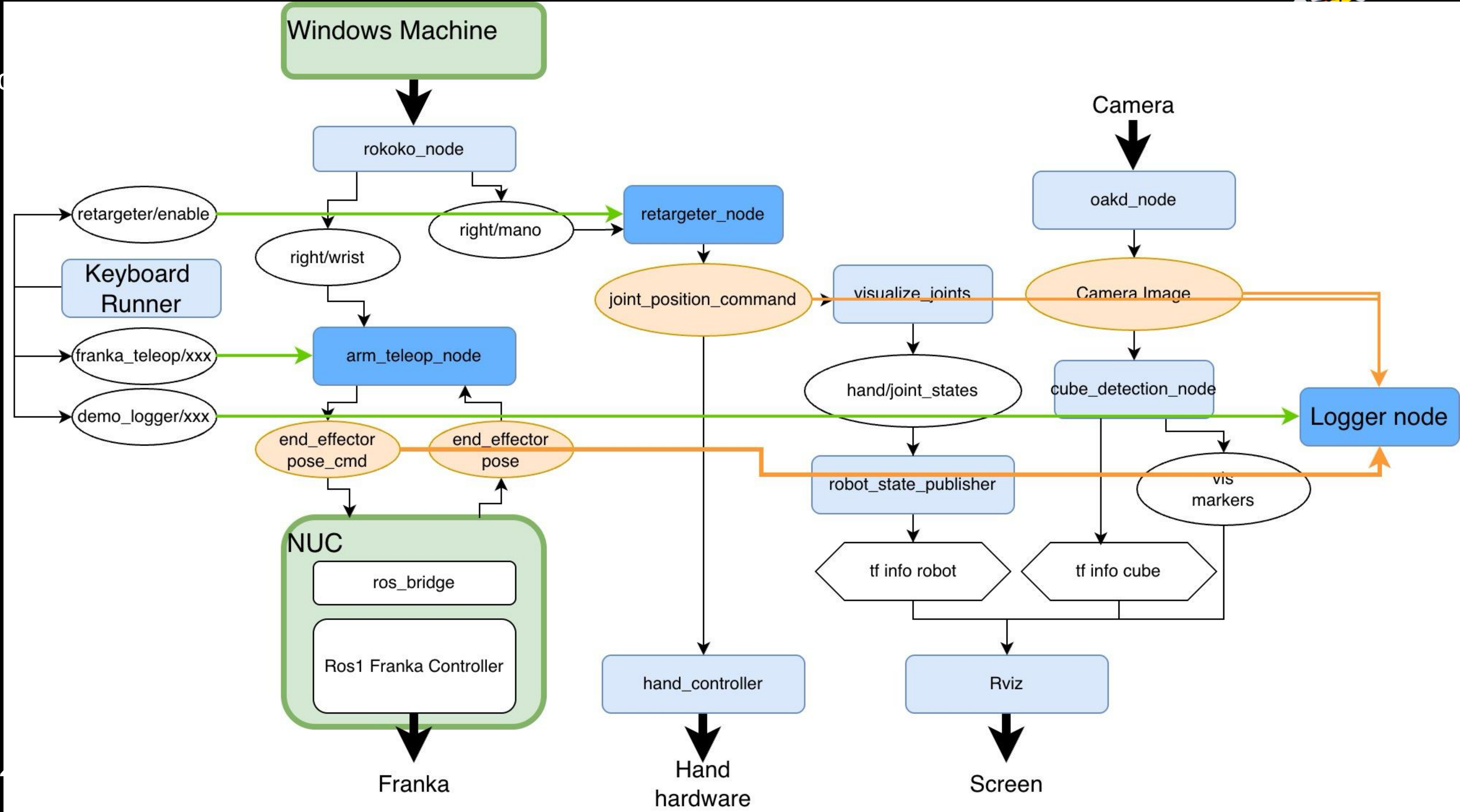
Camera calibration





Software of rwr system

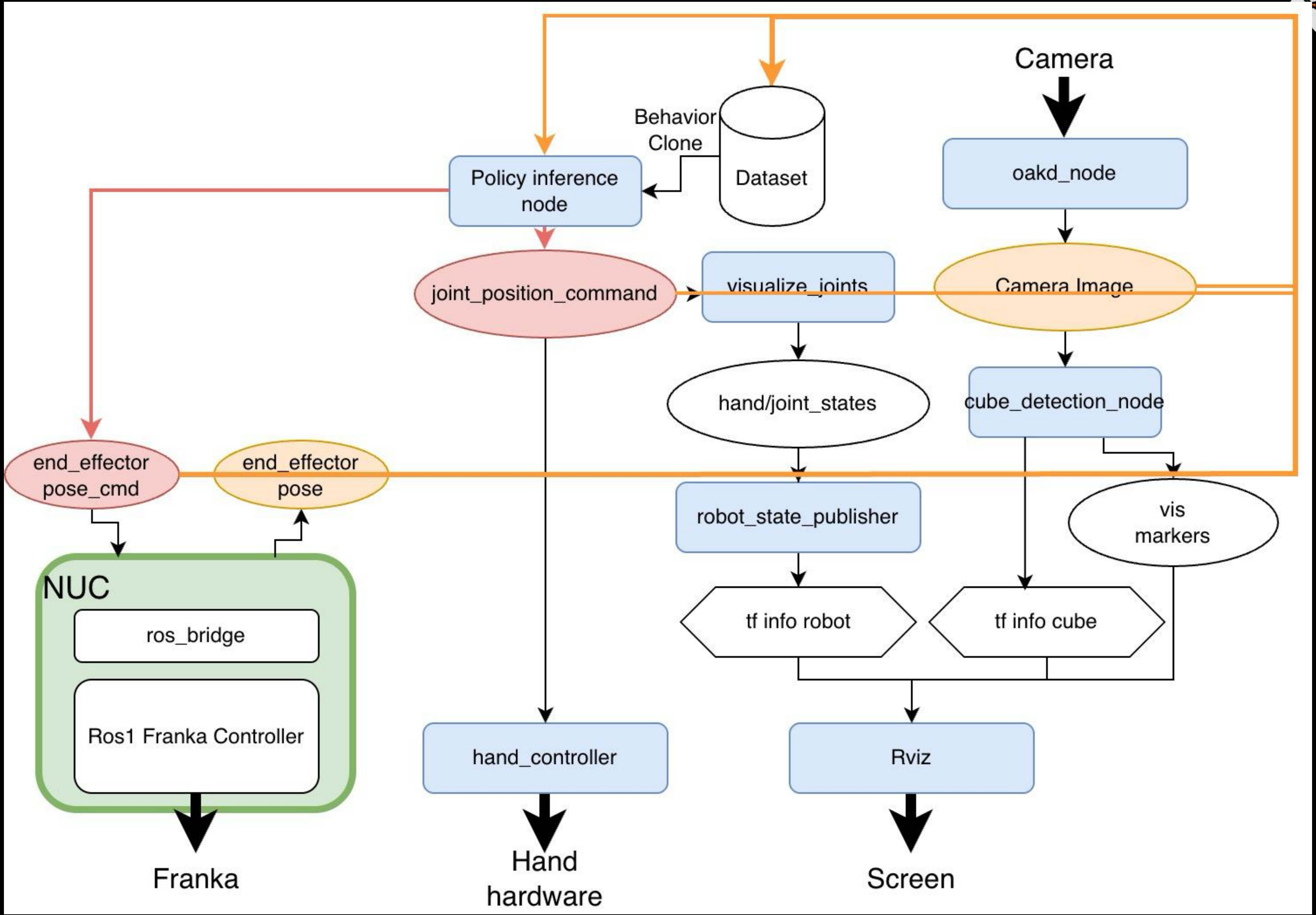
Data c



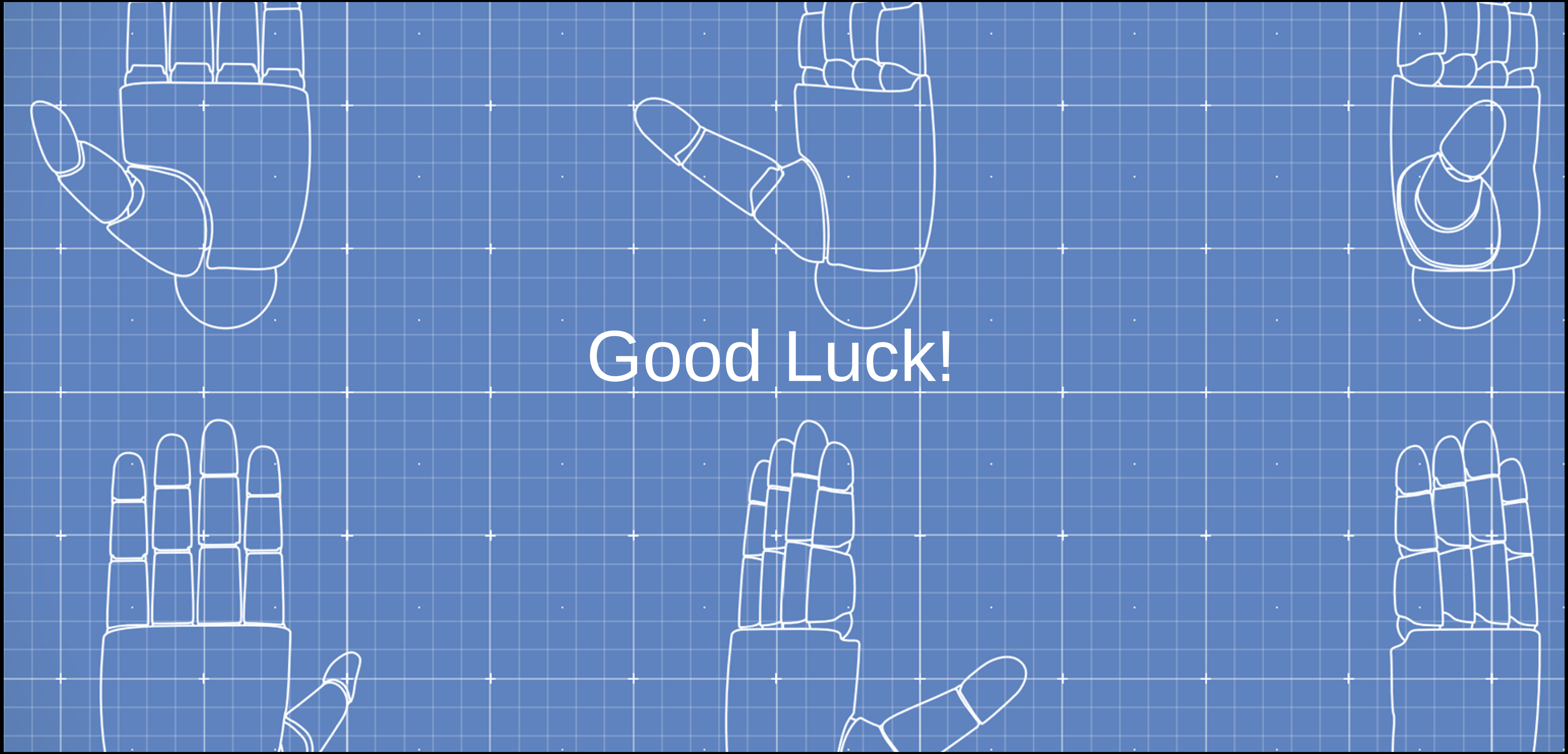
Demo 4: Data Collection

Software of rwr system

Policy Inference



Conclusion - Task overview



Good Luck!