

EE/CprE/SE 492 GROUP PROGRESS REPORT

Group number:

sdmay22-45

Project title: Machine Learning in an Embedded Systems Application

Client: Dr.Rover

Advisor: Dr.Rover

Team Members: Tyler Ingebrand, Amy Wieland, Yi Ting Liew, Chris Hazelton, Sean McFadden, Nathan Bruck, Nayra Lujano

- **Project Summary:** *(Short summary about the project. What are the design goals? Has the direction or scope of the project changed? This should be about a paragraph in length.)*

In this project, we are seeing how machine learning can be incorporated into current or future courses at Iowa State. In doing this, we are using reinforcement learning to teach a robot dog how to walk. The robot will be trained in a virtual environment. This will then be deployed on our robot to walk in the physical world. Our goals are to demonstrate machine learning in an embedded application and to make recommendations on incorporating an embedded machine learning course for the department.

- **Accomplishments** *(Please describe/summarize as to what was done, by whom, when and, collectively as a group since the last report. This should be about a paragraph or two in length. Bulleted points are acceptable as well. Please keep only your technical details related to your project. Figures, schematics, flow diagrams, pseudocode, and project related results are acceptable, but please ensure that they are legible (clear enough to read) and to provide an explanation. If researching a topic, please add a few details about what was learned and how it is relevant to the project. If two or more people worked on a single task, be sure to distinguish how each member contributed to the task. Specific details relating to the assistance provided to other members may be included here.)*

Amy: Since the last group report, I have worked on constructing a stretching agent implementation of the agent interface. This involved determining how much we wanted to move each of the servos on the robot to test whether they were working or not and figuring out a way to make sure the code was instructing the robot to change its positions slowly enough. If the amount we increment the servos by was too large, the robot may not have time to reach the desired position before the program takes in the robot's next state. After completing the stretching agent implementation, I have begun working on figuring out how we will load the pytorch model into our c++ application. Based on my research, I will need to utilize the PyTorch C++ API – also known as LibTorch. Our project was initially configured with a Makefile but LibTorch works better with cmake, so I plan to convert our Makefile to cmake.

Chris: I have created an EmbeddedTest.cpp for testing the Petoibittle Agent. I have also looked into what security features can be put onto a raspberry pi and I think the conclusion is to add a basic firewall with a basic ACL (Access Control List), changing the base port of SSH from 22 to some other number so that the port number is not the same as every SSH in existence, have an auto update script that will keep the raspberry pi up to date so the latest security features are on the pi, possibly could install Fail2Ban which will block attackers from entering passwords more than 5 times in a session, some user settings can be changed so that the root user is not as easily accessible. If possible I would like to use SSH keys to log into the PI instead of username and password.

Tyler: I have been working on the Python virtual training. The algorithms are working pretty well for training but the learned behavior is not what we want. Although the behavior satisfies the goals, it does not do so in a stable walk. Thus, I am reward-shaping to make a more stable walk. I may also need to train for longer periods of time as the training curve has not flattened.

Sean: I have been looking for ways to extend our virtual training beyond walking on a flat plane. I have found a research article about training four-legged robots on non-rigid terrain using reinforcement learning. We may incorporate this into our project if we have time. We have also discussed training the robot to walk on gravel. To do this, I have generated rough terrain in Python using Simplex noise to create an uneven surface for the robot to walk on. I am now trying to incorporate this surface into our physics engine to use for virtual training.

Nathan: I have been working with the Raspberry Pi to interface with the individual peripherals of the robot, specifically the IMU and servo driver. Using the WiringPi library that comes with the Raspberry Pi, I have generated code to receive xyz acceleration data as well as xyz rotational data from the IMU. Currently I am working on generating code to write angles to the servos of the robot.

Yi Ting: I have been working on creating the logger where we can log an event for the embedded, or the agent side. So far I have work on writing into a log file whereas I still have to figure out how we can know if the given log could use system time to give context about the timing for the events. In addition, I need to do some research on how I could write to log an events and send them into the one and only file no matter how many times I have to log through.

Nayra:

- **Pending issues** *(If applicable: Were there any unexpected complications? Please elaborate.)*

Python training: Reward shaping is a long and tedious process. The behavior of the model can vary greatly depending on the reward function. I am therefore worried about the reward function and end results, and I will continue to be worried until it works.

Loading Python Model into C++: We need to find the correct way to load our Python model, where we have done the virtual training, into our C++ project to then run on the robot.

○ **Advisor Input/Signature:**

Please select one of the options below and sign.

_____ I am pleased with the progress the team is making.

_____ The team's progress could use some minor improvements which I will discuss with them.

_____ The team's progress has some major concerns that I will discuss directly with Dr. Bigelow

bigelow@iastate.edu , 515-294-4177

Signature:

Progress report Inbox ×



Rover, Diane T [E CPE]

to sdmay22-45@iastate.edu ▼

Team, I've read the progress report and am satisfied with your progress.

Thanks,

Dr. Rover

Diane Rover

University Professor, F. ASEE, F. IEEE

Electrical and Computer Engineering

Iowa State University