Computer algorithm automatically recognizes soccer formations and defensive strategies

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Credit: Gustavo Rezende/public domain

Though soccer players have assigned roles, it's routine for players to swap positions during the course of a game, or even of a single play. Other players and most fans recognize when this occurs and now, thanks to new work on multi-agent imitation learning, so can a computer.

Researchers at Disney Research, the California Institute of Technology and STATS, a supplier of sports data, used deep learning techniques to develop an algorithm that can automatically recognize formations of teams when analyzing player tracking data.

"To the best of our knowledge, this is the first time an imitation learning approach has been applied to jointly learn cooperative multi-agent policies at large scale," said Peter Carr, research scientist at Disney Research.

From the viewpoint of sports analytics, he noted, this enables a machine to better analyze the play of each athlete in soccer, basketball or other team sports by understanding how players coordinate with each other to shift roles.

"This new capability, however, has applications well beyond sports," said Markus Gross, vice president at Disney Research. "These include robot movement, autonomous vehicle planning and modeling of collective animal behavior."

The team presented its findings Aug. 8 at the International Conference on Machine Learning in Sydney, Australia.

Multi-agent learning is not new, but advances have been modest compared with conventional supervised learning and single-agent reinforcement learning, said Yisong Yue, assistant professor of computing and mathematical sciences at Caltech. That's understandable, he added, given the complexity of the problem and a historic lack of data sources and experimental testbeds.

"The wealth of sports tracking data being amassed by organization such as STATS now makes it possible for computers to learn by watching a bunch of people in action - what's known as multi-agent imitation learning," said Patrick Lucey, director of data science at STATS.

In work presented earlier this year at the MIT Sports Analytics Conference, the Disney, Caltech and STATS team demonstrated that computers could indicate where defending players should have been based on what the attacking team was doing, and identified occasions when defending players were out of position. With this latest work, the computer no longer requires humans to identify the formation being used. Instead, the algorithm is able to discern player roles - and how they change during the course of the game - automatically from the tracking data.

To do so, Yue explained, the researchers extended https://www.stats.com/data-science. single-agent imitation learning approaches into the multi-agent domain by using deep learning, powerful machine learning techniques that use brain-inspired programs called neural networks. But applying deep learning directly to the problem was not sufficient to solve it.

Provided by Disney Research

"If we input raw tracking data to the neural network, it is unable to learn a suitable set of policies that identify the formation," said Hoang Le, Ph.D student at Caltech. "Re-indexing the players at each time step so that the data is arranged in a consistent ordering that reflects the underlying formation of the team is our key insight." In the past, this was handled manually, but the researchers were able to devise a new learning approach that performs this re-indexing automatically, enabling the computer to learn the underlying formation.

In an experiment involving data from 45 games of European professional soccer teams, the researchers used the algorithm to learn the set of roles employed by each team, and then inferred which player was fulfilling each role (not including the goal keepers). They found it substantially outperformed conventional imitation learning methods.

The researchers also ran experiments on a predator-prey simulation game, where four predators and one prey are positioned on a grid. The predators must coordinate their actions to capture the prey in the least possible time. The algorithm quickly approached expert performance, Le noted, far outperforming an unstructured multi-agent imitation learning method, which often failed to capture the prey.

As part of this publication, STATS has released the tracking data to fuel further research in multi-agent learning, noted Patrick Lucey.

Combining creativity and innovation, this research continues Disney's rich legacy of leveraging technology to enhance the tools and systems of tomorrow.

More information: The data is available at