Machine Learning and Artificial Intelligence in Botball
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## I. Introduction

Artificial intelligence has been one of the fields at the forefront of computer science and technological innovation, and has become an important part of our daily lives, whether it be in targeted advertising and trend analysis, natural language processing, computer vision, or a whole host of other fields. Of course, robotics and artificial intelligence are very closely intertwined, and understanding artificial intelligence can allow a look into much of the untapped potential it has in the creation of increasingly advanced robots. Botball, as a sort of microcosm of real world robotics, is a great vessel for looking at some of these more advanced concepts and developing and investigating them on a smaller scale. In this paper, we will discuss the potential of, specifically, machine learning and computer vision as it pertains to Botball, and its theoretical uses and implementations (and perhaps how we may already use it!)

## II. A Brief History of Artificial Intelligence

Most people are no stranger to the idea of artificial intelligence: the concept of hyper-intelligent, sentient cyborgs or full-on robots is "well"-explored in many science fiction works. However, artificial intelligence has its roots in somewhat-old mathematical works, which studied the idea of formal reasoning, and led to the development of Alan Turing's theory of computation and the Church-Turing thesis, considered to be pioneering works in computer science. While these concepts are far too complex for the scope of this paper, the foundations, though interesting, are not necessarily needed for understanding how to implement these concepts at higher levels of abstraction. In the realm of our modern time, artificial intelligence is a rapidly growing field, with numerous different applications. Our focus in this paper will be on machine learning, a subset which focuses on self-improving algorithms, which provide great potential in autonomy, which of course is the focus of Botball robotics.

## III. What is Machine Learning?

Machine learning is based on studying and creating algorithms that learn from data, and eventually make predictions based on this data. Machine learning algorithms learn based on some sort of feedback. There are three main categories of machine learning, which are developed based on the type of feedback which is provided: supervised learning, unsupervised learning, and reinforcement learning. In supervised learning, a computer is given a set of data and expected outputs, and the program develops a set of "rules" which are able to map these inputs to outputs, eventually allowing one to extrapolate more accurate outputs from new, unseen data. In unsupervised learning, a computer is simply given a set of data and told to "find a relationship" -- typically, this is used in data mining, when there is a large quantity of data that is un-analyzed, and the computer is asked whether any useful information can be gleaned. For the purposes of robotics, reinforcement learning is most relevant: the focus of reinforcement learning is in interaction with some sort of environment, where feedback is provided as certain "success" or "failure" signals, and the computer (or in this case, robot) eventually maximizes the amount of "successes" it is able to obtain. We may also note developmental learning as another potentially useful technique in robotics: a robot may develop its own "skills" through algorithms which are produced based on its environment. To separate tasks such as these from other machine learning uses, such as in computer vision or data analysis, this subset is referred to as "robot learning".

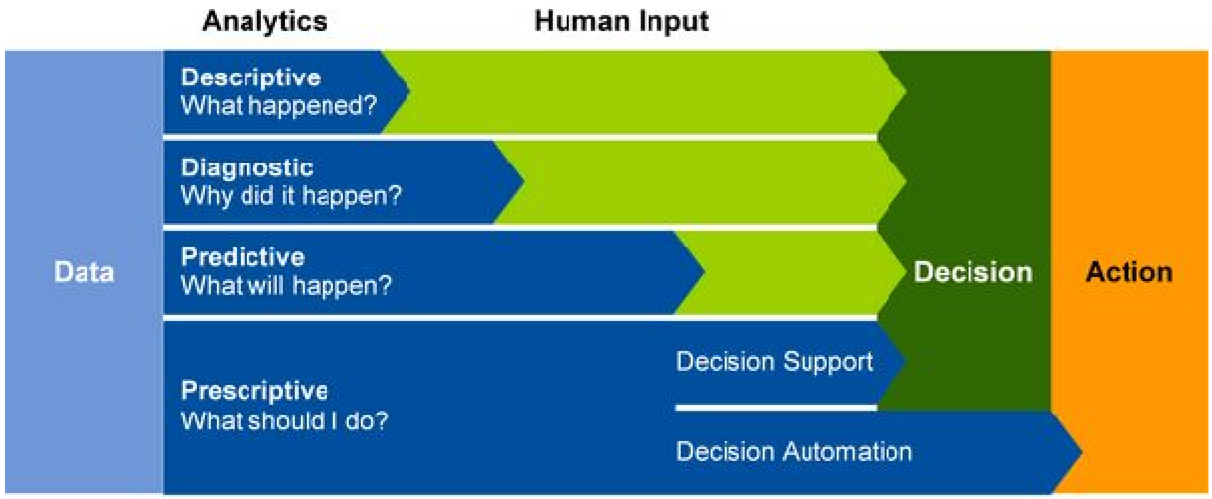


Figure 1: A diagram of machine learning

Figure 1 provides a useful and quick diagram of the process of machine learning. Note that this model closely maps to the way that we (humans) naturally think about processes. For example, in botball, when a robot fails or does not do what we expect, we begin by describing what exactly occurred. Then, we diagnose (or try to diagnose) the problem -- perhaps a part broke, or there was a mistake in the code. The next step is perhaps not as clear a connection: the computer wants to predict an outcome based on previous patterns. However, we can think about this as predicting what will happen given any sort of change. For example, if we remove "x" line of code, what will the robot do? Finally, we should eventually be able to perform an action based on both our previously analysis and our new evidence, which is provided in the form of some new input. In our robot's case, we have plenty of things to look at: walls, point scoring items, etc.

The process of machine learning is very similar to a human thought process when solving a problem: "all" we have to do is have the computer do the thinking on its own.

IV. Possible Implementations of Machine Learning in Botball

Machine Learning is the future of autonomy. From now on, robotics and intelligent systems are the same field in research, development, and in corporate america. Princeton University's robotics school is now called "Robotics and Intelligent Systems." Research done by Princeton on robots and intelligent systems is done by researching not just robots or machine learning systems, but by researching intelligent robots. This research being done on intelligent robots and automated system later gets put to consumer use. Baxter is an intelligent robot made by Rethink Robotics designed to perform small tasks in place of human workers. Baxter uses sensors on its head to adapt to different environments and people nearby, much like how a botball robot must use sensors to adapt to slight differences between the official game board at GCER and the test gameboard a team makes. This can even be seen in this year's Botball game. Many teams pick up and stack the hay bales to score points. Most teams are use a depth (ultrasonic) sensor to find the hay bales in order to pick up and stack them. If a team didn't use a depth sensor, the official game board at GCER may not be the exact same as the game board they built, so their robot may not go the correct distance to be in front of a haybale to pick it up. Robots picking up the hay bales using a depth sensor will be able to adapt to a different distance necessary to pick up a hay bale.

Having teams using sensors to adapt to their environment isn't machine learning though. This puts botball participants at a disadvantage when they look for jobs and internships because they will have no previous experience with practical intelligent robots. It takes a different kind of challenge to make Botball not just autonomous, but intelligent as well. For example, a possible challenge that would require machine learning could be to make the robot run a maze. A create could attempt to navigate the maze by making random turns. When the create hits a wall, its bumper is activated. It then turns and tries a different direction. The create then records whether turn was a right turn, left turn, or a place where it should move straight. The create can use this data to calculate the probability of each turn and guess which way to turn. The create can also record where dead ends are and remember not to go there. The maze would be randomly created before each round.

## V. Conclusion

Botball was made to get young people interested in autonomous robotics and to get them experience in making robots. Botball is an autonomous robotics competition, but the role of autonomous robots in today's society has changed from what it was when Botball was formed. Now autonomous robots are synonymous with machine learning robots. In order to ensure the best future for Botball students, the robotics industry, and the Botball program, Botball should be reformed to include challenges that require teams to build and program intelligent robots.

Works Cited

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