ROBOT DESIGN FOR DEXTEROUS MANIPULATION

UNIVERSITÀ DEGLI STUDI DI GENOVA

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1. MOTIVATION

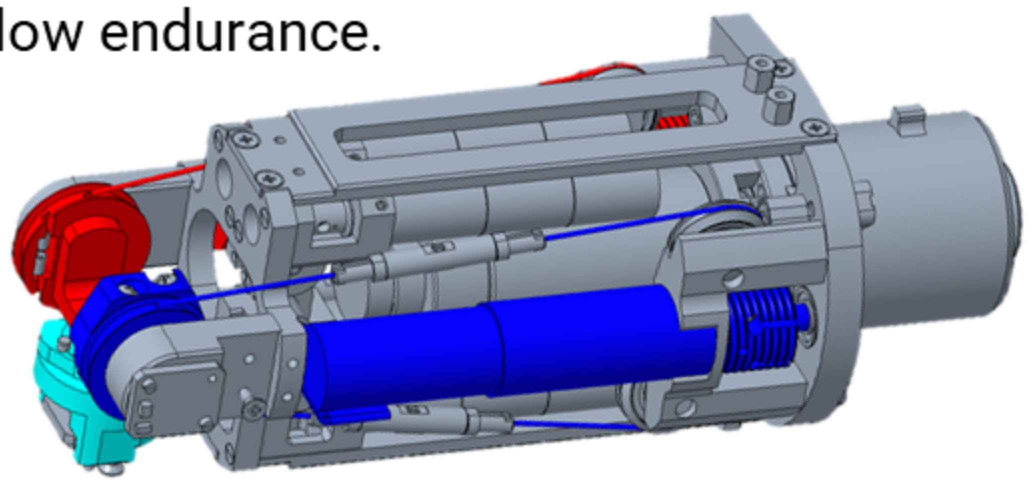
With the current trend in research being towards ***Human-Humanoid Interaction***, it becomes essential for the humanoids to match up to the dexterity of the humans. These skills contribute significantly in their capacities for feeling, exploring, learning, planning and subsequently acting.

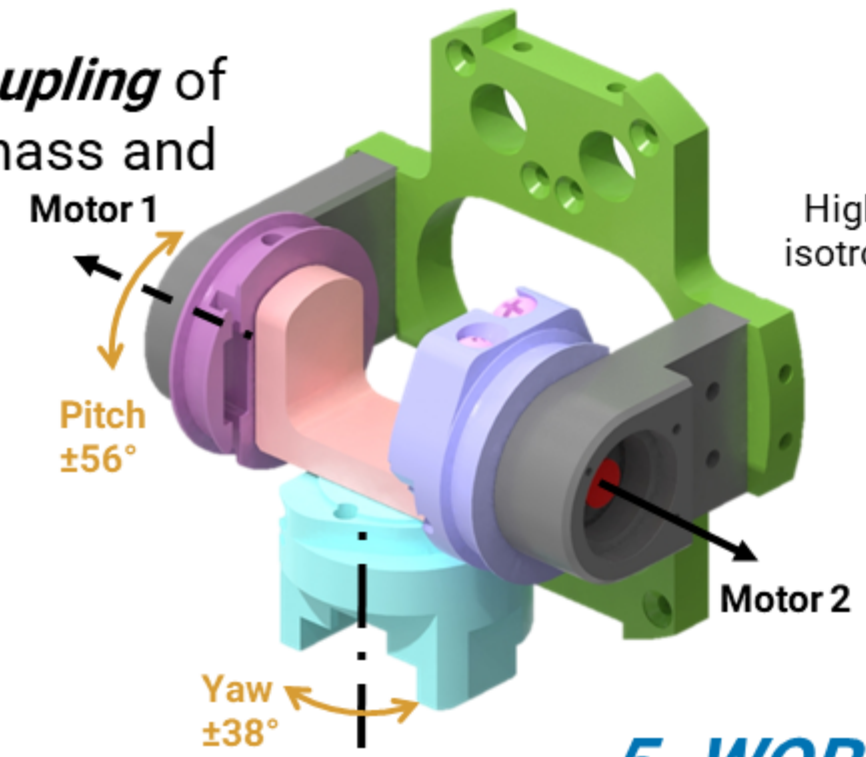
iCub Humanoid, developed at our facility, was designed explicitly to promote research for the same. And in this work, we focus on the enhancement of the ***dexterity*** considering the ***wrist sub-assembly.***

2. ICUB WRIST MK.2.5

The current wrist of the iCub mk. 2.5 is ***a 2-DOF tendon-driven*** coupled mechanism. The range of motion is limited to ***±56°*** for ***Pitch*** and to ***±38°*** for ***Yaw***.

Other concerned limitations include, ***partial coupling*** of motions, ***higher inertial loads*** due to moving mass and low endurance.





3. DESIRED WRIST CHARACTERISTICS

01 Larger Range of Motion
At least over ±45° for both DOFs, ideally ±90°.

02 Regular Workspace
Higher and consistent mechanism isotropy throughout the workspace.

03 Simpler Kinematics
Easy to model and control.

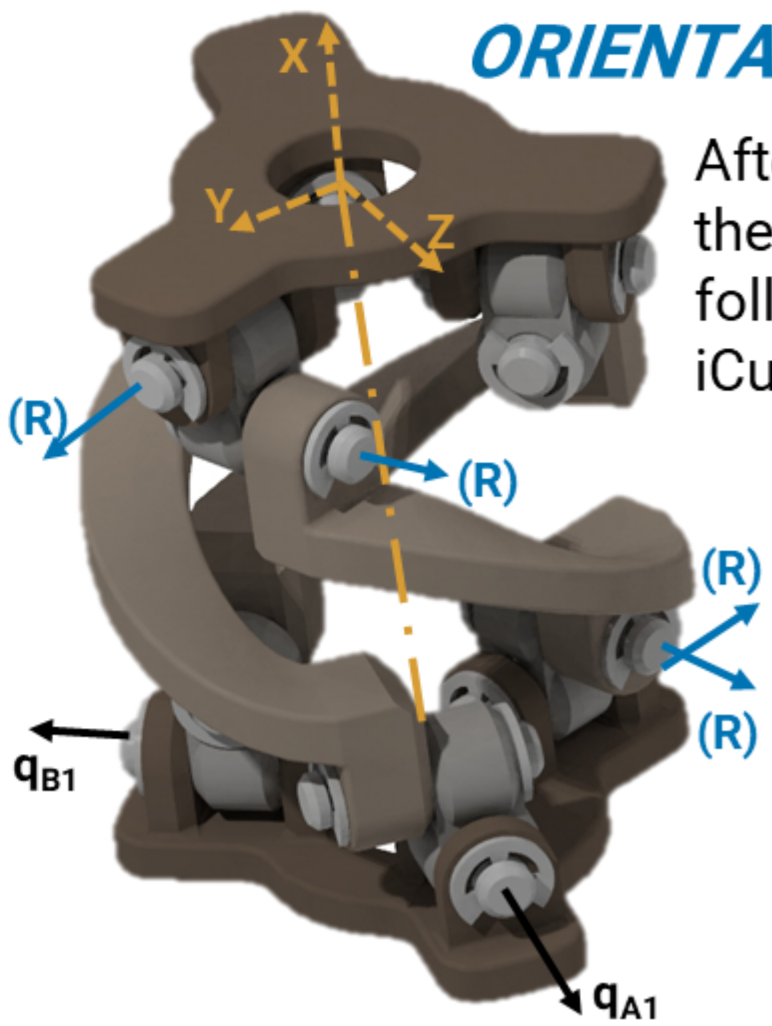
04 Compact Design
To be integrated within the existing forearm assembly.

05 Full Decoupling
Independent Yaw and Pitch motions.

06 Higher Payload-to-Weight Ratio
Increasing the payload capacity, or decreasing the motive power.

Basically, we need a parallel kinematic architecture to emulate the mechanism behaviour of a serial gimbal.

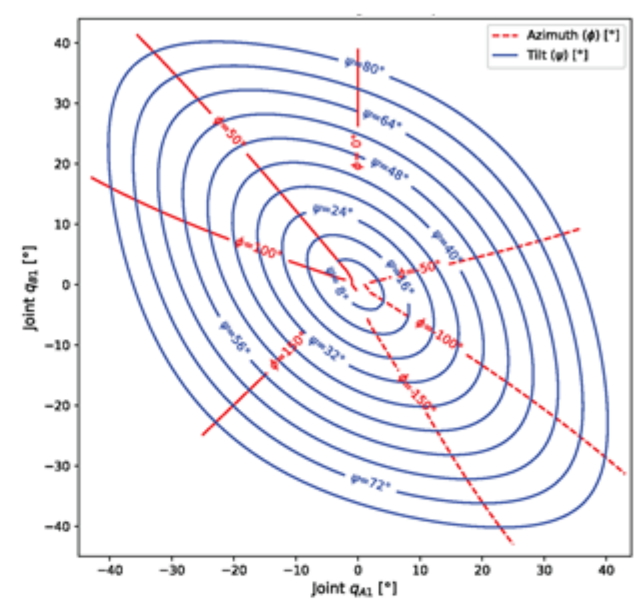
4. PROPOSED 2-DOF PARALLEL ORIENTATIONAL MECHANISM (2D-POM)



After a comparative study of the state-of-the-art of parallel mechanisms **[1]**, the following candidate is proposed for the iCub mk.3 wrist mechanism:

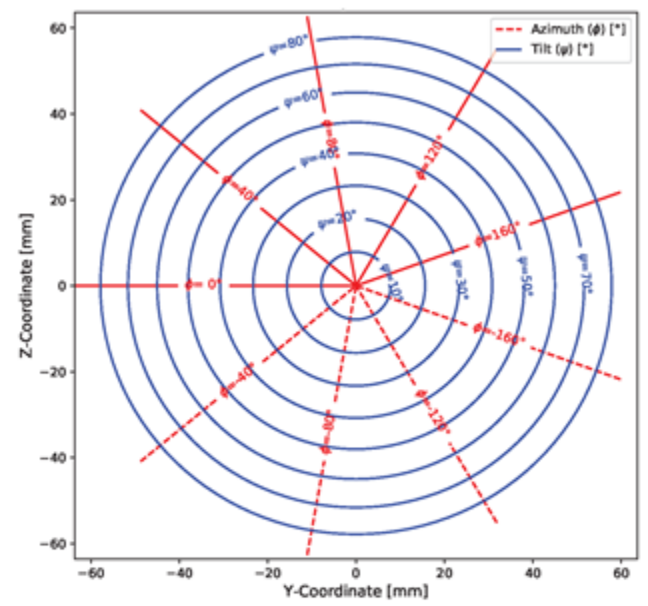
2-DOF Parallel Orientational Mechanism (2D-POM).
It comprises of 3 identical legs each containing a chain of 4 revolute (R) joints. It has ***zero-torsion*** and emulates the pure rolling contact motion of two spheres, thus generating a ***hemispherical workspace***.

5. WORKSPACE ANALYSIS



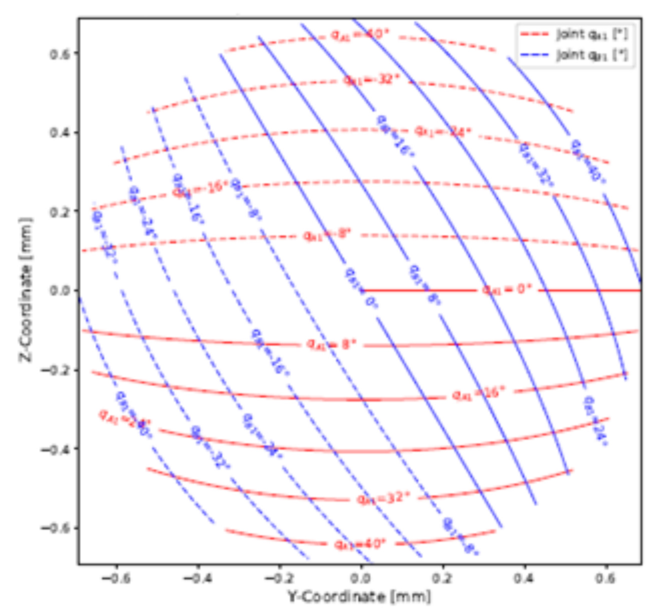
Orientation angles w.r.t. Joint Coordinates

- Input to Output Mapping
- Double amplification
- Control complexity



Orientation angles w.r.t. Cartesian Coordinates

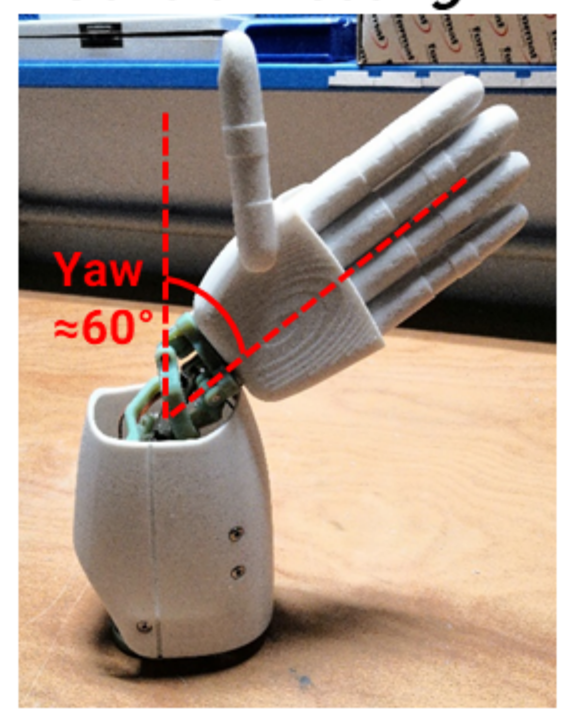
- Uniform workspace
- Full tilt, all around the axis of symmetry



Joint Coordinates w.r.t. Normalized Cartesian Coordinates

- Inverse kinematic mapping
- Fairly regular behaviour

Next Steps:
- ***Prototyping***
- ***Actuation Design***
- ***Control Testing***



[1] Shah *et. al.*, 'A Comparison of Robot Wrist Implementations for the iCub Humanoid', **MDPI Robotics** 2019, 8(1), 11

NEW WRIST = ⚠ Work in Progress...

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