**Information and Brokerage Event**
**Horizon Europe 2023 Call**
**Co-Funded by the DST, Government of India**

HORIZON-CL4-2023-HUMAN-01-01: Efficient trustworthy AI - making the best of data (AI, Data and Robotics Partnership) (RIA)

February 8, 2023

# Reinforcement Learning Based Advanced Robotics

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# Topic to be addressed

## Reinforcement Learning based Advanced Robotics

**Challenges**

1. Mathematical models of advanced robots may be highly complex, nonlinear, and sometimes difficult to determine.
2. Unknown disturbances and uncertainties in system model can degrade overall control systems performance.

**Solution**

1. Model-free feedback control systems design for robots using Reinforcement Learning (RL).
2. Robust design of feedback controllers by adaptation of parameters using RL.

**Characteristics**

- Learning by trial and error.
- Refinement of actions (skill) of robot based on feedback system designed using reward/penalty, similar to human learning.
- Intuitive learning process yielding trustworthiness of AI.
- Lifelong learning akin to humans.

# Specific Contribution

1. Feedback control systems design using Reinforcement Learning (RL).

2. Adaptation for designed traditional controller using RL.

- For arm manipulators, ground mobile robots, multirotor.

- For any generic robot configuration.

- Deep Reinforcement Learning agent design for control generation and/or controller parameter adaptation.

# Core Competencies and Cooperation Needed

**Competencies:**

- Linear and nonlinear control systems design using mathematical models of systems
- Robust control systems design with bounded uncertainties and disturbances
- DRL based feedback control systems design with or without mathematical model of system
- DRL based adaptation of controller parameters to increase robustness
- Trajectory control of robots

**Cooperation Needed:**

- Mechanical design of robots
- Software development for robots
- Digital Twinning of robots
- Instrumentation in robots
- Computer Vision in robots

# Experience

## Relevant Projects:

**Reinforcement Learning based stabilization of liquid surface in autonomous ground vehicle payloads** at IIT Roorkee, India. Sponsored by ARTPARK, IISc as Mentor. 2021-2022. Completed.

**Design and development of a low-cost compact automated guided vehicle for payload movement in housing and urban industries** at IIT Roorkee, India. Sponsored by Divyasampark iHub, IIT Roorkee as PI. 2021-2023. Ongoing.

**Design and Development of a Low Cost Automated Guided Vehicle for Indian Industries** at IIT Roorkee, India. Sponsored by Tetrahedron Manufacturing Services Pvt. Ltd. as PI. 2019-2020. Completed.

**A Collaborative Leader-Follower UAV System to Enable Slung Payload Transportation while Minimizing Swaying Motion of Payload** at IIT Roorkee, India. Sponsored by IHFC, IIT Delhi as PI. In review.

# Experience

## Relevant Publications:

A. Shakya, K. Bithel, G. Pillai and **S. Chakrabarty**, “Deep Reinforcement Learning Based Super Twisting Controller for Liquid Slosh Control Problem,” *IFAC-PapersOnLine*, vol 55(1), pp. 734-739, 2022.

A. Walvekar, Y. Goel, A. Jain, **S. Chakrabarty** and A. Kumar, “Vision based autonomous navigation of quadcopter using reinforcement learning,” *IEEE 2nd International Conference on Automation, Electronics and Electrical Engineering (AUTEEE)*, pp. 160-165, Nov 22-24, 2019, Shenyang, China.

Md. F. Khan, R. K. Gazara, M. M. Nofal, **S. Chakrabarty**, E. M. A. Dannoun, R. Al-Hmouz and M. Mursaleen, “Reinforcing Synthetic Data for Meticulous Survival Prediction of Patients Suffering From Left Ventricular Systolic Dysfunction,” *IEEE Access*, vol. 9, pp. 72661-72669, 2021.

# Keywords

- Deep Reinforcement Learning
- Advanced Robotics
- Robust Control Systems Design
- Feedback Control
- Mobile Robots
- Arm Manipulator
- Trajectory Tracking