GHULAM ISHAQ KHAN INSTITUTE
FACULTY OF COMPUTER SCIENCE AND ENGINEERING

FYP'23

Cutting Edge Real-Time Reinforcement Learning Model Implementation On Autonomous Rover

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Problem Statement

- Reinforcement Learning is not currently used with real time functionality
- Offline models are typically used and the online models used are not trained dynamically, e.g. Tesla
- Current RL models drawback: the agent has to cross the obstacle atleat once
- Existing models don't account for unknown/unprecedented environment

- For Example: Tesla cars cannot operate efficiently in third world countries where roads are riddled with unknown dependencies and conditions
- Our proposed solution: develop a dynamic RL Model that takes real time sensor data as inputs and trains in sync with the simulated environment to propose the optimal pathway

Project Overview

Basic Theory

Our approach is to attempt to develop a system whereby the sensor data is collected and a simulation of the environment is created in real-time. Our RL Model will then take this data as input tensors and perform iterations with our rover as a simulated agent which in turn gives us the optimal pathway. This pathway is then mapped onto the rover as output.

Hardware Fabrication

To demonstrate our Model capability we will be building a Rover with custom designed electronics and hardware. Our primary sensors will be LIDAR and SONAR to work in sync to generate the simulation of nearby environment. The rover will have autonomous navigation, obstacle avoidance and geo-locating capabilities, and can be mapped later onto more specific tasks.

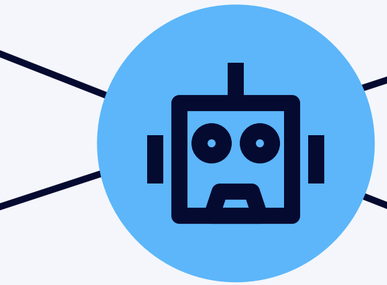
Motivation/ Justification and Ethical Impact

Efficiency

There should be a complete model to replace a human in cases of unknown territory

Accessibility

Perform self driving task in sub-optimal environment like a typical road in a third world country



Technologic Advancement:

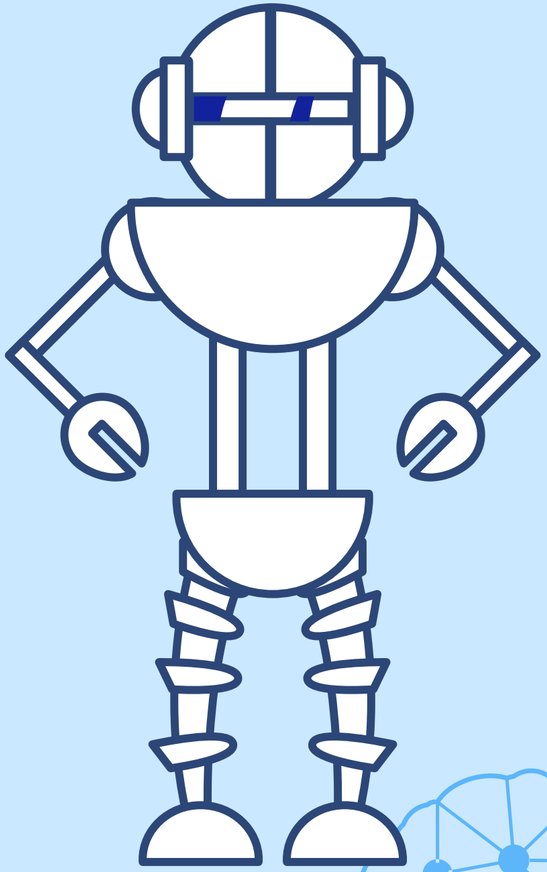
Will improve human lives in applications like medical logistics

Jobs might be affected:

This project aims towards autonomy so it might replace human jobs

Literature Review

- Real-Time Interactive Reinforcement Learning for Robots by Andrea Lockerd Thomaz, Guy Hoffman, and Cynthia Breazeal
- Sim-to-Real Transfer in Deep Reinforcement Learning for Robotics: a Survey by Wenshuai Zhao, Jorge Pena Queralta , Tomi Westerlund
- UGV Navigation Optimization Aided by Reinforcement Learning-Based Path Tracking
- Implementation of Reinforcement Learning Simulated Model on Physical UGV Using Robot Operating System for Continual Learning by Edgar M. Perez, Abhijit Majumdar, Patrick Benavidez and Mo Jamshidi
- Reinforcement Learning and the Reward Engineering Principle by Daniel Dewey



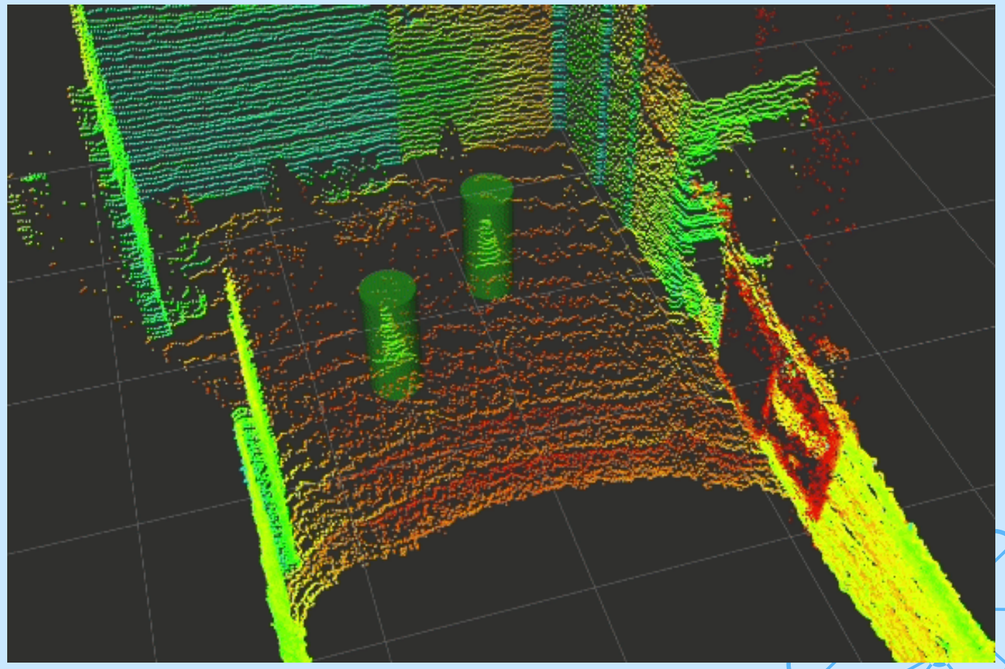
Comparison of Existing Approaches with our Novel Approach

- Existing Online Learning and RL Models don't account for unknown environments and agent has to cross obstacle atleast once
- Real-time training of a dynamic RL Model has never been implemented for autonomy and path-finding
- Our Model will be impartial to the environment and needs no prior training, hence it can work in inhospitable and unknown situations
- Our Model is dynamic and constantly updates in accordance with the environment as it trains in real time whenever an obstacle is encountered

Training Dataset

- We will be using our sensor fleet to generate our own dataset pereodically, in the form of a constantly updating CSV file
- The csv file will then be used to extract input tensor for our model
- The csv file will also be used to construct the virtual 2D Map of the environment

- In case of failure to generate our own dataset, we intend to use pre-trained models



In Depth Engineering/Computing Knowledge

- The scope of this project demands in depth understanding of basic machine learning/deep learning concepts
- Reinforcement Learning and Online Learning, with good understanding of RL concepts like agents/environment, reward and punishment etc.
- We will have to be fluent in python and its libraries like Tensorflow, OpenCV and also in virtual simulator engines like Unity.
- We will have to be familiar with hardware and electronic design and fabrication

Hard Tools

- 3D Printer
- CNC router, laser cutting
- PCB Fabrication Tools

Soft Tools

- IDEs: Arduino, PyCharm, Mujoco, Linux terminal
- Languages: Python, C++ and MATLAB

TensorFlow AUTOCAD

Project Attributes

01 Wide ranging/conflicting technical issues

02 No obvious solution

03 Diverse group of stakeholders

04 Components and sub-parts

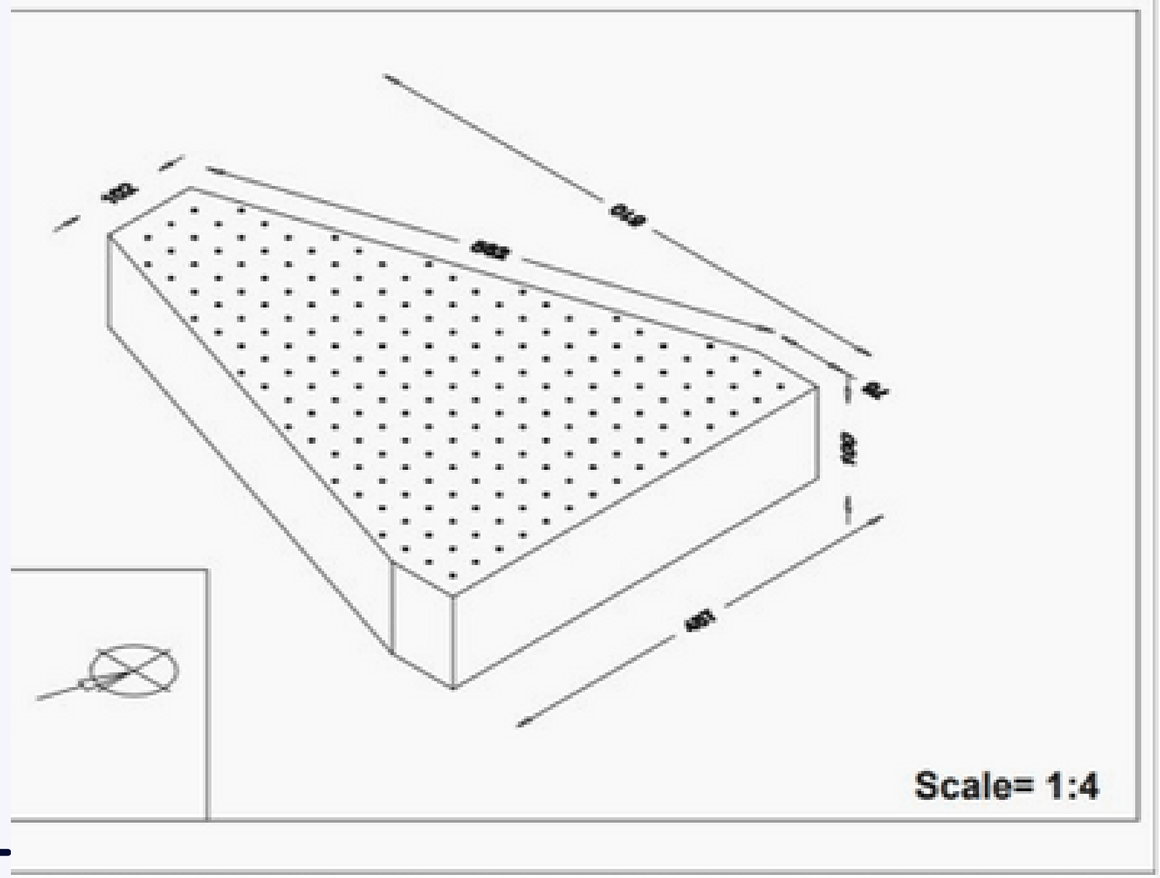
Justification

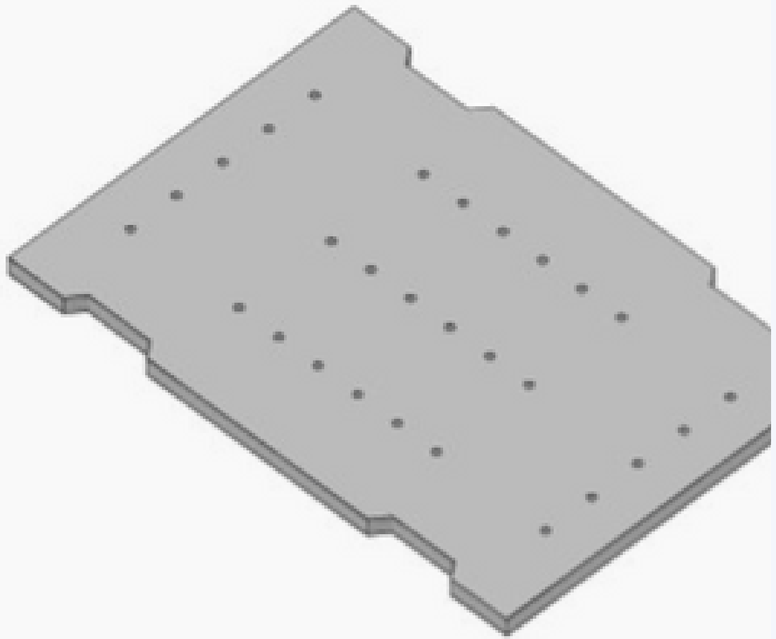
01 There is no microcontroller able to handle on-board training plus we have to generate our own dataset

02 There is no pre-defined solution for real-time model training (online learning)

03 There is no pre-defined solution for real-time model training (online learning)

Rover Fabrication Progress as yet...



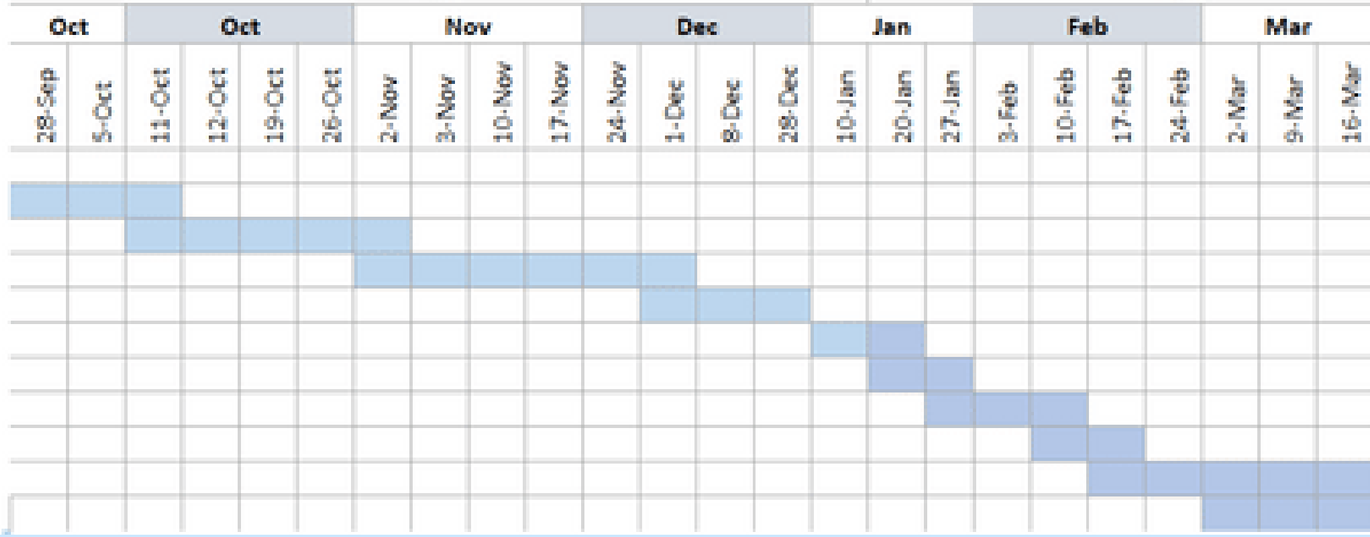


TimeTable and Gantt Chart

Project Start Date: 28-Sep-22

Project Name: eal Time RL Model Impementation on Auto

#	Activity	Start	End	Days	Status	% Done
1	Research and Discussion	28-Sep-22	11-Oct-22	10	In-Progress	50%
2	Familiarizing with IDEs and Languages	12-Oct-22	2-Nov-22	16	Not-Started	0%
3	ML and RL Theory and Implementation	3-Nov-22	1-Dec-22	21	Not-Started	0%
4	Hardware Design and Fabrication	2-Dec-22	28-Dec-22	19	Not-Started	0%
5	Sensor Data Collection and Simulation	10-Jan-22	20-Jan-22	9	Not-Started	0%
6	Testing Hardware on Pre-trained Models	23-Jan-22	30-Jan-22	5	Not-Started	0%
7	Developing our Custom RL Model	31-Jan-22	6-Feb-22	5	Not-Started	0%
8	Testing this Model on Rover	7-Feb-22	14-Jul-22	114	Not-Started	0%
9	Optimizing and Fine Tuning the Finalized Rover	15-Feb-22	1-Mar-22	11	Not-Started	0%
10	Writing final report and/or Research Paper	2-Mar-22	17-Mar-22	12	Not-Started	0%



Workload Distribution

01 **Awaiz Adnan**

- Hardware and Electronics
- RL Model Development
- Hardware and Software Interfacing
- Simulation
- Cloud Deployment

02 **Faiz ul Hasan Gardezi**

- CAD Modeling
- Harware/Chasis Fabrication
- Documentation

03 **Zain ul Furqan Shahid**

- Python Implementation of ML and RL Models
- RL Model Development
- Testing and Debugging

04 **Jahanzaib Khan Ludin**

- Pycharm and Tensorflow
- RL Model Development
- Front-end Development
- Testing

Thank You