Introduction to Robotics

Xu Chen
Mechanical Engineering, UW

Robot: a machine capable of carrying out a complex series of actions automatically, especially one programmable by a computer

Robotics: the branch of technology that deals with the design, construction, operation, and application of robots

Why 2024 will be the year of robotics

Enrique Dans · Follow
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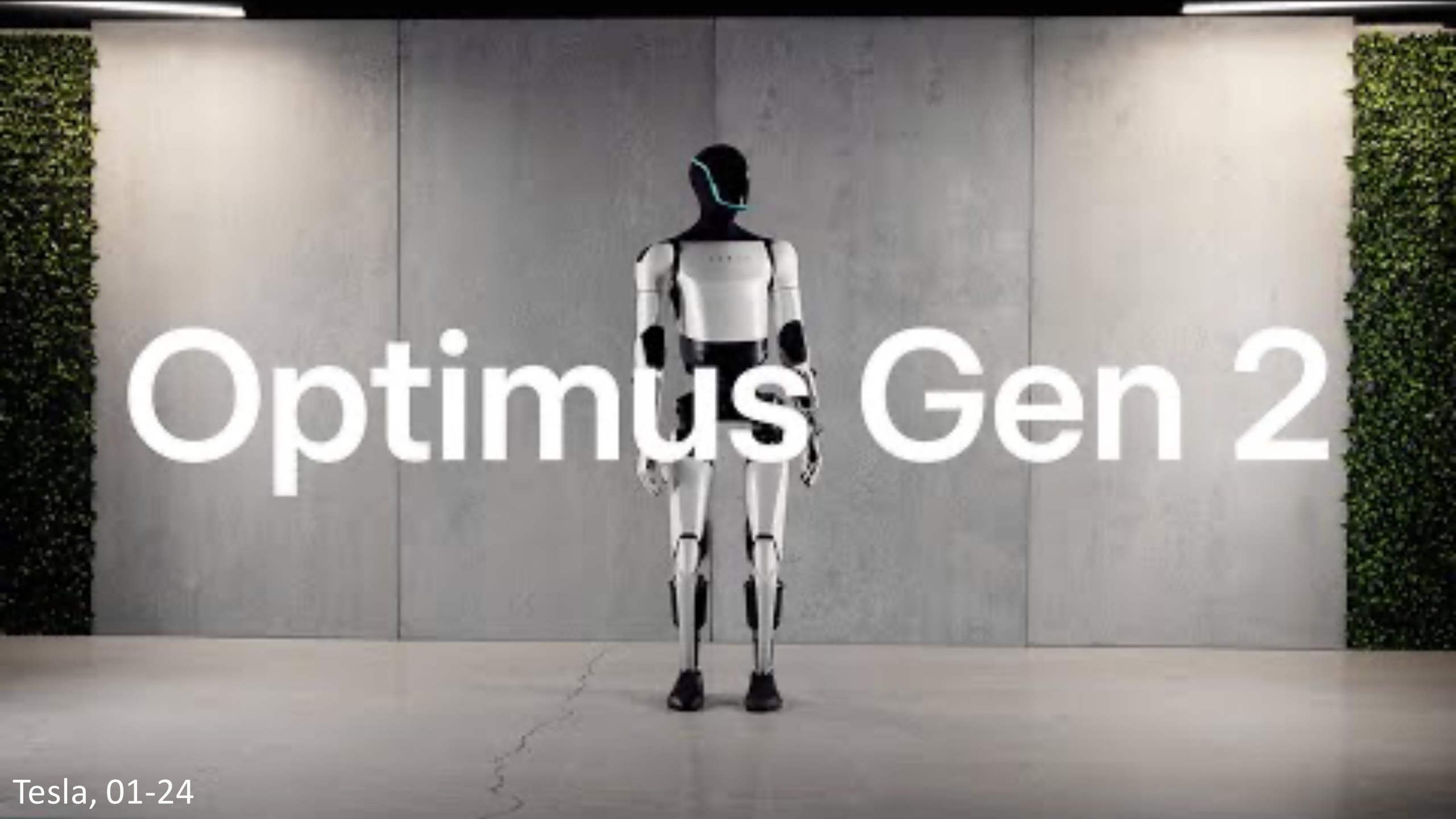
Robotics to be the “biggest thing in 2024”

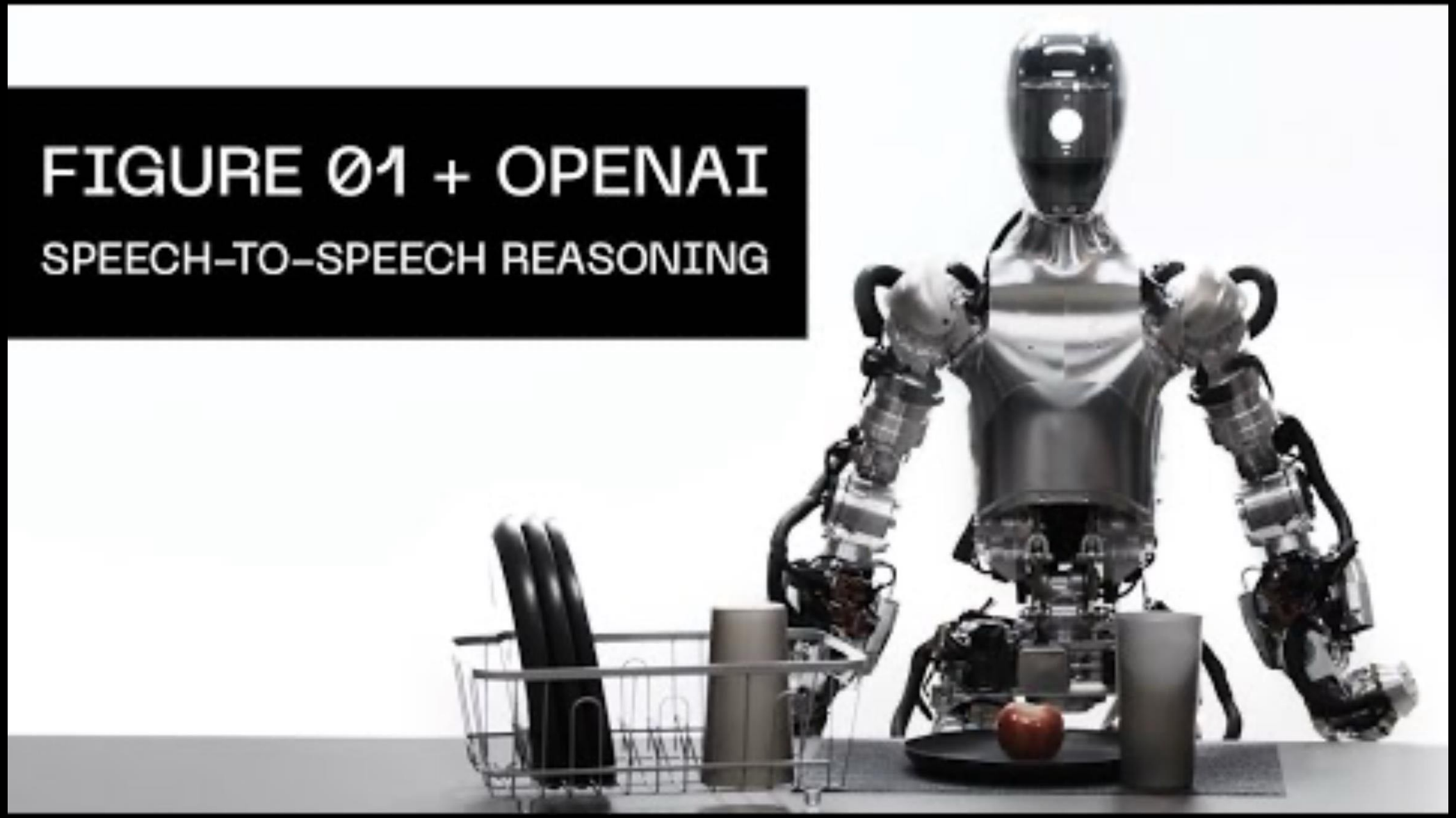
Updated on: January 04, 2024 8:42 AM

Ernestas Naprys, Senior Journalist

Credit: Jim Fan, NVIDA



Tesla, 01-24



03/13/24 Source: FIGURE

NVIDIA Announces Project GR00T Foundation Model for Humanoid Robots and Major Isaac Robotics Platform Update

Isaac Robotics Platform Now Provides Developers New Robot Training Simulator, Jetson Thor Robot Computer, Generative AI Foundation Models, and CUDA-Accelerated Perception and Manipulation Libraries

March 18, 2024

Project GR00T, a general-purpose multimodal foundation model for humanoids, acts as the mind of robots, making them capable of learning skills to solve a variety of tasks.

NVIDIA GTC 2024 Keynote

Don’t Miss This Transformative Moment in AI

Watch NVIDIA CEO Jensen Huang’s GTC keynote to catch all the announcements on AI advances that are shaping our future.

Source: NVIDIA

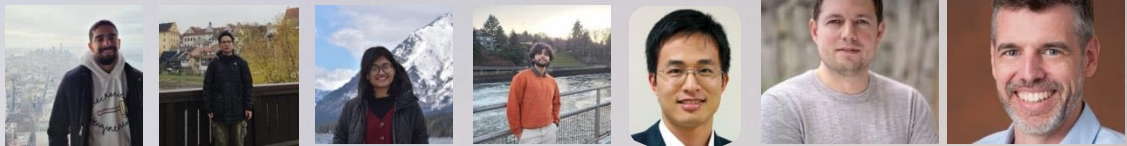
Eureka 10/23: Human-Level Reward Design via Coding Large Language Models

Example Research

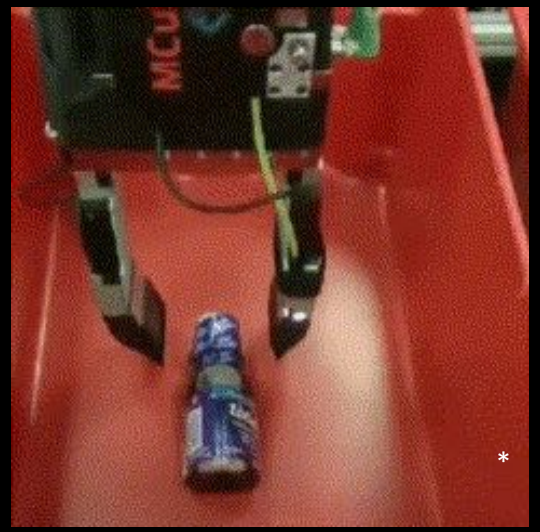
amazon | science

Intelligent Grasping of Heterogeneous Objects

IROS 2024, MECC 2024, Mechatronics (Elsevier)
2024 ASME DSCD Best Paper on Robotics Award



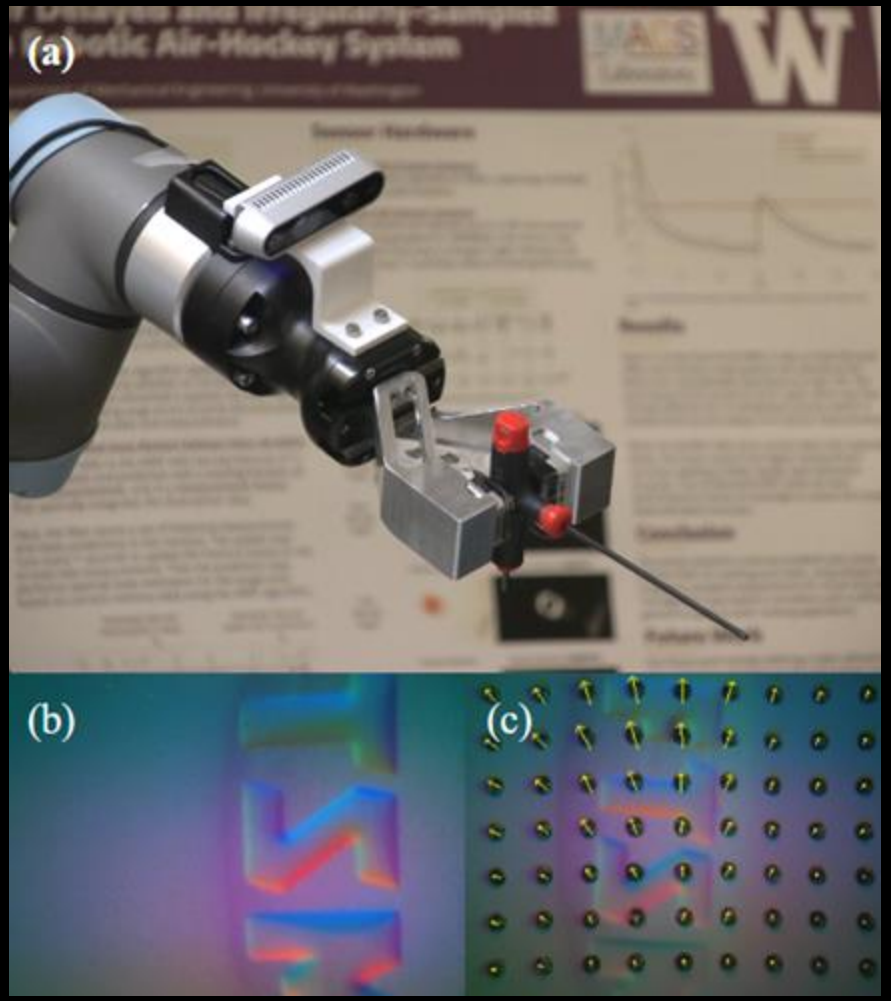
Boundary Condition of Robot-Material Interaction



“grasping is one of the hardest problems in robotics” 2022 Frontiers in Robotics and AI, Article 973208**

* Rueckert, E. (2019). Data-Driven Methods for Co-Design of Materials and Devices [Doctoral dissertation, Massachusetts Institute of Technology]. DSpace@MIT. https://dspace.mit.edu/handle/1721.1/125476.
** Morales A, León B, Chinellato E, Suárez R. Editorial: Current Challenges and Future Developments in Robot Grasping. Front Robot AI. 2022 Jul 11;9:973208. doi: 10.3389/frobt.2022.973208. PMID: 35899073; PMCID: PMC9310340.
*** https://busymockingbird.com/2013/08/27/collaborating-with-a-4-year-old/

Understanding and Controlling Grasping



a) Overall system grasping T handle hex key b) Image contour, c) Shear force visualization

X. Hu, A. Venkatesh, Y. Wan, G. Zheng, N. Jawale, N. Kaur, X. Chen, and P. Birkmeyer. "Learning to detect slip through tactile measures of the contact force field and its entropy" *Mechatronics*, 104, December 2024. https://doi.org/10.1016/j.mechatronics.2024.103258.

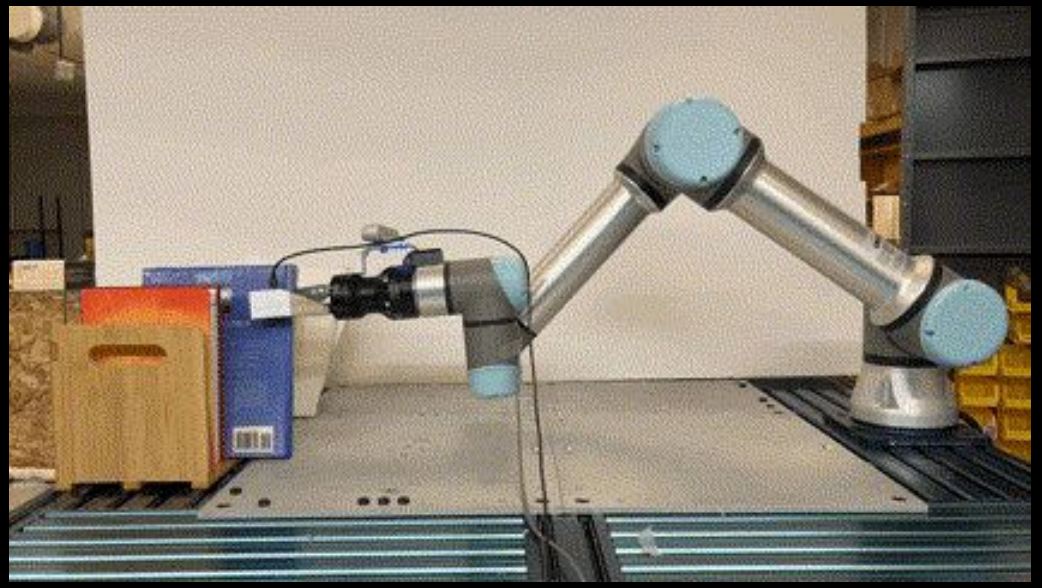
Learned Slip-Detection-Severity Framework using Tactile Deformation Field Feedback for Robotic Manipulation

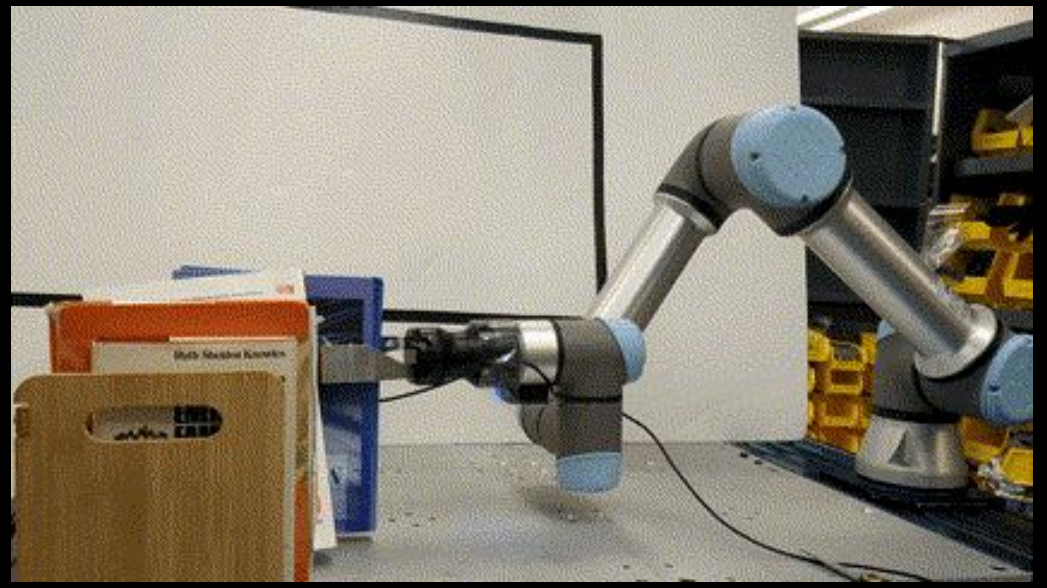
Neel Jawale*, Navneet Kaur*, Amy Santoso, Xu Chen ‡

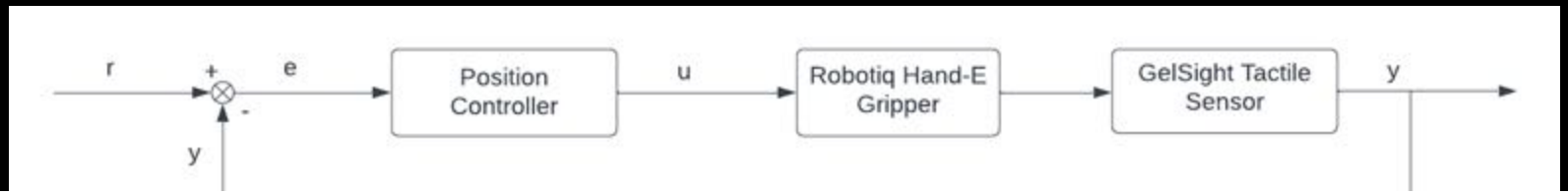
*: equal contribution ‡: corresponding author

Proceedings of IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS) 202. https://doi.org/ras.IROS24.2687.e2244470.

Towards More Active Feedback for Fast Manipulation





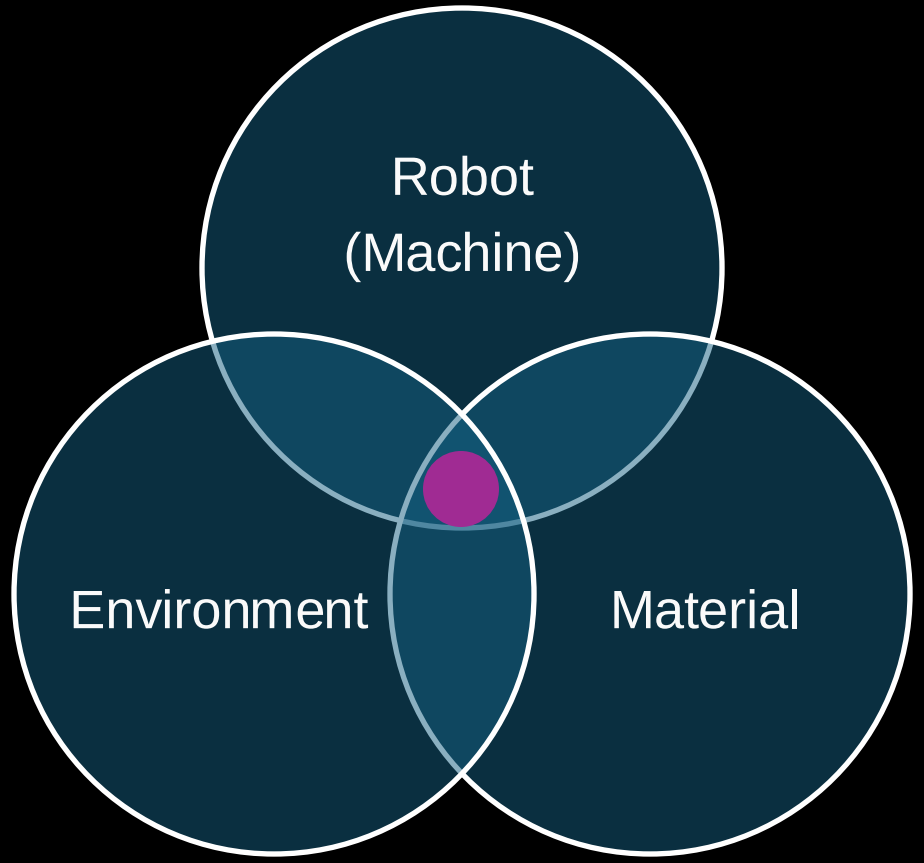


Key: Understanding the Machine-Material Interface

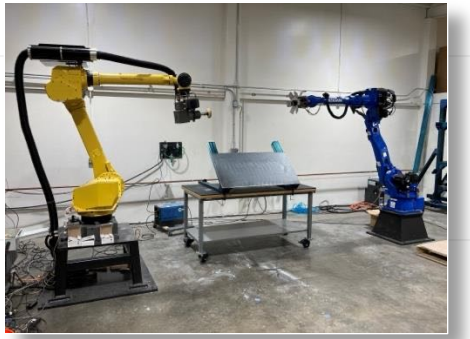
Opportunities: Safe Material Handling

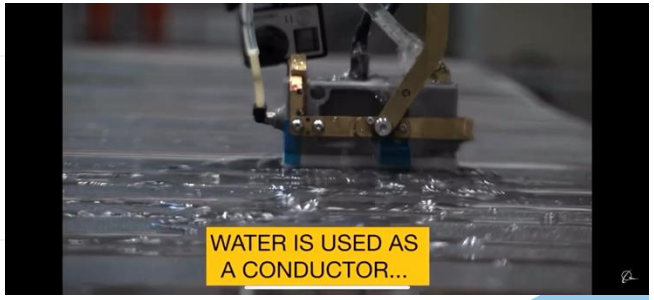
Robotics, Control, Optimization, Manufacturing

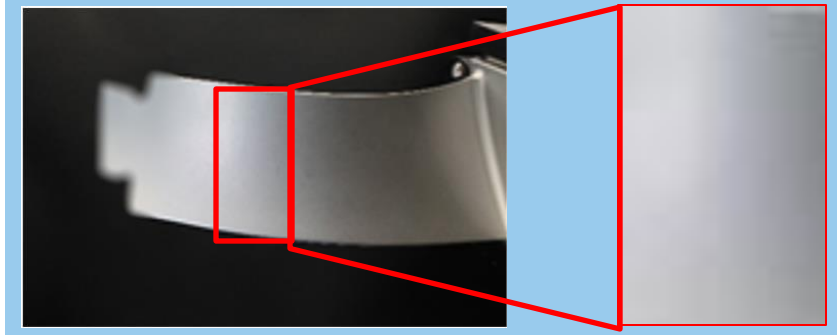
Inspection and Quality Assurance

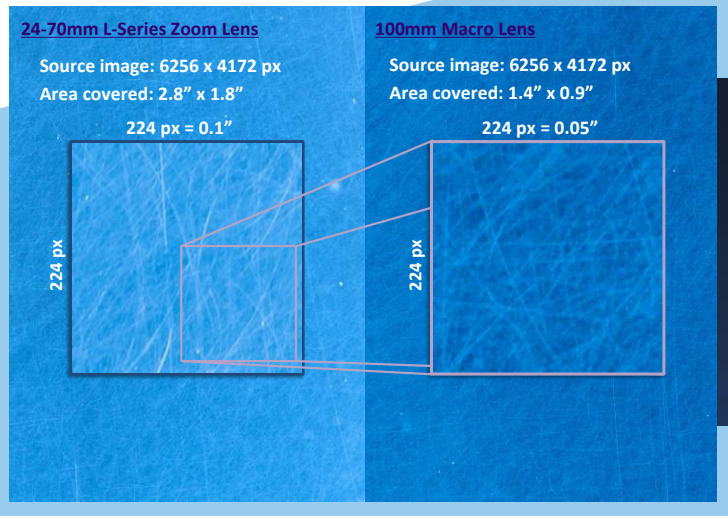


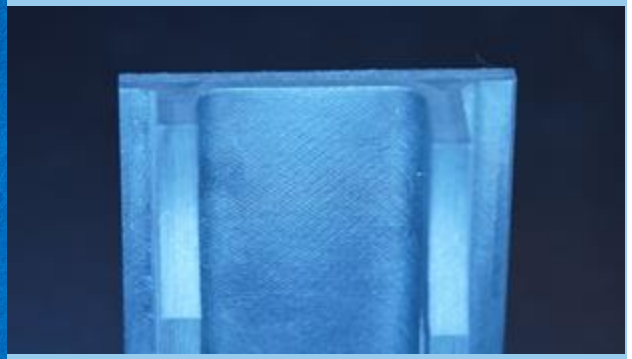
A multiscale robotic inspection roadmap











Metallic

Acrylic

Composites

UNIVERSITY of WASHINGTON

NIAR Wichita State University

GKN AEROSPACE

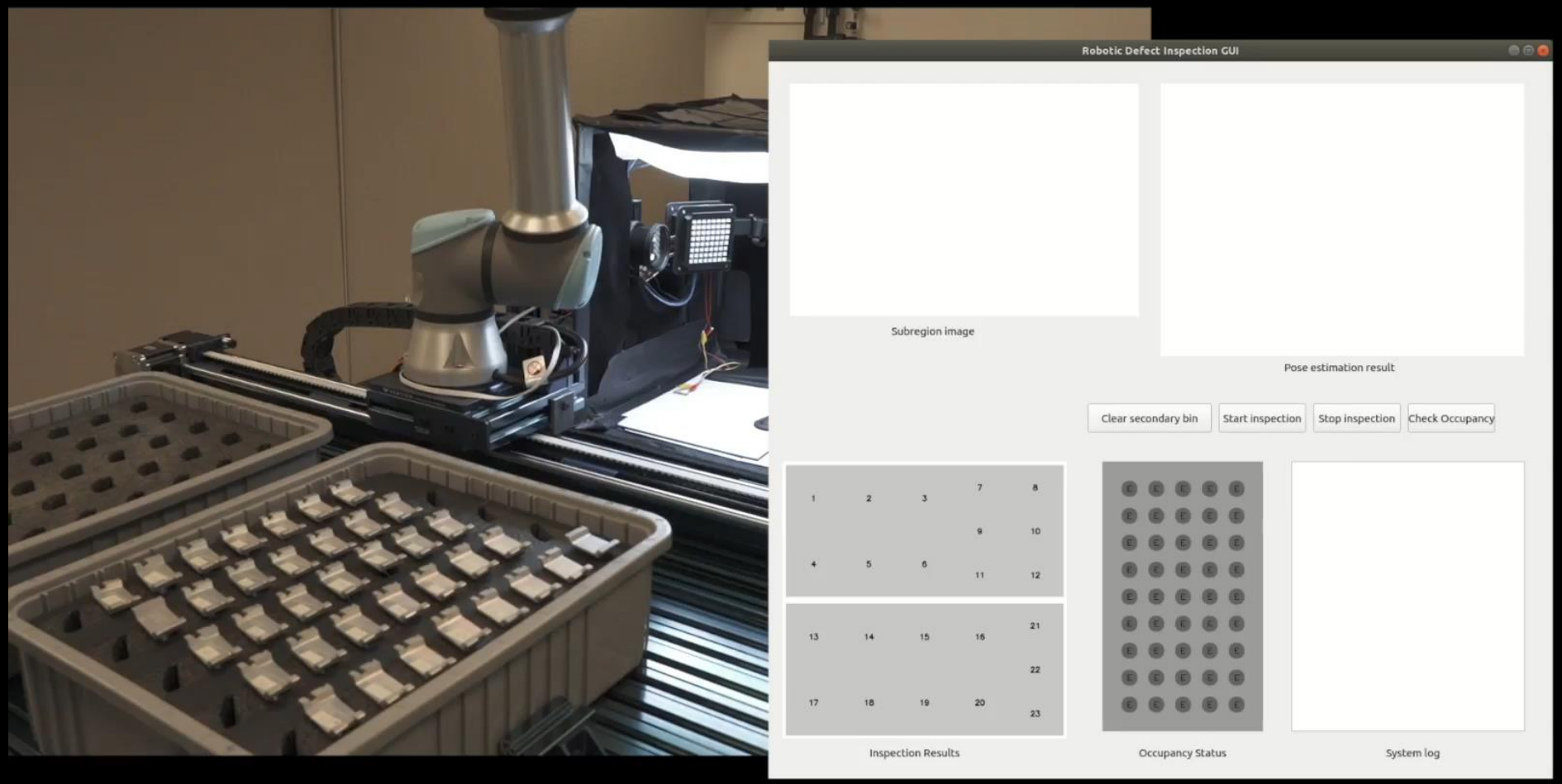
EWI

GRAY MATTER ROBOTICS

GE Research

BOEING

Robotic Inspection and AI for Aerospace (2019)



The ARM Institute, "DoD advanced robotics for manufacturing institute panel discussion: achievements using ai/ml in fab/finishing/logistic processes and their impact", October 2020.
The ARM Institute, "Project highlight: automated defect inspection of complex metallic parts", 03 2021.

Mark Gerges and Xu Chen. "Adaptive lighting for uneven and non-uniform topographies in opto-mechanical inspection systems" IEEE/ASME Transactions on Mechatronics, 27(6):5792-5802, December 2022.
Patent application 49201.02WO2 // 21-0494-WO

Key Performance Parameters

Metric	Baseline	Threshold	Demonstrated
Defect detection rate	70-80%	85%	**>95%**
Average time to inspect per piece	6 min	5 min	**1 min**
Return of investment	$200,000 / system	100% (=baseline)	**345% (1 site)**
			1870% (8 sites)
			3012% (20 sites)

Robotic Mechanisms

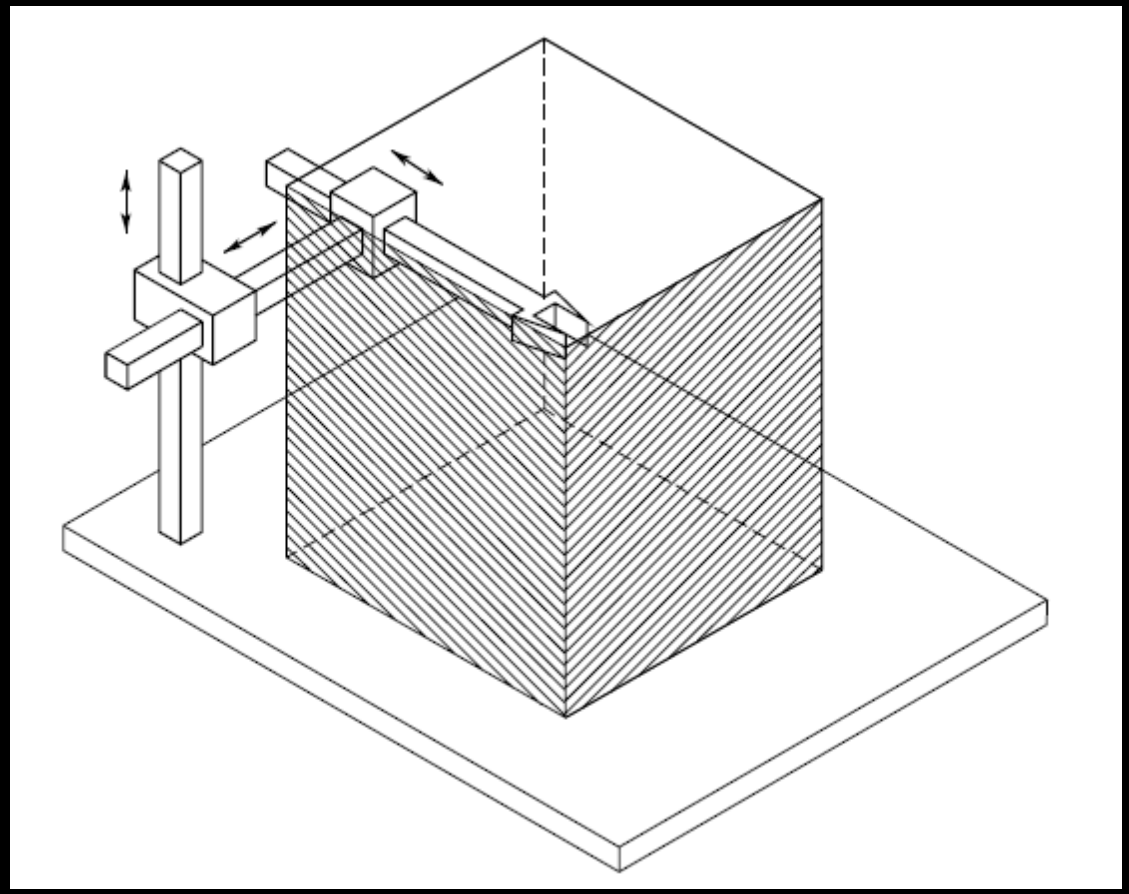
Classification of mechanical structures

Accessing the 3D space

Robot manipulator with a fixed base

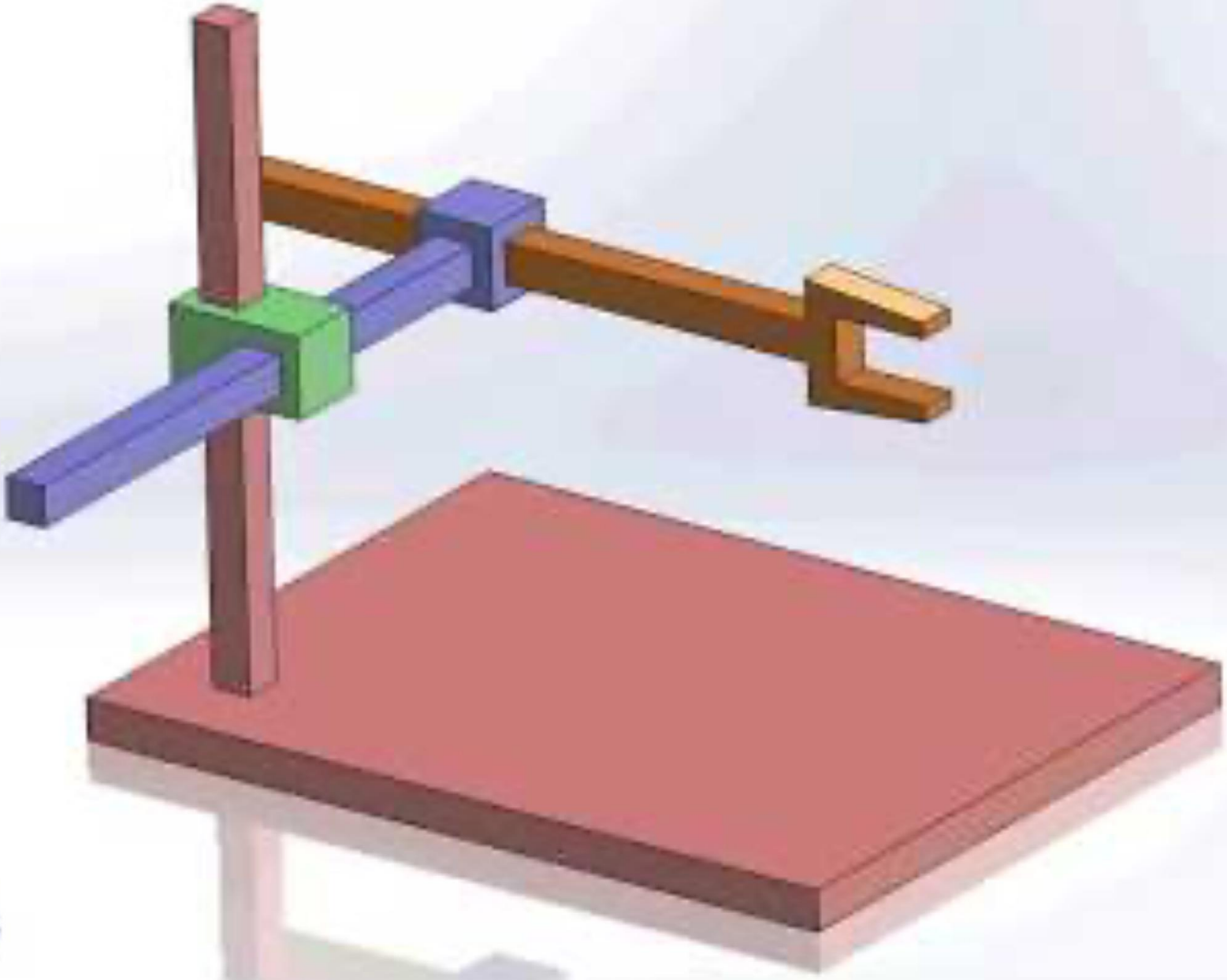
a kinematic chain composed of a sequence of links interconnected by joints

- e.g., Cartesian manipulator



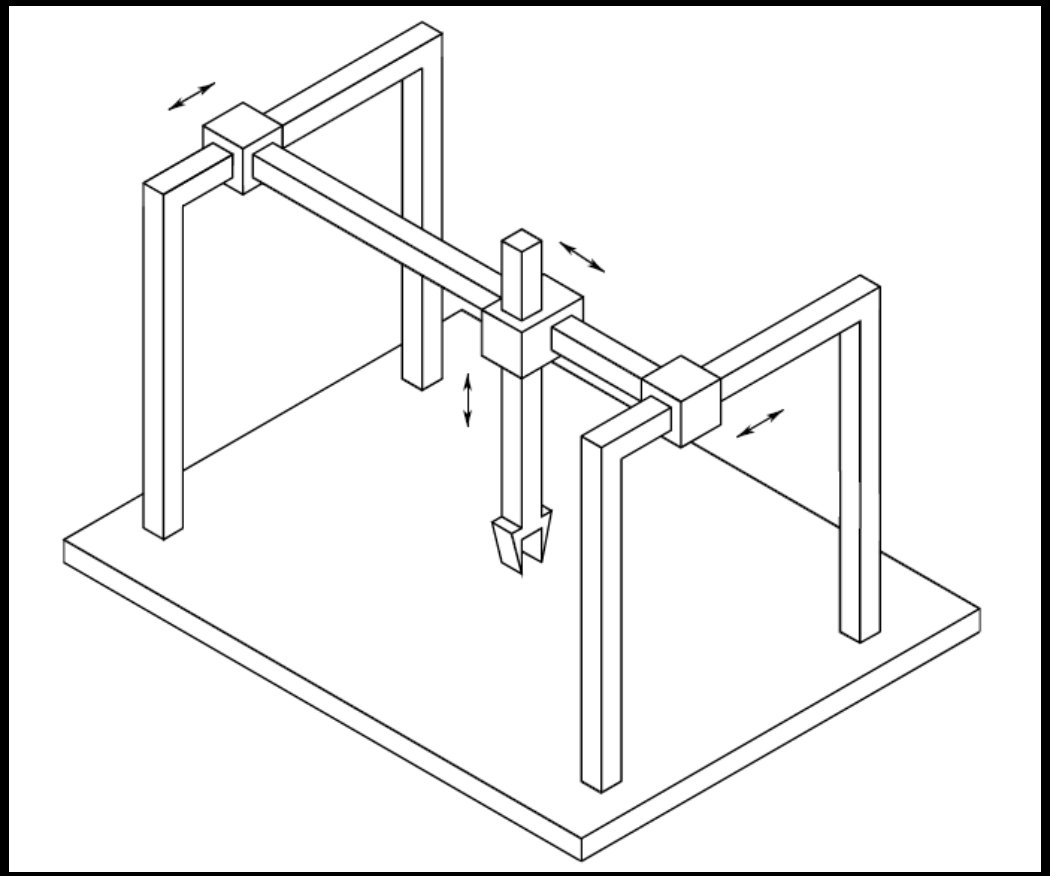
Siciliano et al, Robotics–Modelling, Planning and Control, Springer

Robotics:
Cartesian Manipulator



Created By:
Abhishek Pratap Singh, PhD

Gantry manipulator



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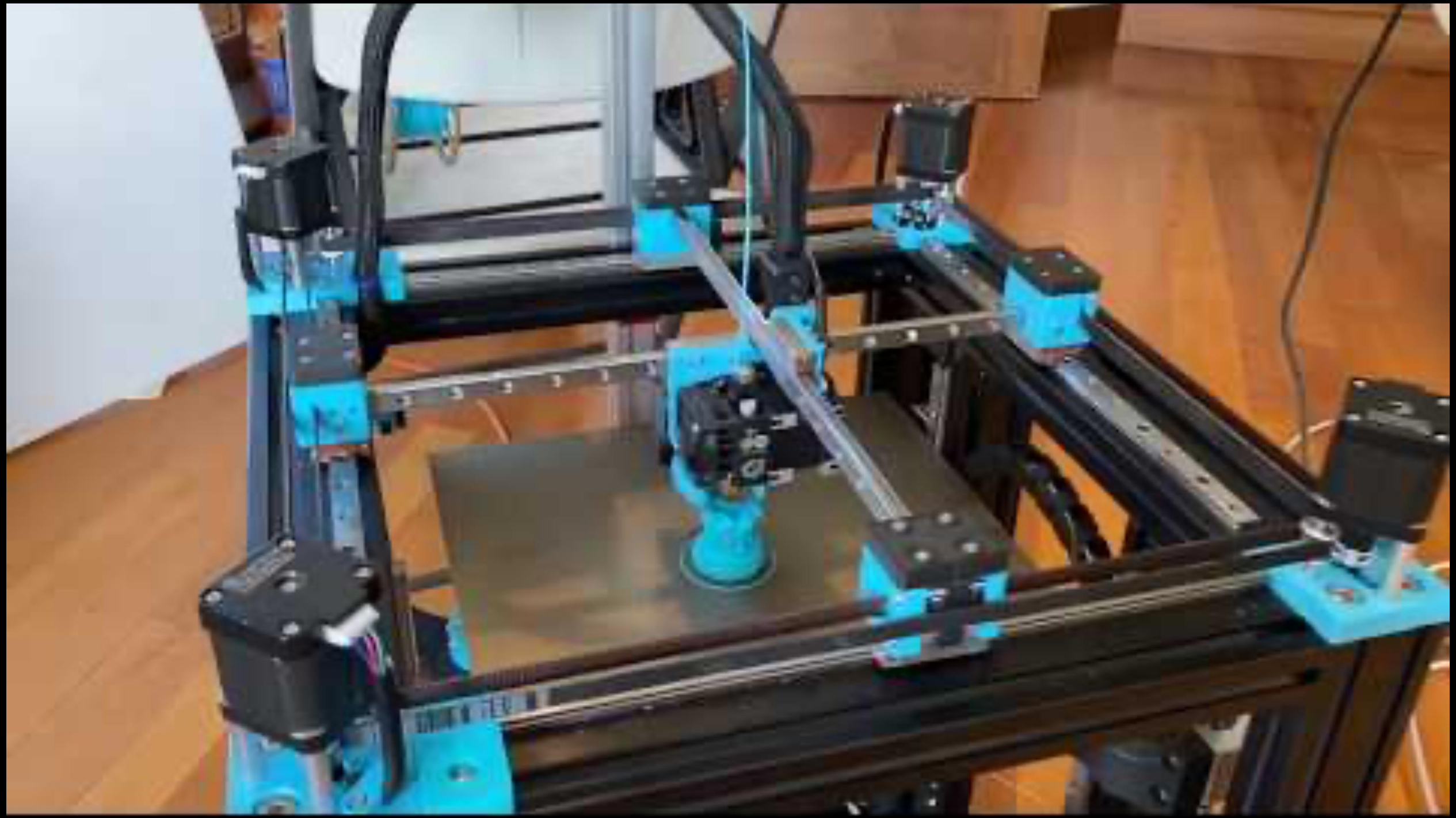
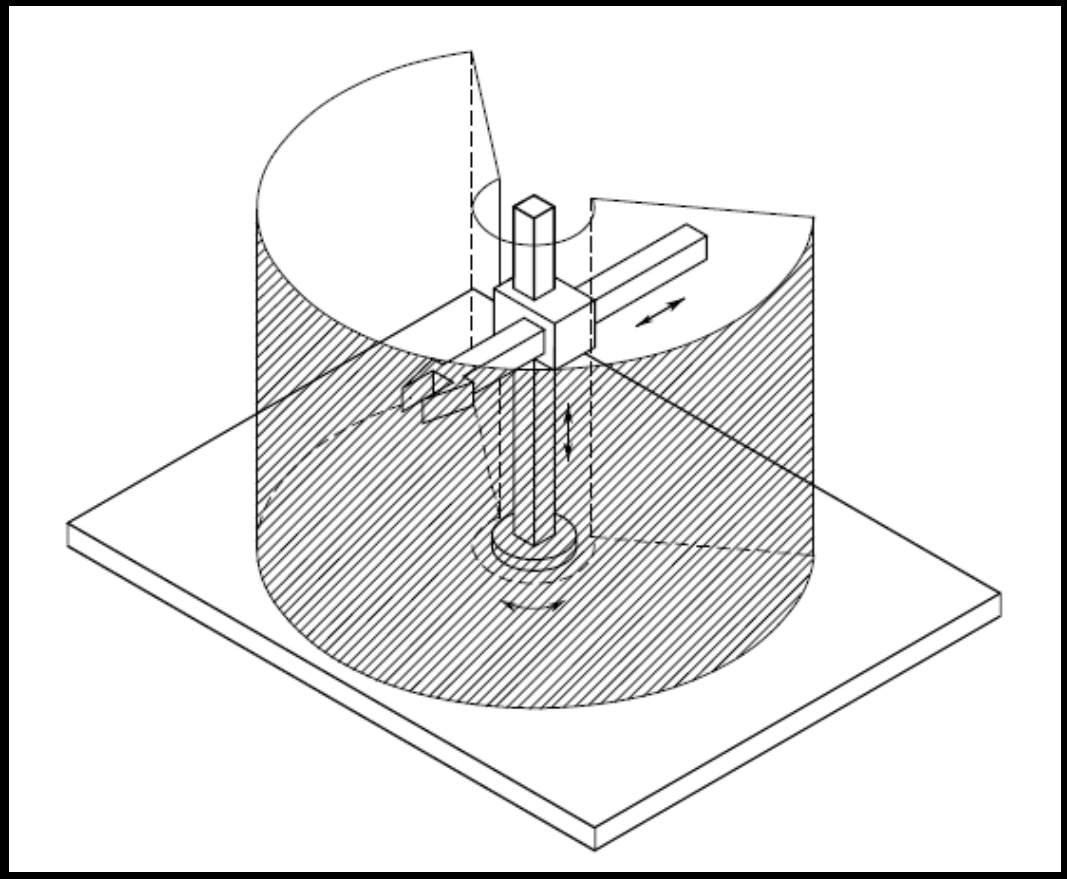


Cylindrical manipulator



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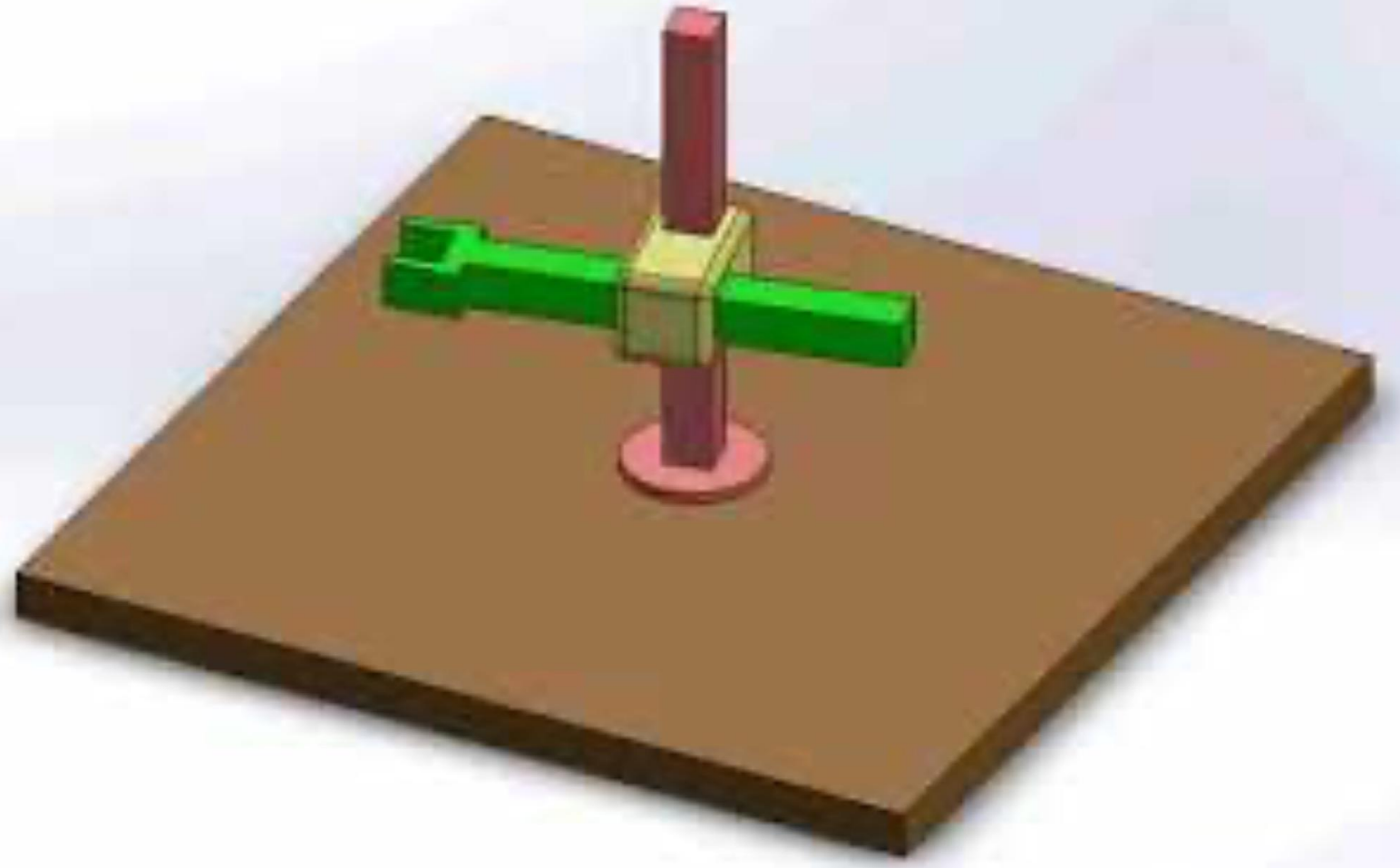
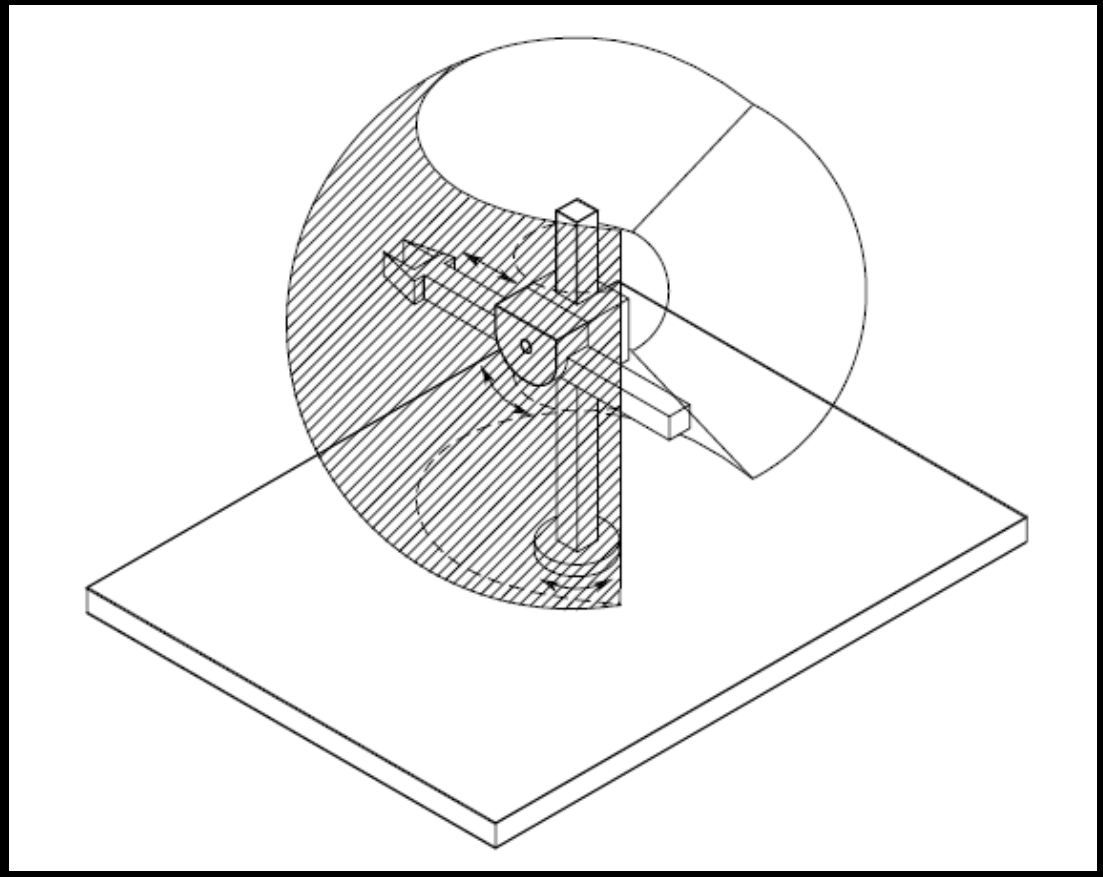
Robotics:
Cylindrical Manipulator



Spherical manipulator



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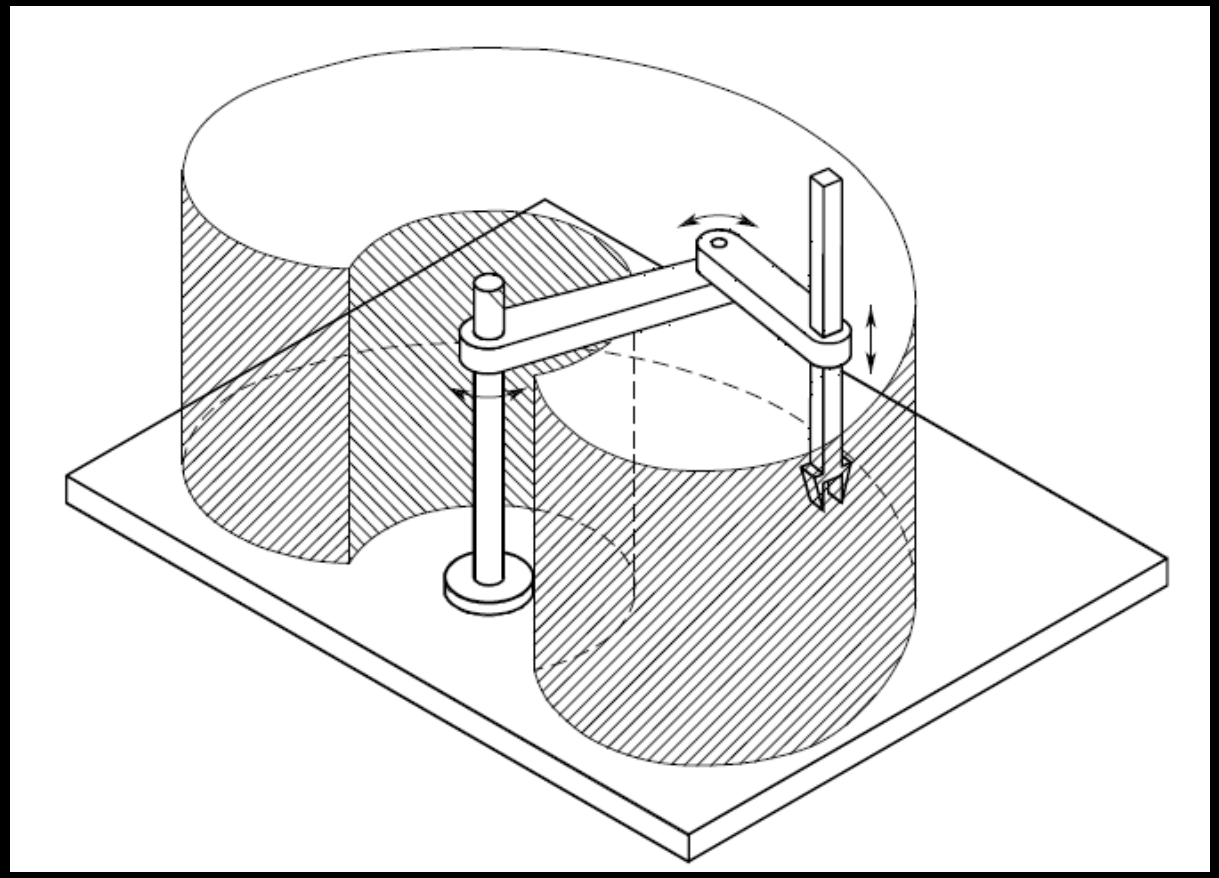
SCARA (selective compliance assembly robot arm) manipulator



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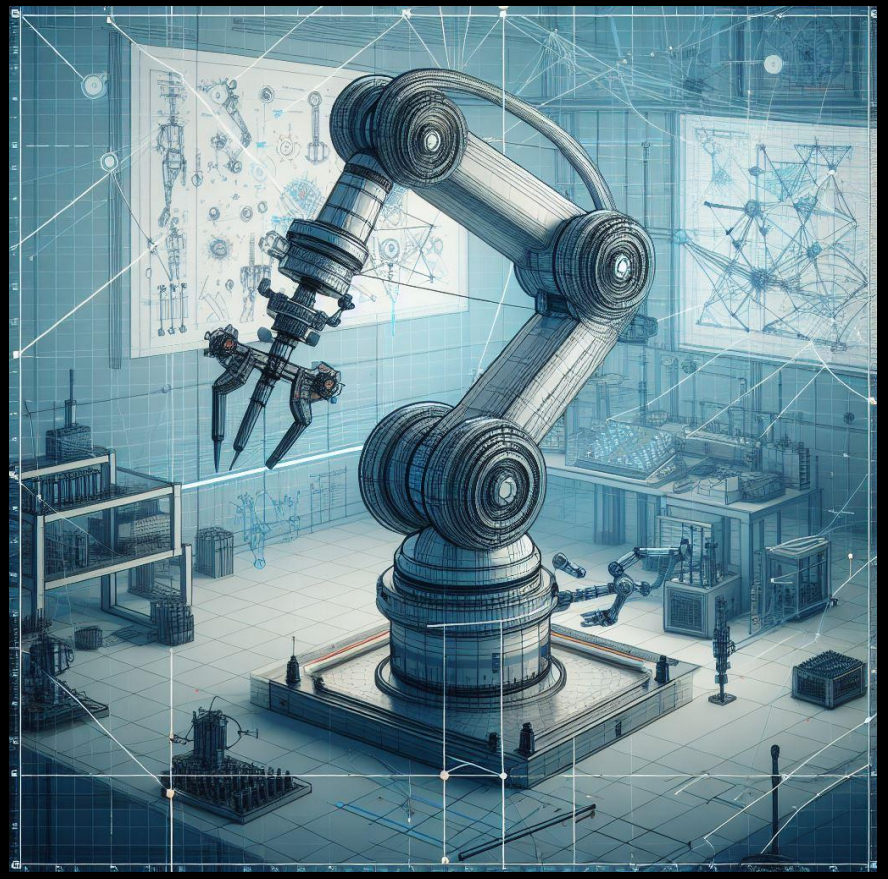
FANUC SCARA Series

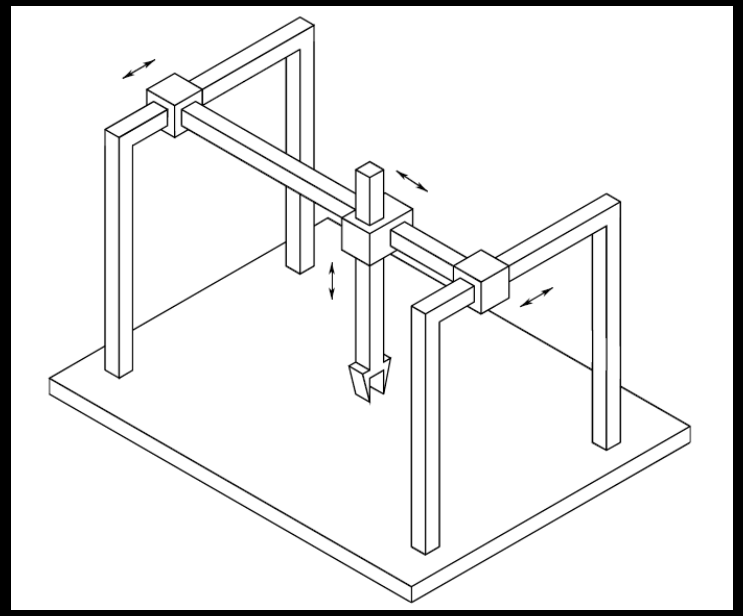
SR-3*i*A
» 3kg payload

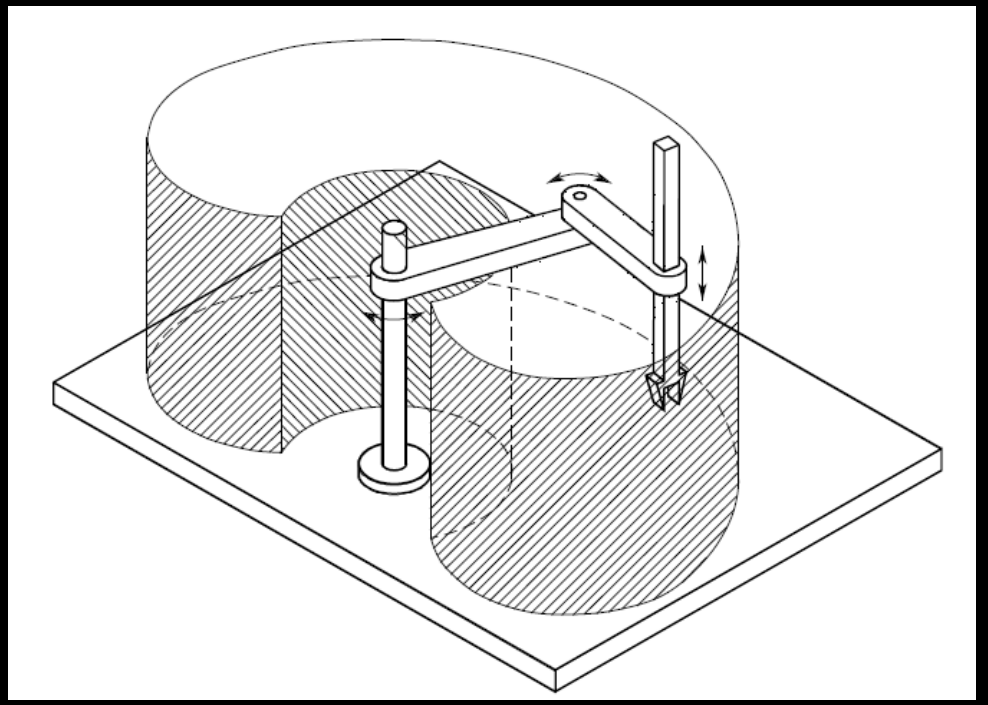
SR-6*i*A
» 6kg payload

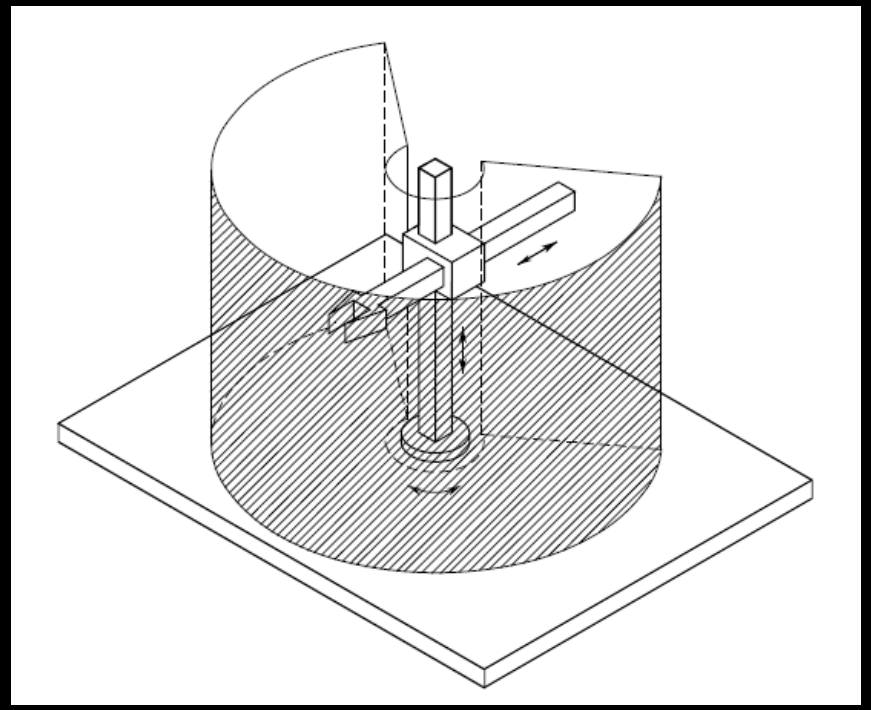
Anthropomorphic manipulator

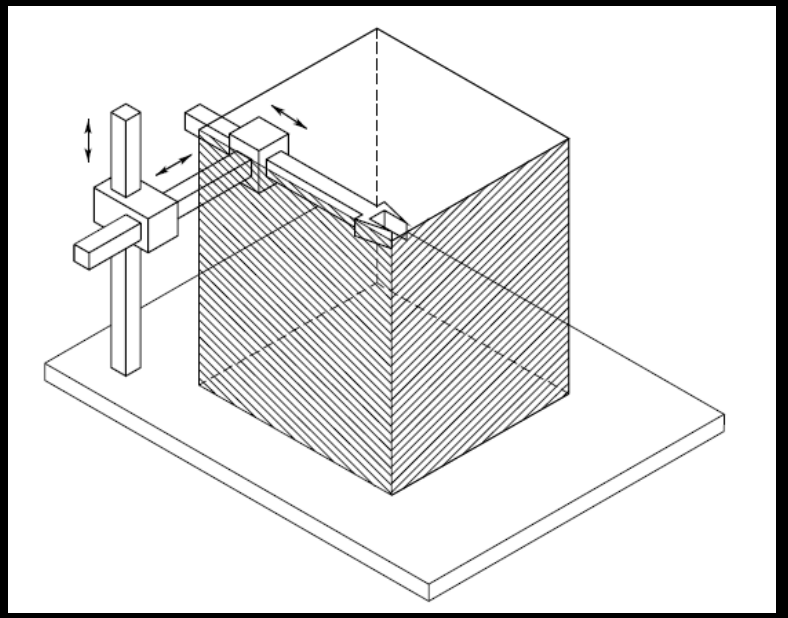


Work Envelop

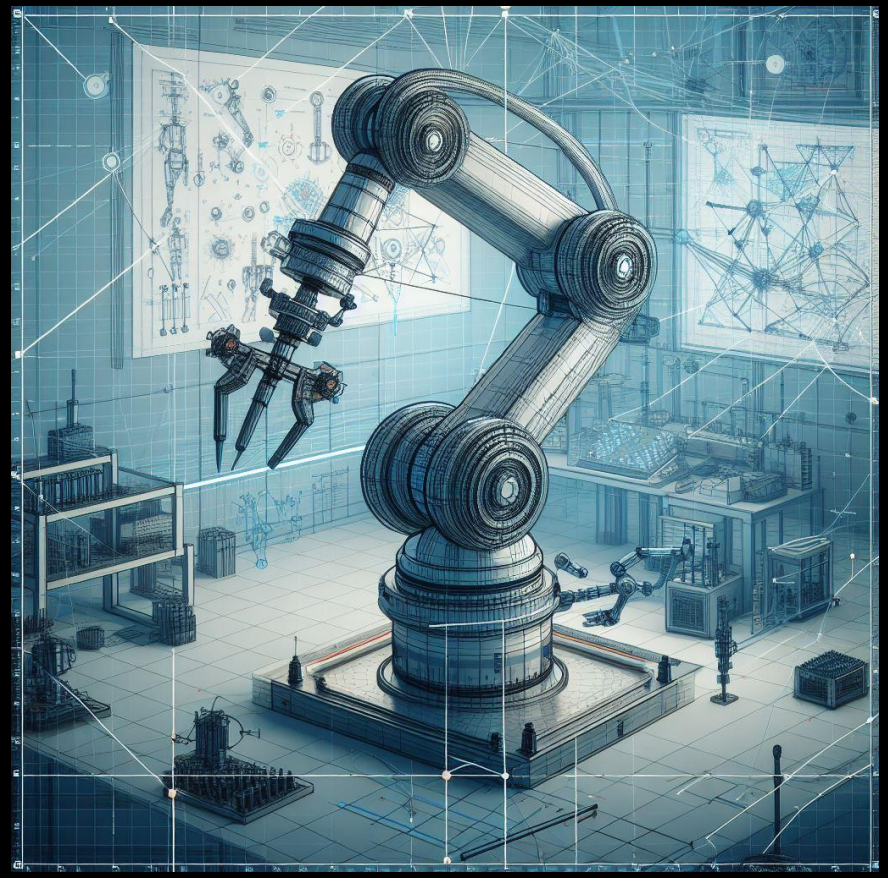


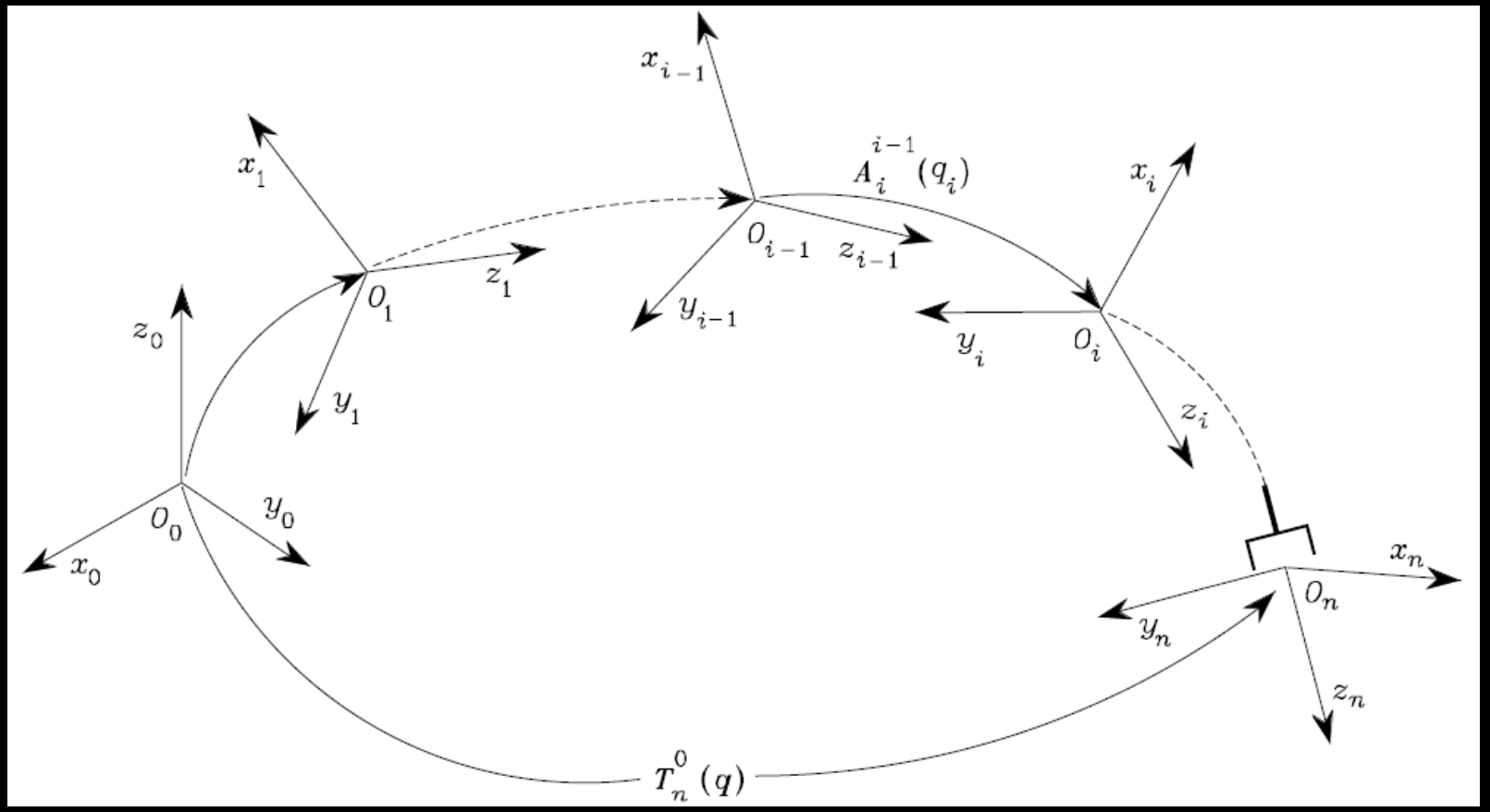




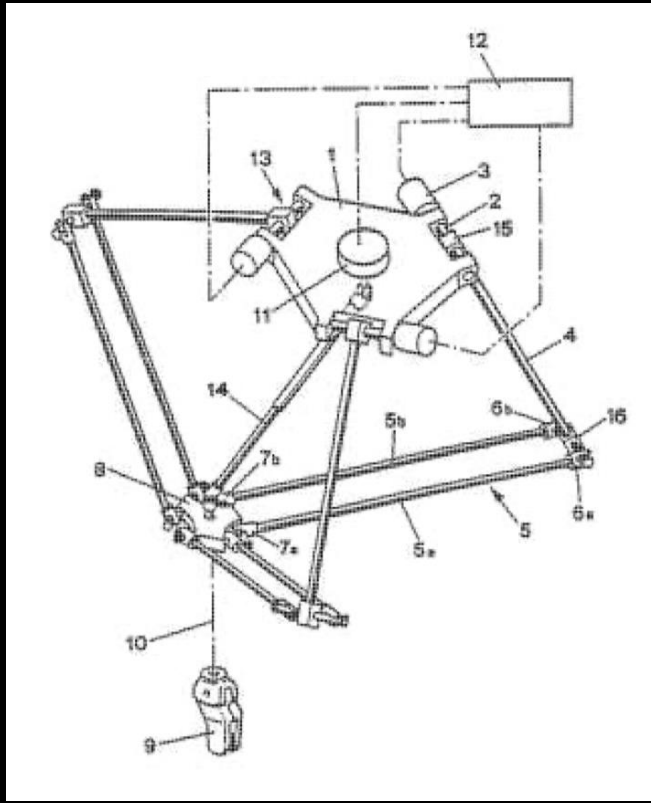


Open and closed kinematic chains





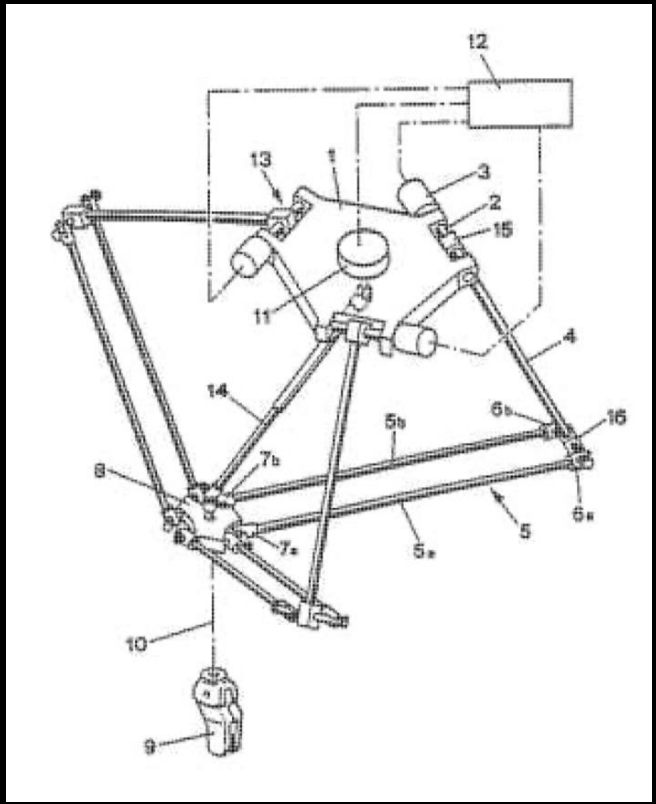
Delta robot with closed kinematic chains

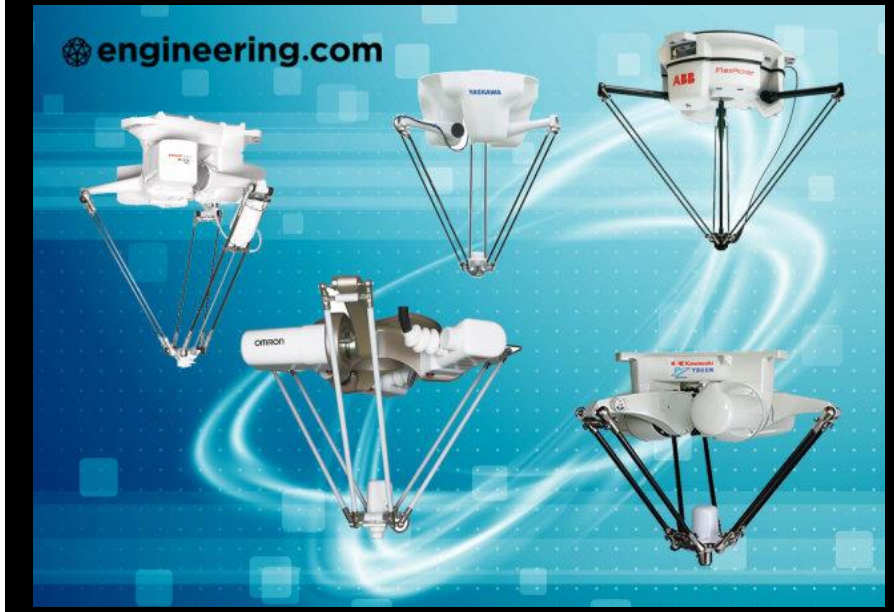


Device for the movement and positioning of an element in space

Page bookmark	US4976582 (A) - Device for the movement and positioning of an element in space
Inventor(s):	CLAVEL REYMOND [CH] +
Applicant(s):	SOGEVA SA [CH] +
Classification:	**- international:** ***B25J11/00; B25J17/00; B25J17/02; B25J9/06; B25J9/10;*** (IPC1-7): B25J9/12
	- cooperative: **B25J17/0266**; **B25J9/0051**; **B25J9/1065**; Y10T74/20207
Application number:	US19890403987 19890906
Priority number(s):	CH19850005348 19851216
Also published as:	US4976582 (X6) WO8703528 (A1) → JPS63501860 (A) JPH0445310 (B2) EP0250470 (A1)

Delta robot and Delta 3D printer

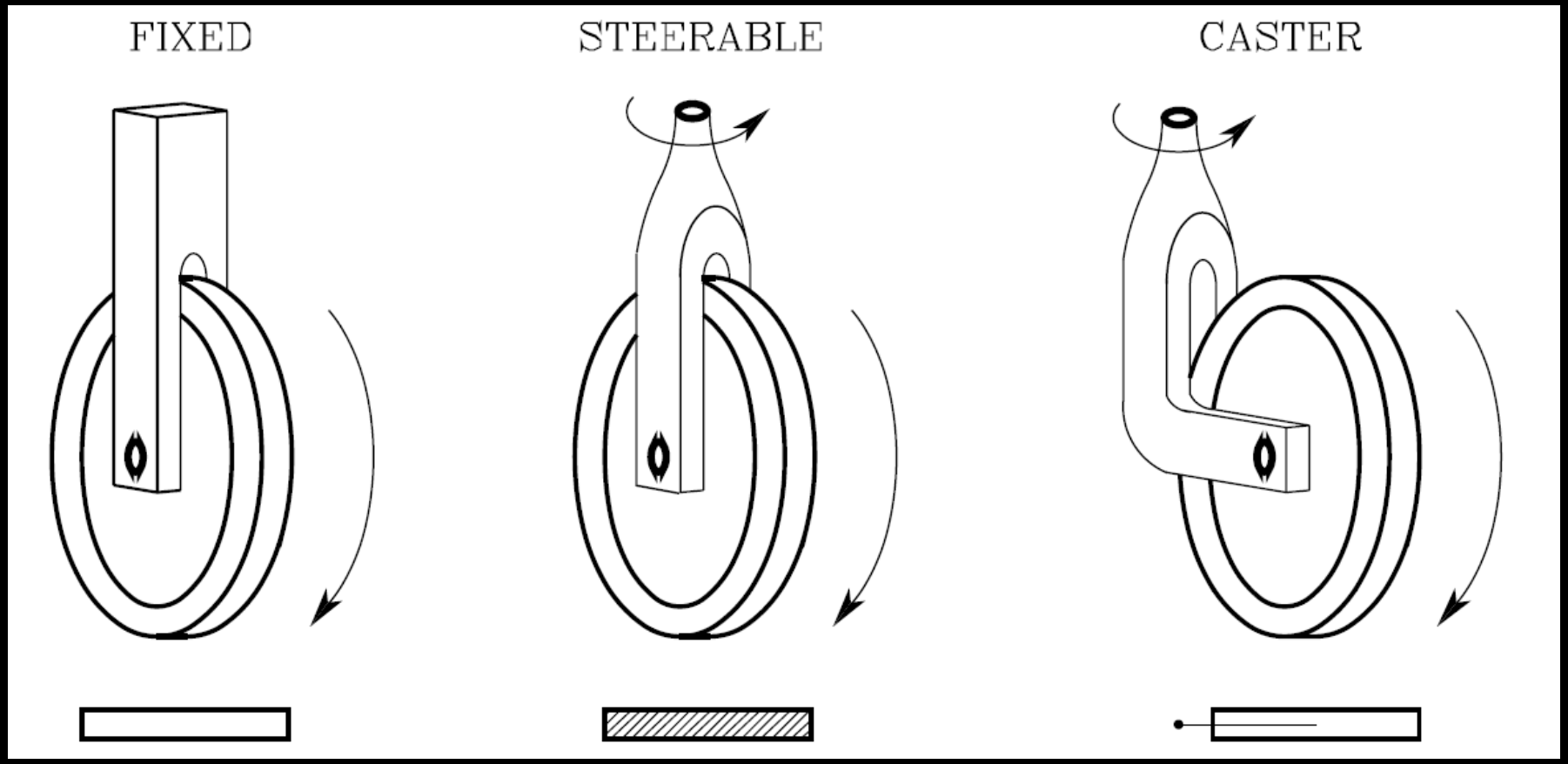





robo motion

Mobile robot

equipped with a locomotion system (wheeled or legged)



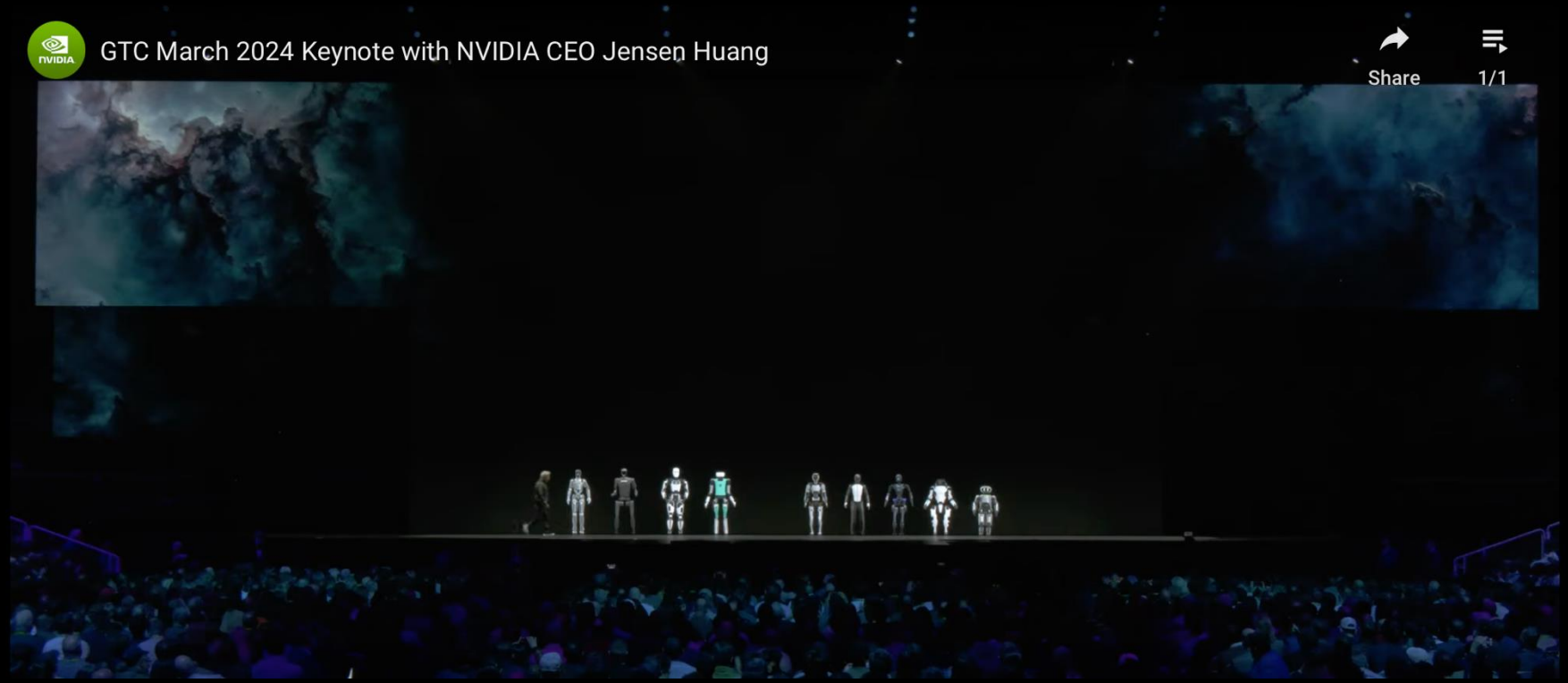
Siciliano et al, Robotics–Modelling, Planning and Control, Springer

Humanoid robot

NVIDIA GTC 2024 Keynote

Don’t Miss This Transformative Moment in AI

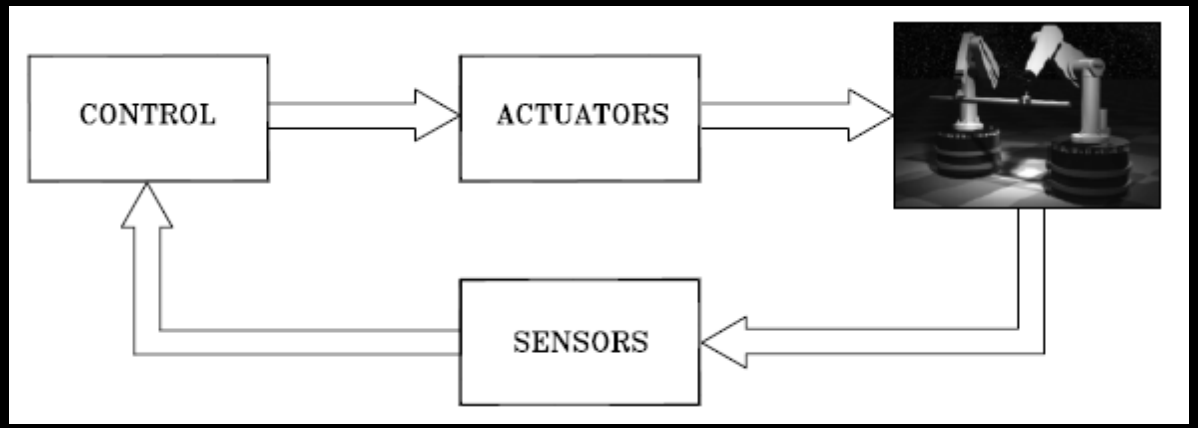
Watch NVIDIA CEO Jensen Huang’s GTC keynote to catch all the announcements on AI advances that are shaping our future.



Source: NVIDIA

Essentials of a robot

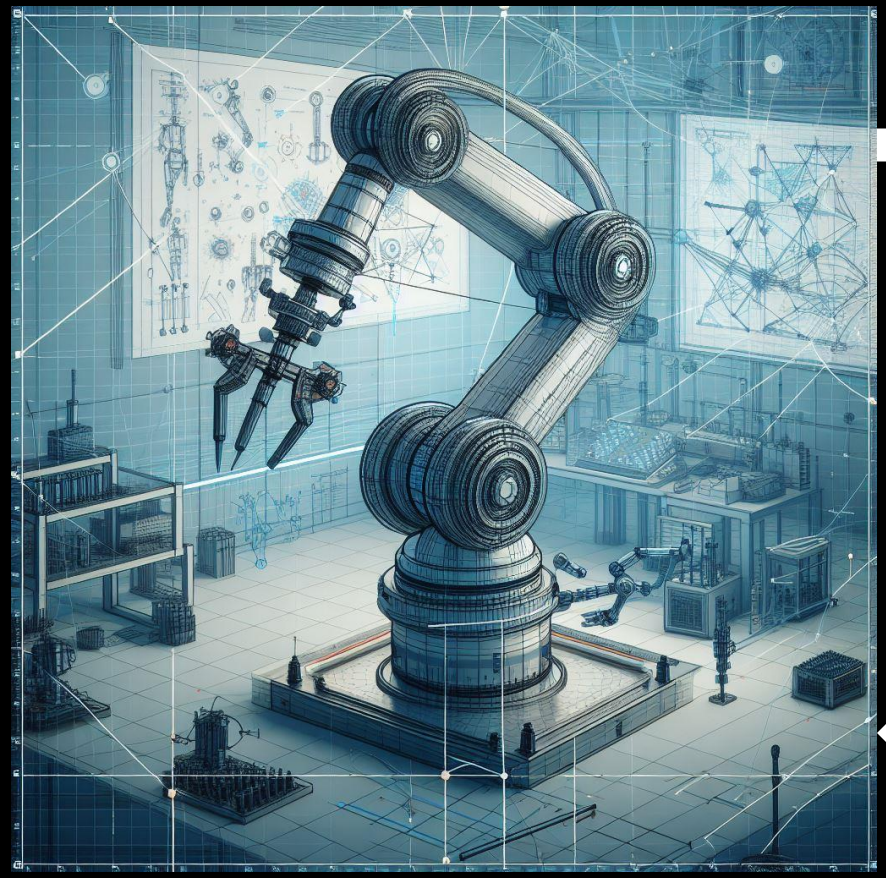
An interdisciplinary subject concerning the cultural areas of mechanics, control, computers, and electronics

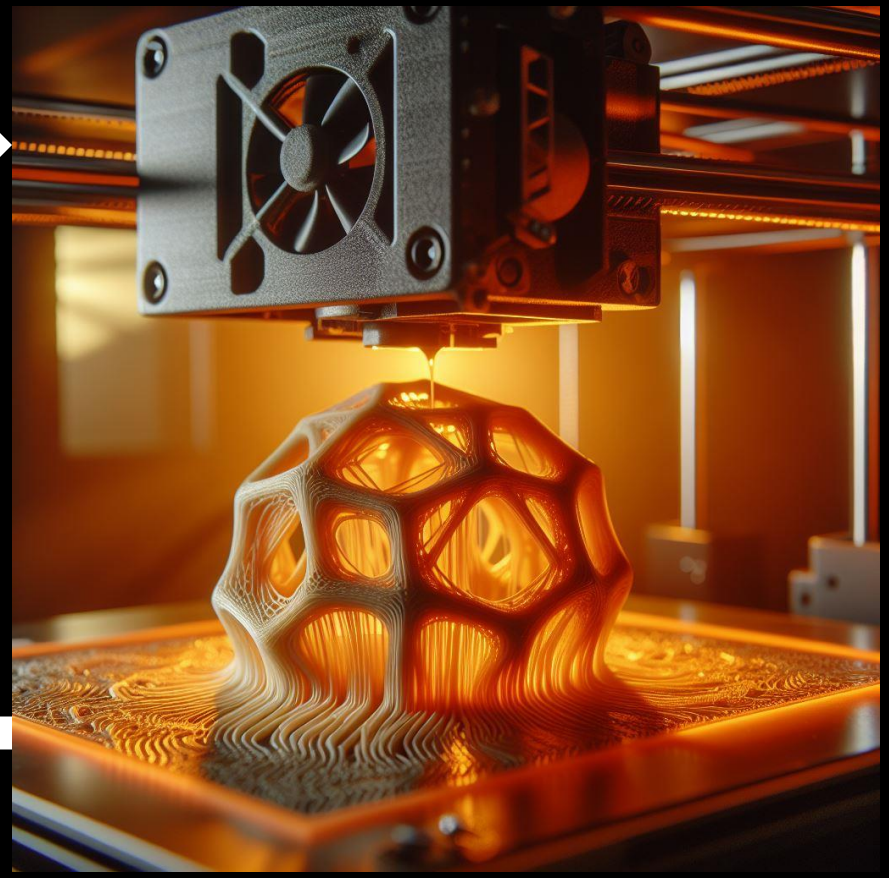


- Mechanical system: manipulation apparatus (mechanical arms, end effectors, etc) and locomotion apparatus (wheels, mechanical legs, etc)
- Actuation system: servo motors, motor drivers, transmissions, etc
- Sensors: position transducers, force sensors, cameras, etc
- Control system: task planning, modelling, motion control, etc

Siciliano et al, Robotics–Modelling, Planning and Control, Springer

3D printers as robots





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