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 continued working on getting the c++ application to compile using a cmake file rather than a MakeFile. After talking with Sean, we realized that the dependencies for the embedded side would only work with the raspberry pi and not on a laptop. As a result, I handed off the c++ compilation to Sean since he had the pi to be able to test if the c++ application would compile with the cmake. I created an additional branch on git that doesn't use the pi dependencies for compiling on the laptop to test the neural network agent and anything else that we would want to test using a laptop. I also worked on transferring the logger over to the new c++ application and making some updates to fit our applications needs. The logger now functions with our application and can be used for debugging. Aside from the mentioned tasks, I have been assisting with our final poster and final report.

Chris: Since last group report, I have implemented the following security features on the Raspberry PI. I have changed the user to not use the default PI user as it is the most brute forced account in the world. I have changed the SSH port from its default port 22 so that attackers will be slowed down trying to find the correct entry port into the PI. I have set up an application that will block attackers from trying to enter in passwords for more than 5 times. This can block attackers for as long as you want to block their IPs for. I have set up a firewall so that only certain people can access the PI remotely. I am currently working on a security lab that could be used in a classroom setting.

Tyler: Since the last group report, I did a few different tasks aimed at getting the neural networks ready. First, I wrote a script to convert the NN from .pth to .pt so that we can use it in C++. This script also generates some sample inputs and outputs to check for correctness/corruption. Second, I investigated the units of our state and action to make sure they are consistent between simulation and real life, and fixed bugs relating to that. Since we have found bad results of applying the NN in real life, and we wanted to test if we can make the policy more static, I also changed the environment to only allow small actions. Unfortunately, this changed the learned policy for the same reward function to no longer be walking. Given enough time, it is maybe possible to fix it, but I will not have time in the next two weeks. I also investigated the scale of our units, because too small of a scale led to bad results. Therefore, we had to keep track of an arbitrarily changed scale in order for the magnitude to work in the NN. I also produced a presentation on RL for our advisor/client for her to show to her class.

Sean: I have been working on making sure the servo positions and IMU data the robot uses are the same as in simulation. To do this, I created a way to make micro adjustments to our servo positions to correct any alignment issues caused by how the legs are attached. I have also been debugging a problem where acceleration values when running an agent were much noisier than when we were unit testing. I have been trying to find good balances for how far our neural network agent is allowed to move a servo and how long it should wait to let the servo move.

Nathan: In order to get a stable yaw value from our IMU, I attempted to integrate a 9 DOF IMU to take place of the 6 DOF IMU that came with the robot. In my research to implement the magnetometer I found that our onboard IMU has a Digital Motion Processing unit with proprietary algorithms that will recognize when the yaw is drifting and correct for it. After implementing the library for the DMP, we can now generate stable pitch, roll, and yaw values.

Yi Ting: Since the first draft of my the created poster, I changed the layout for the entire sections to make it looks neat and easy to glance through the words. Before the meeting began, I've messaged Amy to review the second draft and she shared her thoughts via Discord. As the

poster is due on the 28th , we have let our advisor/client to review and share the thoughts if there's any modifications needed in our poster. Our client shared her feedbacks on what we could add on into our poster and also a confirmation that the each of the requirements from poster contents should be included in our project poster as well.

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++: The method to load the python model into C++ required a transition from a Makefile to a cmake file. Configuring the different dependencies needed for the embedded side in the cmake file presented some issues when compiling from a laptop versus a pi.

- **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:

_____

Diane Rover 1:33 PM

I have read the report and am satisfied with the progress of the team. --Dr. Rover