HELLO!

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IEEE/ASME AIM (Virtual), July 2020

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CONSTANT LENGTH TENDON ROUTING MECHANISM THROUGH AXIAL JOINT

IEEE/ASME AIM , Virtual, July 2020

I

INTRODUCTION

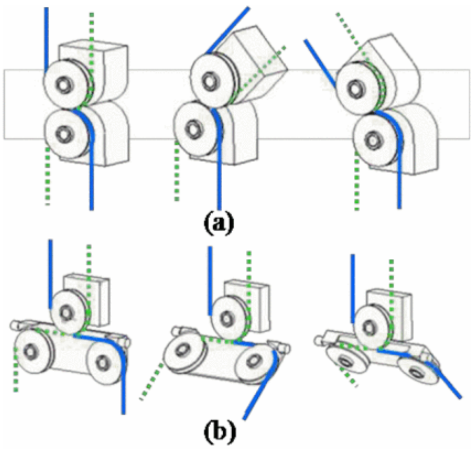
- Safe and Compatible
- Light-weight
- Backdrivability

- Actuator relocation & Tendon transmission

- Tendon Routings ??

BARETT TECHNOLOGIES
WHOLE ARM MANIPULATOR (WAM)

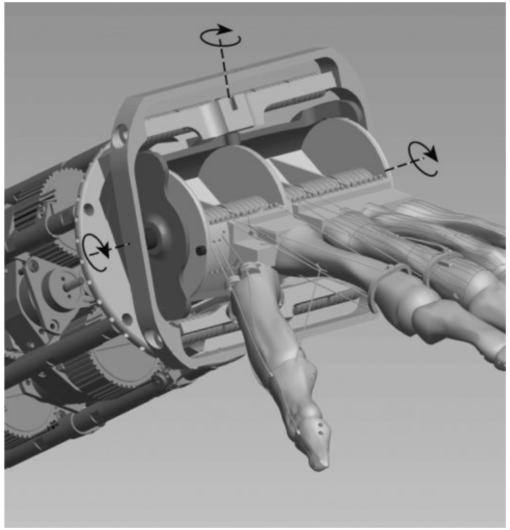
ROLLING CONTACT & OFFSET PIVOT



RoboRay Hand

KIM *et.al.*, ICRA 2014

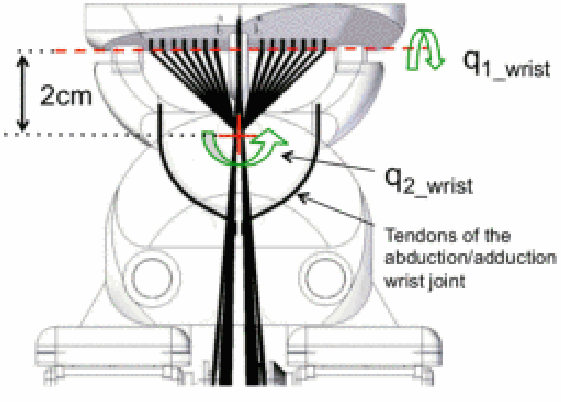
PAIR OF SHEAVES



ACT Hand

DESHPANDE *et.al.*, T-MECH 2011

PASSING AXIALLY



(c) Frontal view.

UB Hand - IV

SCARCIA *et.al.*, ROBIO 2015

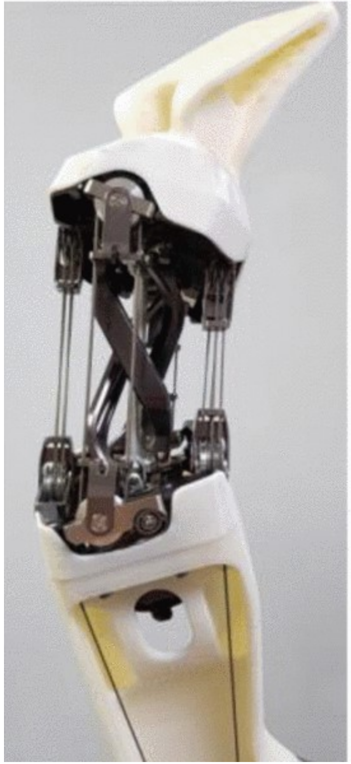
AXIAL JOINT ???

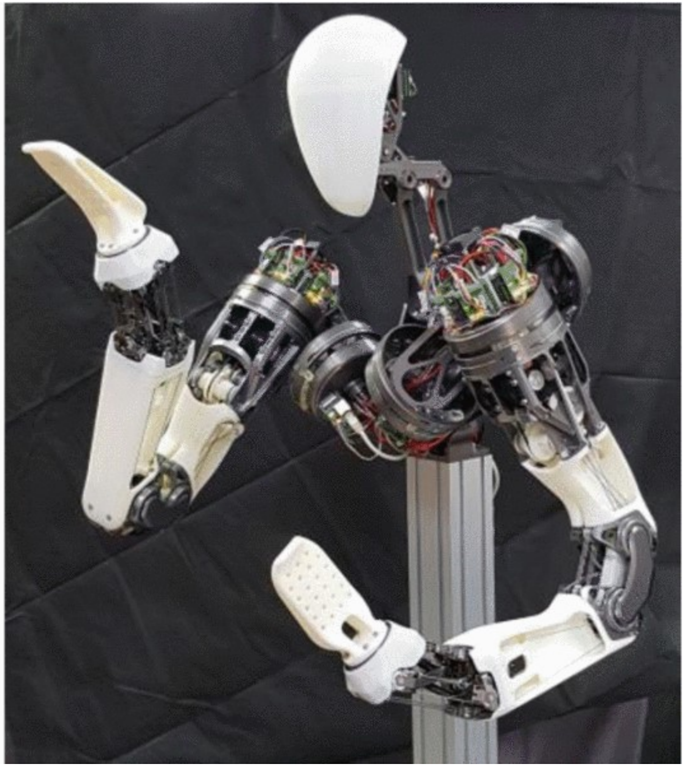
Tendon routing through axial joints is missing …

II

DESIGN CONSIDERATIONS

LIMS ARM

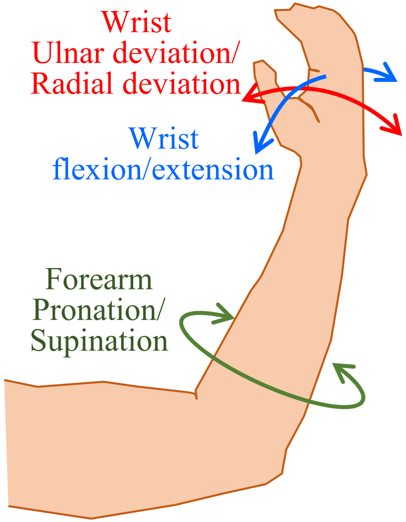




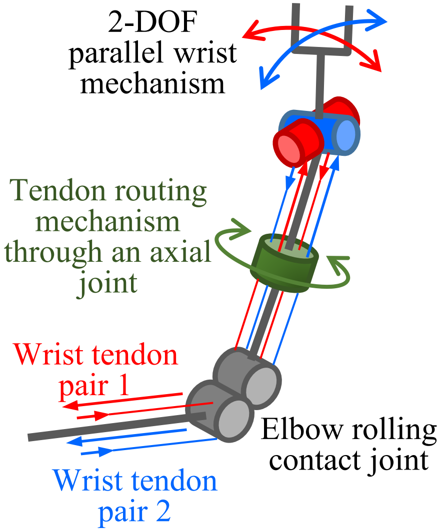
LIMS ROBOT ARM AND QUATERNION WRIST

KIM *et.al.*, IROS 2018

HUMAN ARM



DESIRED ROBOTIC ARM

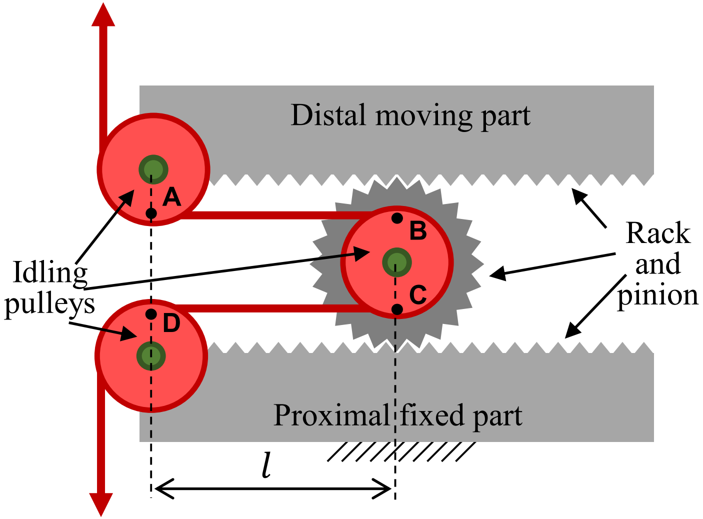


- 1 DOF Rotational Axial Joint
- Range of Motion: ±180°
- Multiple tendon routing (4 for wrist)
- Fulll decoupling

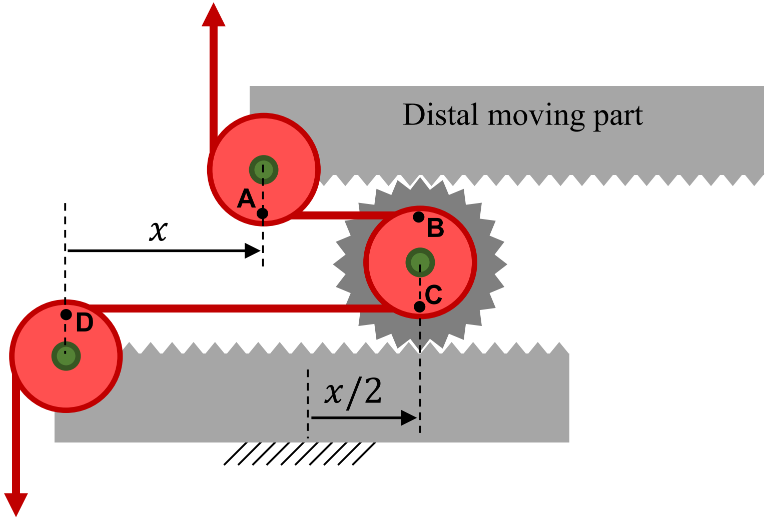
III

SYSTEM DESIGN

CONCEPT IDEA – MOVING PULLEY SYSTEM



$$\overline{AB} = \overline{CD} = l$$

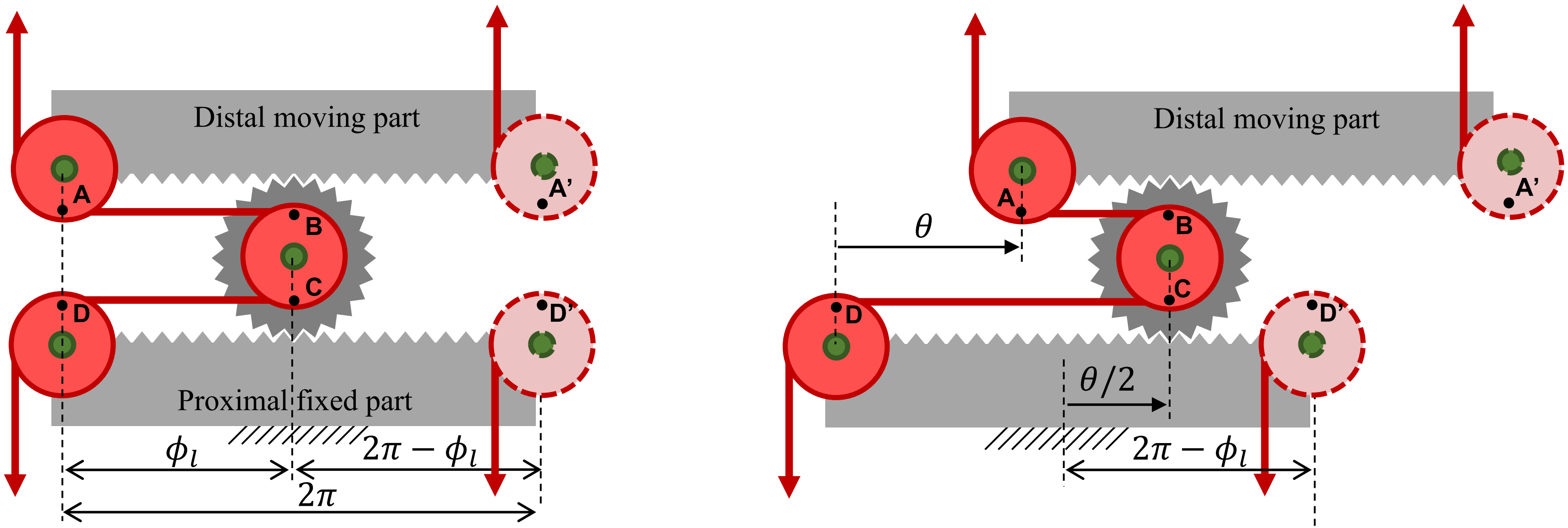


$$\overline{AB} = l - \frac{x}{2} \qquad \overline{CD} = l + \frac{x}{2}$$

The maximum range of motion would be:

$$-2l + 2d_p \leq x \leq 2l - 2d_p$$

CONCEPT IDEA – MOVING PULLEY SYSTEM

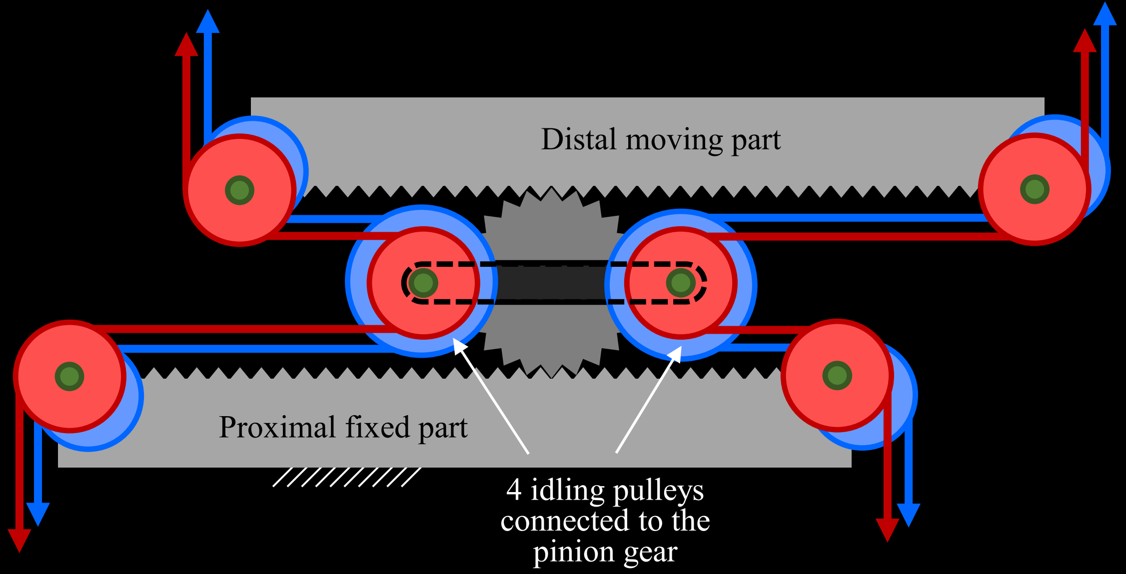


$$-2\emptyset_l + 2\alpha_p \leq \theta \leq 2\emptyset_l - 2\alpha_p$$

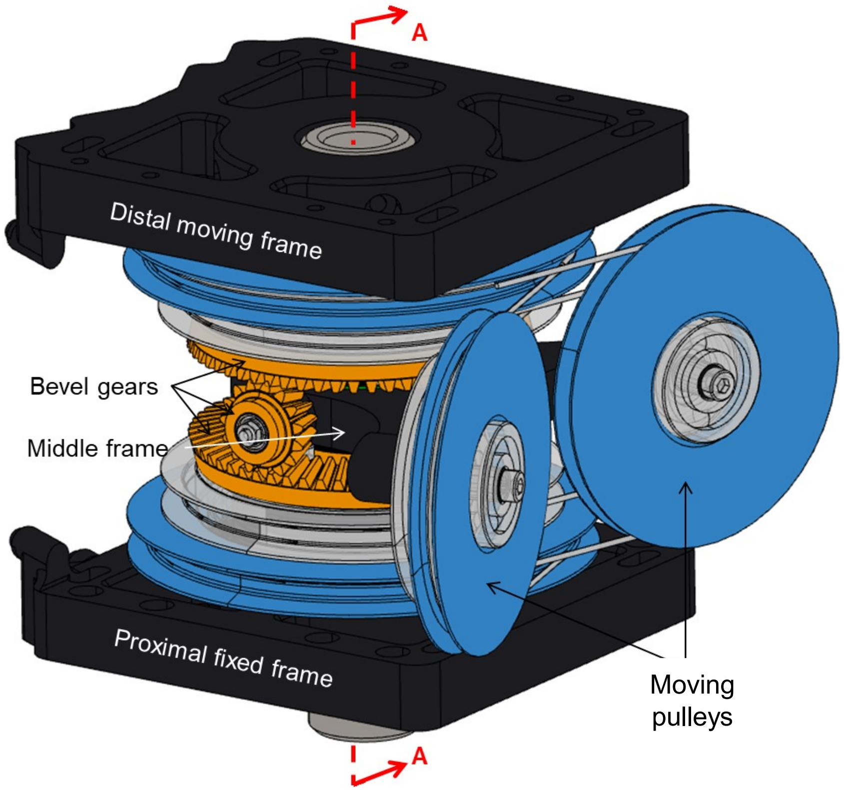
The maximum range of motion would be:

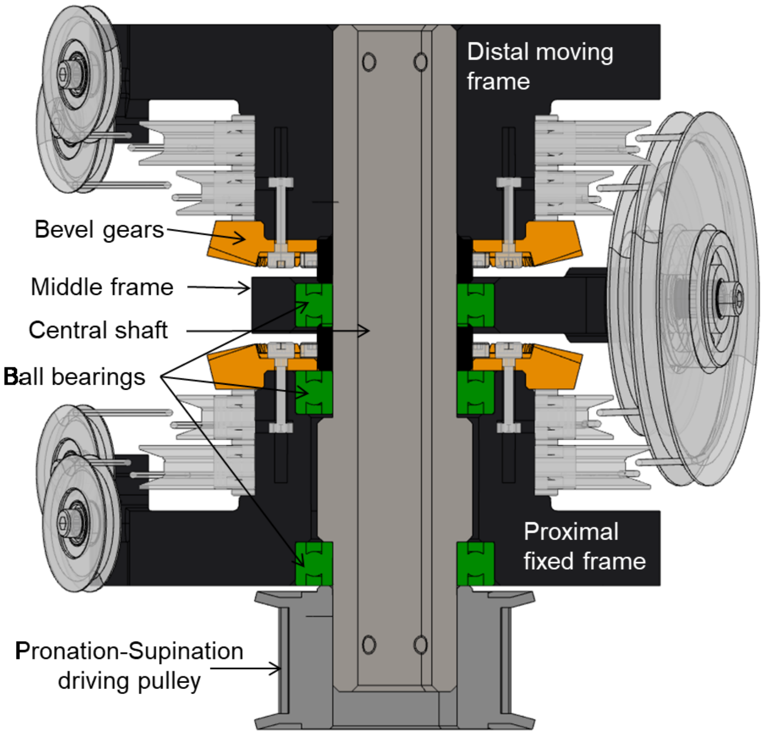
$$-2\pi + \alpha_p + \beta_p \leq \theta \leq 2\pi - \alpha_p - \beta_p$$

MULTIPLE TENDONS



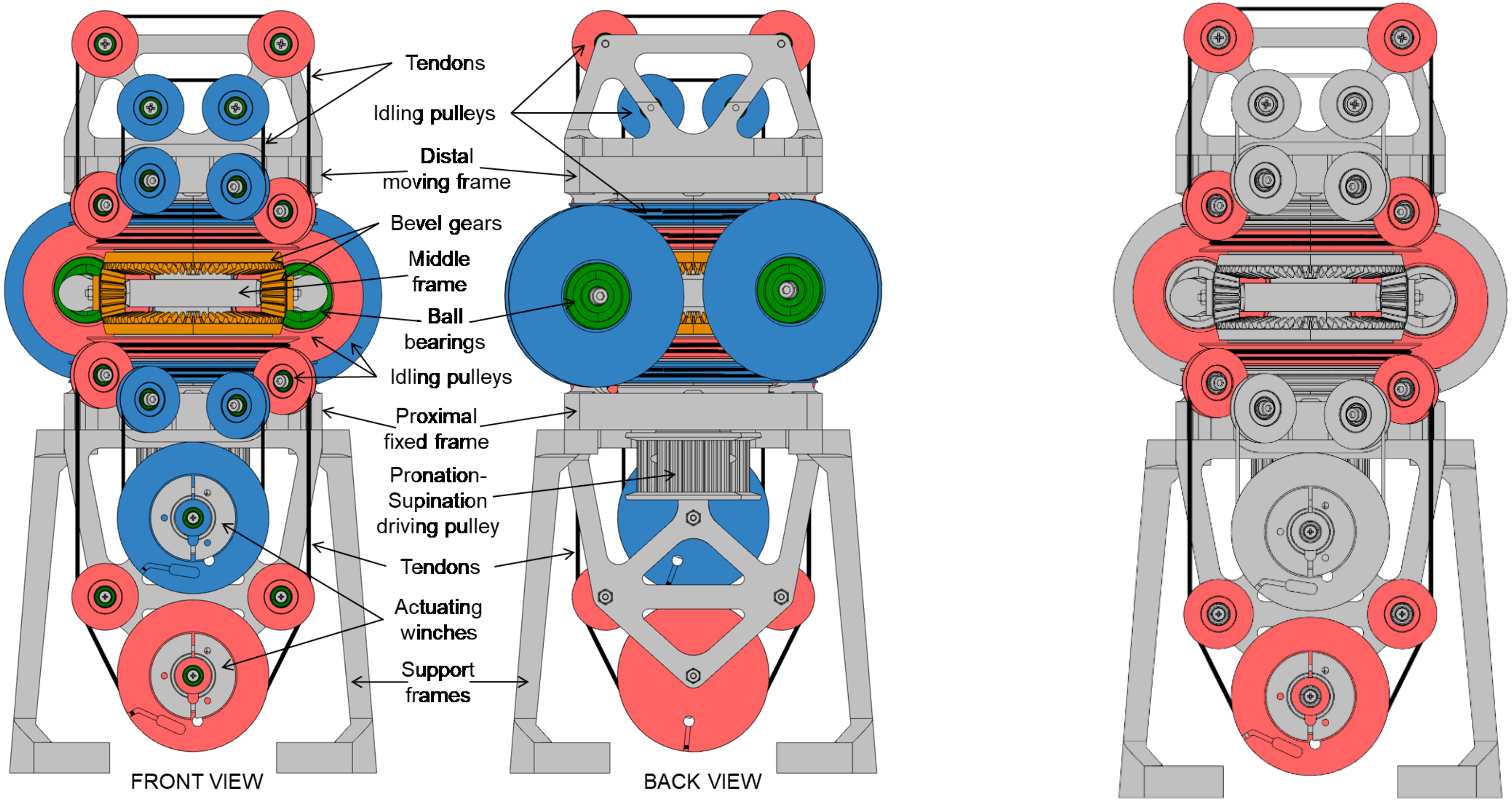
CAD MODEL - SECTIONAL VIEW





SECTION A-A

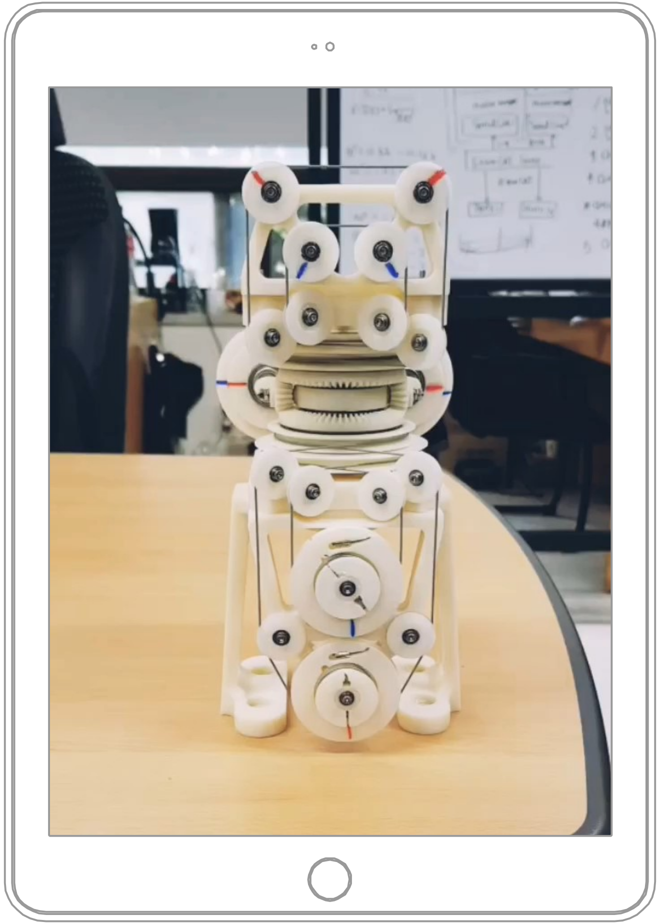
CAD MODEL - TENDON LOOPS



IV

PROTOTYPING AND VALIDATION

PROTOTYPE DEMO



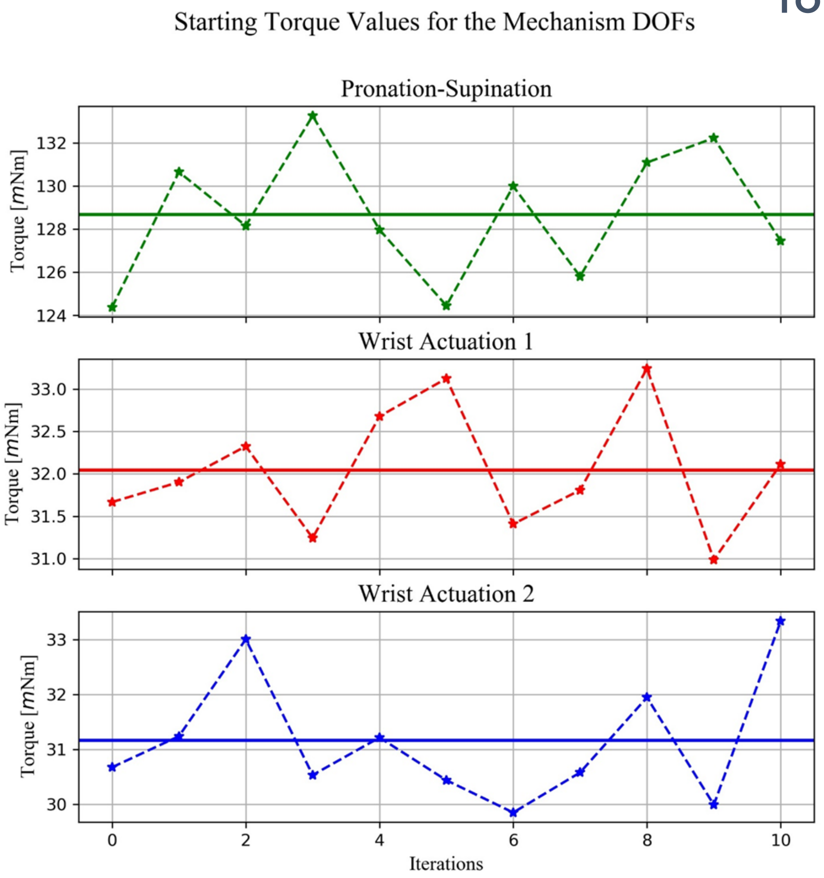
Rapid Prototyping using 3D Printers

SCAN THE QR TO WATCH THE VIDEO ONLINE

Actuation using DC motors and timing belts

SCAN THE QR TO WATCH THE VIDEO ONLINE

VALIDATION – COULOMB FRICTION TORQUE



Joint	Average Torque & [Standard Deviation]
Pronation-Supination	**128.68 *m*Nm** **[2.9 *m*Nm]**
Wrist Actuation 1	**32.05 *m*Nm** **[0.7 *m*Nm]**
Wrist Actuation 2	**31.17 *m*Nm** **[1.1 *m*Nm]**

V

CONCLUSIONS

CONCLUSIONS

Novel tendon routing mechanism through **axial joint**, like the forearm pronation-supination.

Exploits the concept of **moving pulley** to achieve **full decoupling** between joint and tendon motions.

Provides simultaneous routing for all **4 wrist tendons**.

Joint Range of Motion: **±180°**.

General applicability and can be exploited for any axial joint and any number of tendon pairs.

Concept idea, **design**, **prototyping** and validation are presented in this work.

The next steps would focus on **load testing**, design optimization and integration within the arm.

THANK YOU!!!

Any Questions ?

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- iCub Tech & Mechanical Workshop Facilities at Italian Istitute of Technology (IIT)

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iit iCub Tech ISTITUTO ITALIANO DI TECNOLOGIA

iit MWS ISTITUTO ITALIANO DI TECNOLOGIA

“

FIN.