Requirements, Constraints, and Engineering Standards

1.1 Problem Statement

The main goals of our project are to successfully demonstrate embedded machine learning on an interesting application and to make recommendations for incorporating embedded machine learning in a course for the CPR E department. Initially, one of our main tasks has been to decide on what application we would like to apply embedded machine learning to. With the open-endedness of our project, defining requirements has been a little bit challenging as there is not a specific application and hard requirements or constraints detailed in our project abstract.

Our team has decided to train a robot to walk via reinforcement learning as our chosen application for our embedded system machine learning project. The machine learning algorithms that are chosen must be applicable to the robot and, thus, will be restricted to the resources of the robot's embedded system. We plan to utilize a combination of virtual environment and physical environment to train the robot throughout the project time duration.

1.2 Requirements & Constraints

Our functional requirements include training the robot virtually using the OpenAI Gym and MuJoCo toolkits. Virtual training allows us to utilize more computing power for training, and the physical components of the robot will take no wear or damage. The inference process must be done locally on the robot. The robot should be able to walk stably without having to send information to an external device to process the data. Our current goal is to have the robot travel a minimum of three feet within 20 seconds, but this is subject to change once we get access to the robot and test its capabilities.

Another type of requirement the team needs to be aware of is the different types of resource requirements the project has. Firstly, the team intends to use the Petoi Bittle Robot Dog as the test bed for our embedded machine learning application. The reasoning for using the Petoi is because it is easily repairable and we wanted to be able to have a usable device that could easily be repaired and maintained in working condition. With those considerations in mind, the Petoi Bittle is now the chosen platform to use for our application, hence it is a resource we will require. Secondly, we need to ensure that we are using a platform that supports the embedded system usage we are aiming for. Because of this, we will require a resource such as a Raspberry Pi or a type of Microcontroller that allow us to program the Petoi Bittle Robot Dog. These two resources in mind, we will also need to keep our system somewhat modular, since we want to be able to add external functionality to our application for scalability and practical usage for student projects or other classroom and university applications. Lastly, one of the other most important resource requirements we've identified is being able to use resources a

university would have access to for course implementation. This includes using affordable and accessible components and using systems and coding languages the university has access to.

Other requirements of our project include compiling a list of useful machine learning resources that demonstrate new learning the team has acquired as well as attending keynotes at Imagine 2021 and completing the Coursera course on embedded machine learning. These resources and new learning will help facilitate the development of a machine learning course. Additionally, given our project is more open ended, part of the main initial requirements of the project is to define exactly what our project focus will be and figure out what requirements are necessary for the selected application. One of the main goals of the project is to be able to incorporate what we develop and learn into a course at ISU; therefore, it is important that we develop in a way that is modular so that course implementation is feasible.

As for constraints, we are working on a clock and need to have the project done by the end of the spring semester of 2022. We need to be able to get the robot in time and then train the robot.We are working with a budget of $600 which should be plenty as the robot costs $300. Since we are trying to create a class or concepts for a class out of this project, we need to use reusable components such as common coding languages, specifically C++ and Python. The tools that we will be using for training the robot are OpenAI gym and MuJoCo as the 3D simulator training area. The inputs that we get are IMU readings and servo positions and the output that comes from that is raw motor data.

1.3 Engineering Standards

The first engineering standard associated with this project is the UM10204 I^2Cbus specification. The chip onboard the robot is the ATMEGA328 and will not likely have the computing power necessary for our application. The board has the ability to switch communication from the ATMEGA328 chip to an I^2C bus controlled by a Raspberry Pi. The next two standards relate to the design and testing of autonomous robots. The IEEE P1872.2 standard for autonomous robots ontology set guidelines for building autonomous systems consisting of robots operating in various environments, and the P2940 standard for measuring robot agility will provide quantitative test methods that are useful to show how well our robot walks. The Petoi Bittle robot dog is powered by a lithium ion battery pack sized for its current peripheral load. However, as we add more functionality, the battery pack may need to be expanded to accommodate the extra load. The standard that will apply to this is the IEEE 1725-2021 standard for rechargeable batteries for host devices such as mobile phones. Lastly, we may want to incorporate wireless communications for control of the robot, which will be accomplished through the Raspberry Pi. The IEEE 802.11 standard for wireless local area networks will guide our use of the wireless network.

1.4 Intended Users and Uses

Being an open-ended project for a professor, the intended users and uses are more broad. First of all, our project will be a proof-of-concept for creating a machine learning application using a robot in one semester. In doing so, our project will provide resources for learning about and jump starting a machine learning application. The intended use of our project is to demonstrate that a 1 semester course could be designed around machine learning in embedded systems, and to provide resources for creating that course. The user of this project will be Dr. Rover, who will take the information we provide and the results we achieve to determine if she is interested in creating a course.