# ROBOT DESIGN FOR DEXTEROUS MANIPULATION

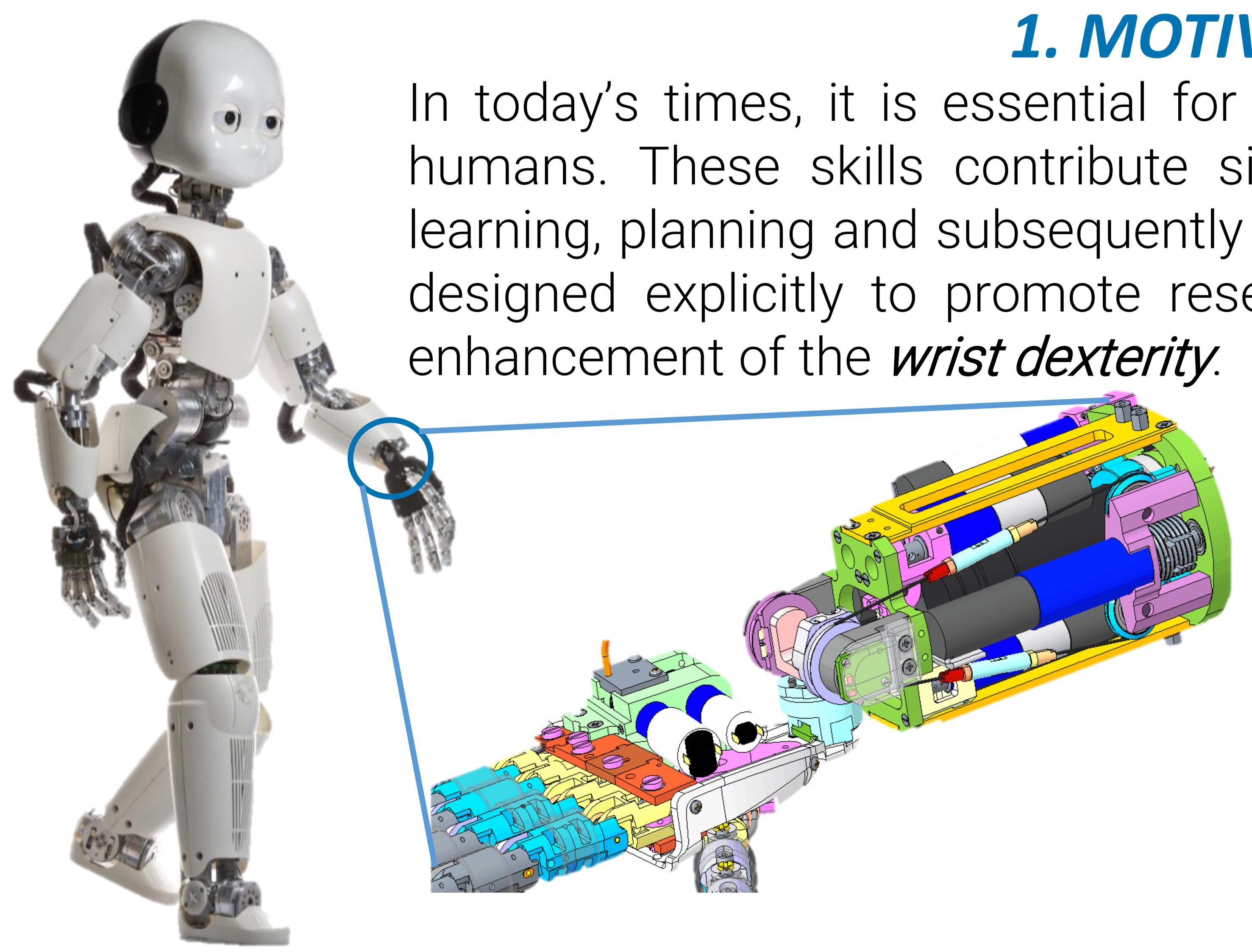
UNIVERSITÀ DEGLI STUDI DI GENOVA

**Divya SHAH** (PhD Student) ; **Giorgio METTA** (Vice Scientific Director) ; **Alberto PARMIGGIANI** (Technologist)

**iCub Facility**; **Istituto Italiano di Tecnologia,** Genova, ITALY

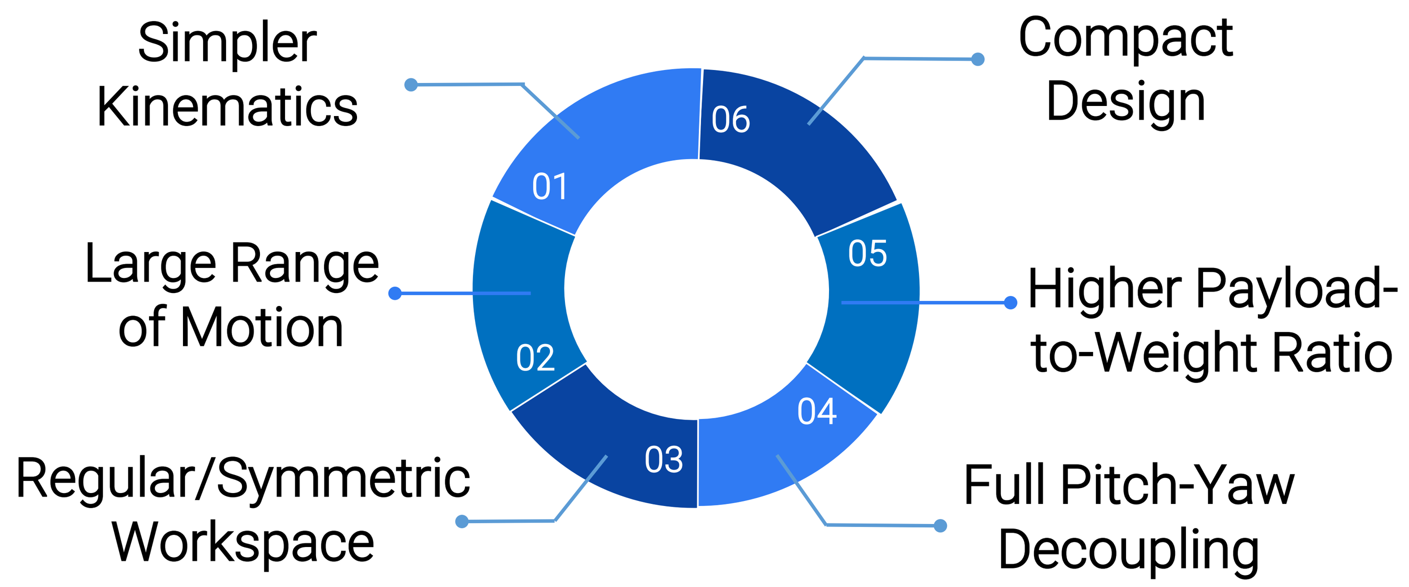
ISTITUTO ITALIANO DI TECNOLOGIA

## *1. MOTIVATION*



In today's times, it is 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. In this work, we focus on the enhancement of the *wrist dexterity*.

### DESIRED WRIST CHARACTERISTICS




## *2. CAD-BASED APPROACH*

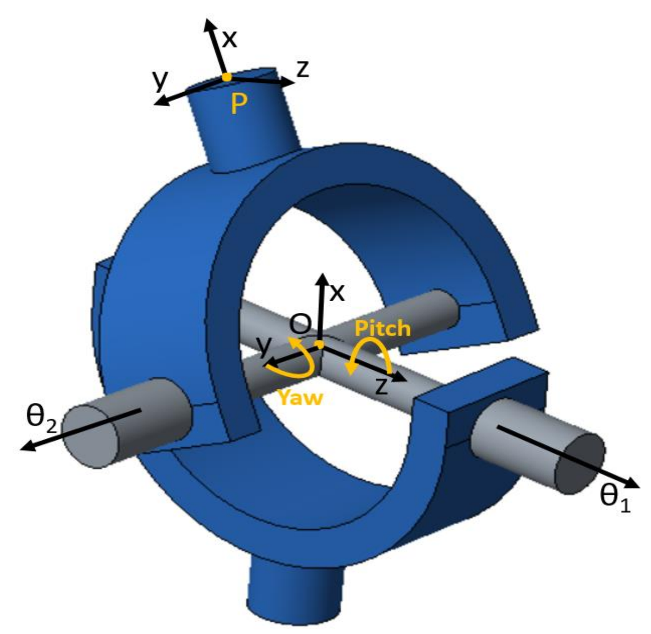
Spherical Parallel Mechanism → CAD Model of the architecture → Multibody Mechanism Simulation → Extract Workspace Measures → Contour Plots

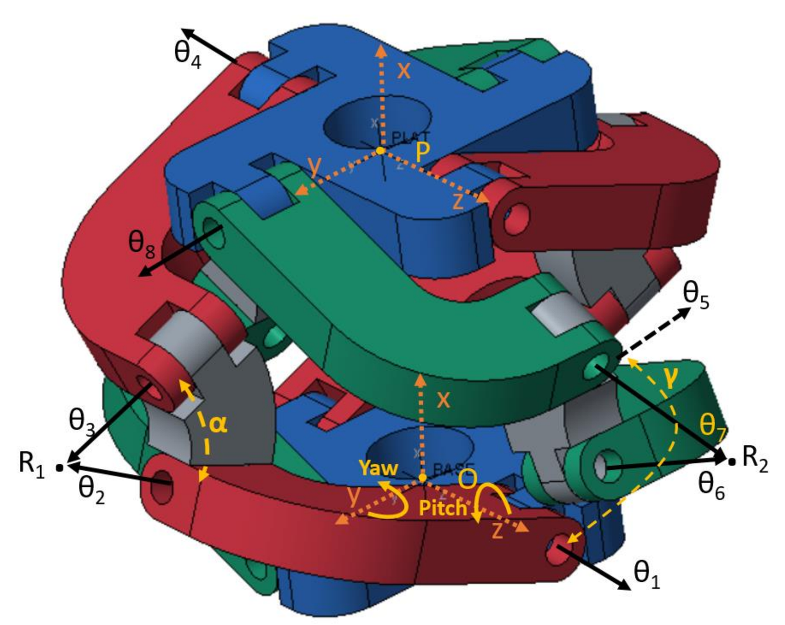
### MECHANISMS

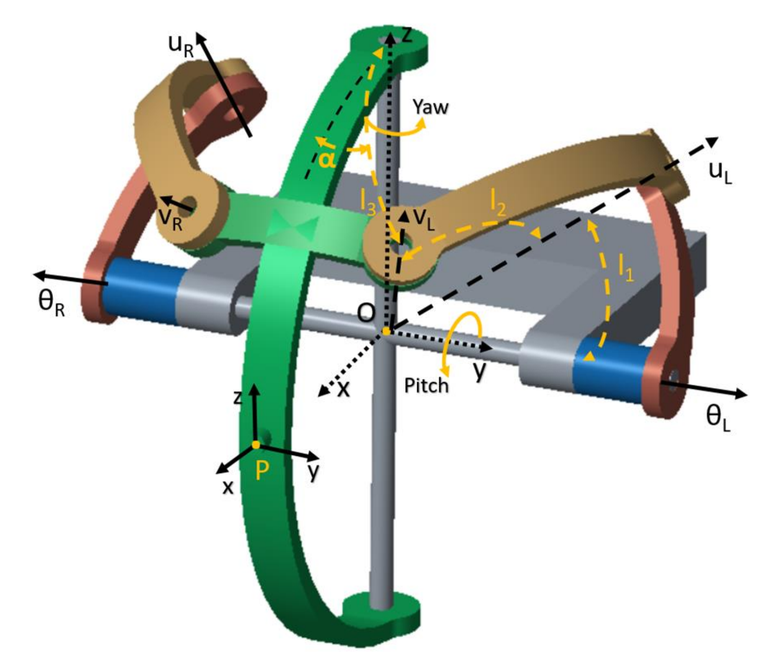
**1. 2DOF Gimbal Mechanism**
Serial mechanism with the desired behaviour. This is our point of reference.

**2. 4-UU Mechanism**
4 identical limbs with mirror-symmetric architecture of RRRR chains.

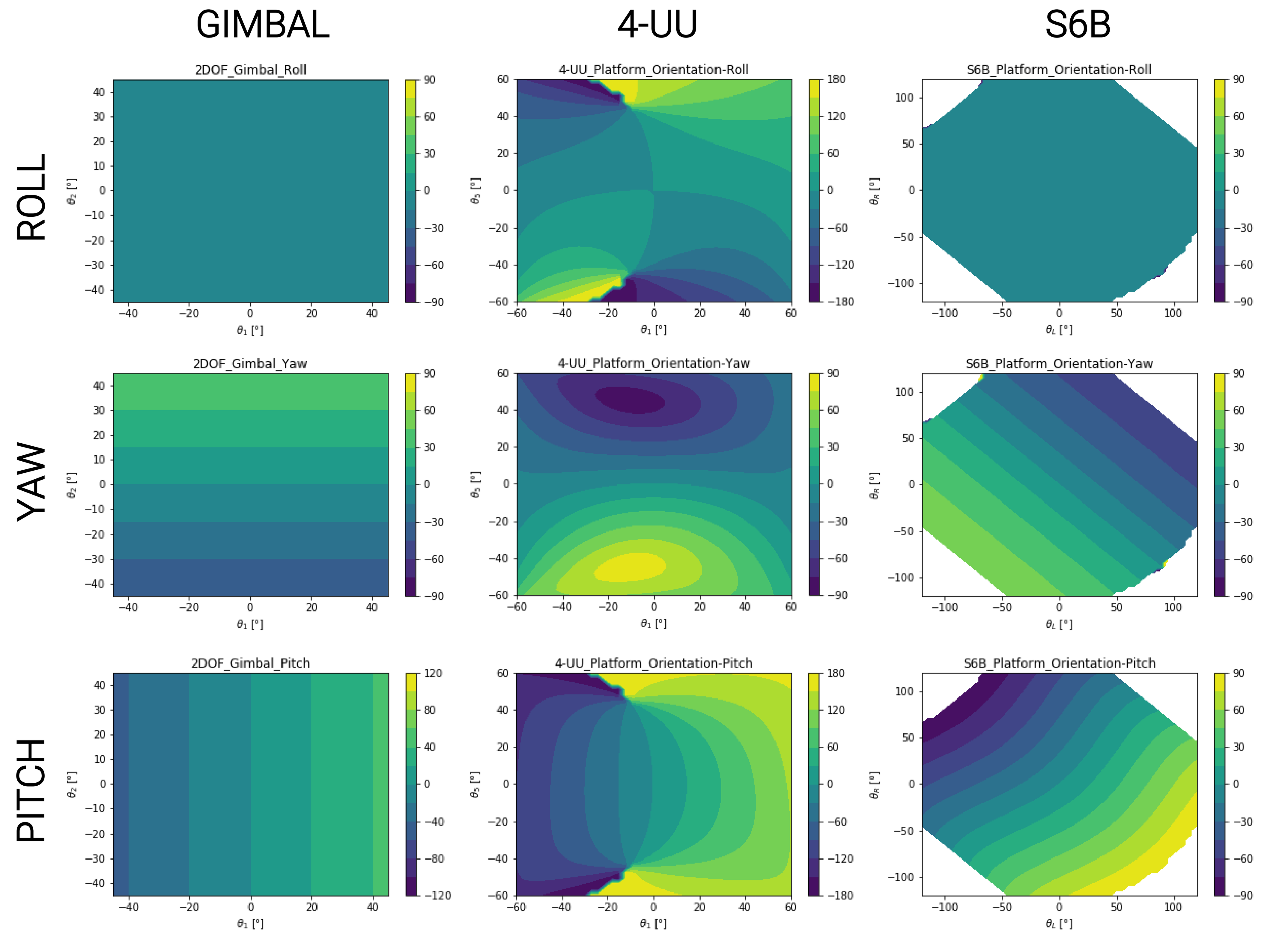
**3. Spherical Six-Bar Mechanism**
Six spherical linkages connected by *R* joints with a central gimbal.



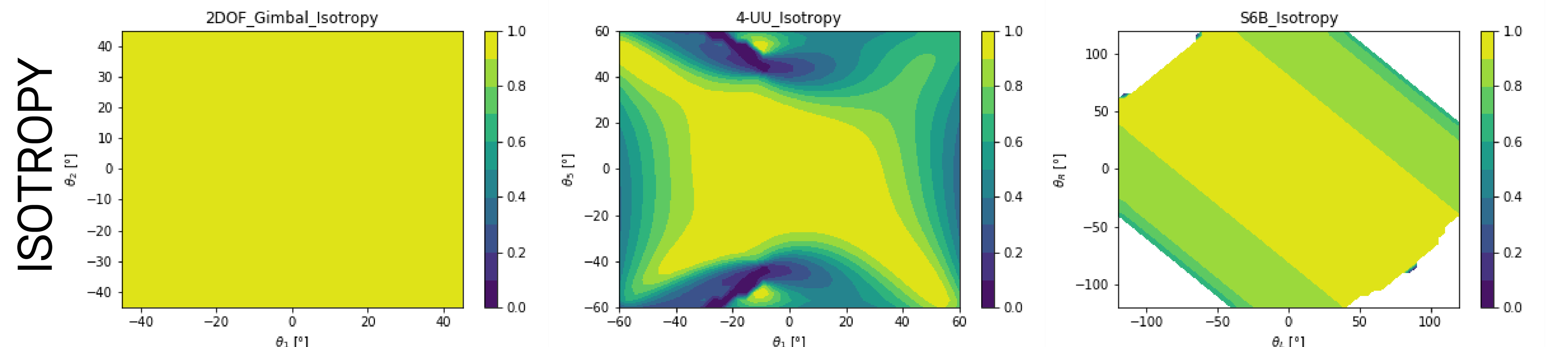

## *3. ORIENTATION WORKSPACE ANALYSIS*




## *4. ISOTROPY ANALYSIS*

The mechanism isotropy is defined as follows; where 'J' are the Jacobian matrices computed numerically from the simulation data and '*m*' is the order of the task space:

$$\Delta = \frac{M}{\Psi} = \frac{\sqrt[m]{det(\mathbf{JJ^T})}}{trace(\mathbf{JJ^T})/m} \qquad \mathbf{J} = \begin{bmatrix} \frac{\partial\theta_p}{\partial q_1} & \frac{\partial\theta_p}{\partial q_2} \\ \frac{\partial\theta_y}{\partial q_1} & \frac{\partial\theta_y}{\partial q_2} \end{bmatrix}$$




## *5. CONCLUSIONS*

**a) Warping in the Workspace:** Mechanism behaviours are not symmetric, i.e., the plots are not centered with absolute zero. Workspace diverges towards the extremes, as in case of 4-UU.

**b) Yaw-Pitch Coupling:** Unlike gimbal, pitch and yaw contours are not straight lines, i.e., the motions are coupled with each other and one input produces both outputs.

**c) Asymmetric Parasitic Roll Motion:** Platform posses undesired Roll motion in case of 4-UU, which becomes difficult to be compensated. Central gimbal prevents the same for S6B.

**d) Anisotropy:** Mechanisms are not fully isotropic throughout the workspace. S6B best with $\Delta \geq 0.9$ for significantly large section of the workspace.

**NEW WRIST = ⚠ Work in Progress …**

iit.it/people/divya-shah

divya.shah@iit.it

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