Cynthia Aranda

Esmeralda Morales

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Prof. W. Kuang

Introduction to Reinforcement Learning

 Machine Learning is the study of using algorithms to find patterns in large amounts of data. The sub-branches of machine learning depend on what the data found is used for. Machine Learning can be split off into three categories: unsupervised, supervised, and reinforcement learning. Unsupervised occurs when an algorithm has no particular goal in mind and tries to find patterns on its own. This is used in situations where data needs to be grouped and associated without any outside assistance. Supervised learning uses already grouped and labeled data to make future predictions when put in a certain situation. Supervised learning is used especially in image recognition and detection of wanted patterns. Supervised learning models are one of the most widely used due to their wide variety of applications. Data sets to train a network to recognize handwriting or differentiate between male and female portraits are great for supervised learning networks, but not for learning the best strategy in a game of chess, or knowing when an automated car should speed up or slow down in a busy road. In situations like these, there are too many variables to consider, making data sets for these networks too expensive and time consuming to make, or even impossible. A supervised learning network is also limited to the data set it is being provided, so if there is any human error or bias in a data set that is provided in a network, the network performance will not be as optimized.

 Reinforcement Learning (R.L) models can compensate for all the things supervised learning cannot. Similarly, to how supervised learning uses error to determine how well it is performing, reinforcement learning algorithms use the amount of reward to evaluate their performance. The agent (the algorithm) gets its own data by interacting with the environment it is getting its reward from. There is no target label that the neural network should follow in R.L because a lot of the times the best action to take is unclear in problems reinforcement learning is trying to solve. It is up to the algorithm to find the most optimal sequence of actions to take. Like how the goal of supervised learning is to minimize error, the goal of R.L. is to maximize the reward given to the agent.

 Reinforcement learning requires a learning agent to learn from the environment rather than being guided what to do. The learning agent knows what to do regarding mapping the situation to actions in order to increase the chances of the targeted rewards. As a result, the learning agent relies on past experiences as well as exploring the new choices. With the lack of designated guidelines and uncertain chances of matching the right actions, the reinforcement learning is indeed a trial-and-error learning. In contrast to the supervised approach, optimal strategy by sampling actions and observing which one leads to the desired outcome, this action is learned not from a label but from a time-delayed label called a reward. A numerical reward is used as a reinforcement signal to encourage the learning agent to successfully keep matching the expected outcomes. Thus, the learning agent must learn how to select the right actions that will maximize the accumulated reward. Reinforcement learning emphasizes more on learning a problem rather than learning a method. The learning agents will be guided by the problems they have encountered in past experiences and try to avoid them. Ensuring sensitivity to the environment from which they are deducing the lessons from. This results in relating the state of the environment and the goals they tend to achieve. The chances of getting numerical rewards are determined by the learner’s actions and how well they favor the state of the environment. As most learning goes, the learning agents are required to learn from their own experience rather than an external knowledgeable supervision.

 Reinforcement systems usually develop models of the environment to fully understand the behavior of the environment. The use of models makes it easy for the learning agent to be aware of possible future situations and the reward associated with them. As a result, the reinforcement learning becomes more effective as the learner becomes more aware of which actions pertain to a higher probability of attracting a reward without the need for guidance. The actions the agent take also depend on the discount applied to future actions. If a low discount factor is applied to moving to future states, the agent is going to be incentivized to obtain more immediate rewards instead of finding actions that will maximize reward in the long term. If the discount is high, the agent is going to find ways to maximize long term reward, or value. One of the challenges in Reinforcement learning is finding a balance between immediate and long-term reward.

Reinforcement learning works best with systems that involve hardware or some level of human interaction. For instance, Reinforcement Machine Learning has many applications in control systems. Machine Learning Control is a subfield of Machine Learning where control systems are solved using these techniques. Most notably, control systems become complex and difficult to analyze when they are nonlinear and typical methods of analysis do not apply. Machine learning algorithms allow these kinds of systems to be analyzed and for a model of the system to be found. Experience and data are used to learn what type of controller can be most effective given a particular scenario. One specific application where machine learning can be used to solve a problem is when coefficients of a PID controller transfer function must be calculated. A change in performance of a system can trigger an update in the control law using reinforcement learning. Training procedures involving data from simulations and experiments can be used to find the most suitable control law, or policy, for a given system. In terms of applications on actuation mechanisms, thermal control, turbulence control, and altitude satellites are some of the few examples where Machine Learning can be used. Anything that requires optimization or automation is best handled by Reinforcement Learning models. Although this is a newly discovered model in Machine Learning, it shows a lot of promise and can be the next step to making technology more human.

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