

Machine Learning for Servo Control

Introduction

Low Earth Orbit satellites are utilized for many systems that are used everyday by much of the world. From communication devices to map imaging, the use of Low Earth Orbit satellites continues to grow at an exponential rate, and with that comes the need for stations on the ground to communicate with and track the satellites. The ground dishes face obstacles in tracking the satellites such as harsh weather which can disrupt the tracking system. These disruptions can be corrected through the use of machine learning programs which can provide servo inputs to keep the ground dish pointed at the satellite. This technical review summarizes techniques used in efficiently controlling machines via machine learning, how machine learning works, and provides a method for efficient autotracking.

Machine Learning to Efficiently Control Machines

Servos are a vital part to many machines. They are devices which can rotate pieces of machinery with precision and efficiency, therefore making them a powerful component in the operation of ground dishes which rotate to track orbiting satellites. In the context of the machine learning application, modern day applications are found often in robot control which “offers the capability of recovering from motion drifts and inaccurate motion planning [1].” This is seen in Industry 4.0’s visual servoing model incorporating a sensor on the robot which uses machine learning to rapidly adjust to outside inputs and provides direct feedback, thus giving the robot faster reaction times. Industry 4.0 uses an image based learning technique to decrease processing time of the robot [1].

Another use of machine learning in the industry is a sorting system operating a machine learning algorithm to sort recyclable material from ZenRobotics. The machine is a complex system but looking specifically at the robotic arm, the algorithm trains the arm to pick the most monetarily valuable items from the belt as long as it is recognized from the sensors sending data [2]. An advantage of the ZenRobotics machine learning over a traditional program in this application is that the model can evaluate several recycling candidates at once and pick a handle position to maximize the success of picking up the selected object [2]. Where a non-adaptive program would have a limited selection in items to choose from and grabbing positions, machine learning can continue to improve its efficiency of choosing the ideal object to recycle as well as improve the effectiveness of the arm by pinpointing strong hold positions.

Technology of Machine Learning Algorithms

Basic Functionality

Machine learning is a computer programming concept that builds on the general idea of coding. Where a typical software project has a fixed number of potential outcomes, machine learning steps in to

create a dynamic environment to adapt the algorithm to unexpected outcomes. The difference between a machine learning algorithm and a typical programming algorithm is the ability to learn from the input data to grow more efficiently over time in a changing environment [3]. For example, a balancing robot with typical programming would be able to be pushed at various levels of force and find its way back to balance after the software ran various computations to calculate the changes needed to be applied. Unless a user has somehow programmed every possible force input into the static program the robot would not ever change the speed at which it balances. However, that same robot given a machine learning algorithm could take the input data over time and know, or estimate, how much force needs to be reapplied after a certain input force is detected. So rather than make slow changes to achieve balance, a well developed machine learning algorithm could estimate the output force needed and reach the balance point faster than a static program. When a program first begins, limited data is available and it would seem as though the machine learning algorithm is no more efficient than a static code structure but over time, with thousands of data points, the program is able to analyze events in the past to use in predictions of future events. Having data points readily available is an essential part of an effective machine learning program as the more data the algorithm has to operate with, the faster and more accurate the predictions will be and efficiency and accuracy are vital to a powerful algorithm [4].

Improvements of Machine Learning

The phrase “Machine Learning” dates back to 1952 and is mostly a concept of dynamic programming leaving little to change to the underlying features. That said, the accessibility of machine learning tools is the largest improvement in recent years [4]. With platforms such as Microsoft Azure and Amazon’s SageMaker, the option to take advantage of machine learning for all has increased exponentially. Azure has block style coding which allows users to drag and drop functionality in place of a standard coding style [5], this gives those with no coding knowledge an option to create a machine learning algorithm for their use. Similarly, SageMaker also has the drag and drop design as well as frameworks to use as a skeleton for a beginner coding step into machine learning [6]. These improvements are not large technological leaps but the more accessible machine learning is, the more people can take advantage to create a smarter and more interconnected world.

Implementation of Machine Learning Into Servos For Autotracking Ground Dishes

Implementation of a machine learning algorithm for servo control in ground dishes should follow a simple enough process and could have a wide range of costs. Given that the auto tracking data will be starting from scratch, sample data could be purchased anywhere from \$8,000 to \$80,000 all depending on the complexity of the data required [7]. The data would not be extraordinarily complex in ground dish use as the servos operate on a single, or at most two, axis to keep the dish pointed correctly meaning the cost

would not reach the extreme heights seen in other algorithm development. Under the assumption there is no algorithm already created for the project, the cost of production for a typical machine learning project is up to \$37,000 once hardware, API, and maintenance are factored in [7]. It's apparent that the cost of the machine learning implementation can vary wildly but the algorithm needed for auto tracking systems would be less complex than the more expensive end of machine learning applications. Sensors would be on the dish to detect anomalies such as load frequencies, thermal or sensor noise, and input saturations would send input data to the machine learning program [6]. The data would be compiled with the previous data in order to improve future calculations. With the current input data of ground dish position, previous satellite position, and position change needed to resume tracking, the algorithm would output signals to the servos with the new desired positions. The servo would then be able to rotate to the position given by the machine learning algorithm and keep the ground dish pointed at the orbiting satellite. As is the case with all effective machine learning software, the more times the algorithm will correct the position of the ground dish, the faster and more accurate the changes would be.

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