Executive summary - Autonomous Referee

MSD cohort 2023 - 2025

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A new feature has been implemented into the Autonomous Referee project, enabling the determination of which team last touched the ball before it went out of play with an accuracy of 80% and a confidence interval of 73%, compared to a human referee of an accuracy of 97.8%.

The Autonomous Referee project is the first in-house project of the Engineering Doctorate program in Mechatronic Systems Design (MSD), which has been ongoing since 2016 by MSD trainees. This project aims to create an autonomous referee for RoboCup Soccer Middle Sized League (MSL), an international competition where teams of five fully autonomous robots play soccer on a reduced field size.

Currently, the matches are overseen by human referees. Human referees can misinterpret information, are biased and can be influenced by their emotions, causing wrong and inconsistent decisions, impacting the fairness and, potentially, the outcome of matches. There is thus a need for an autonomous referee system that follows the RoboCup MSL rules, is objective and makes consistent decisions in real-time. Furthermore, this system should communicate its decisions with proof to the robots and audience. As multiple years have been working on and will be working on this project, the system should be built upon the progress from previous years. Moreover, the system should be technically challenging and should fit within the interests and learning goals of the trainees.

Due to time limitations, the project scope has to be reduced. We reduced the project scope based on the needs discussed above. In this year's project, the focus is on creating an assistant refereeing system that decides which team touched the ball the last time before it went out of play. This rule has not been implemented before, is hard to detect for human referees (and thereby increasing the objectivity of matches), is technically challenging and fits within the interests and learning goals of the trainees.

Our project introduces an Assistant Referee System, achieved through a comprehensive development approach divided into four key components. Firstly, our sensor system, powered by OptiTrack technology, accurately captures ball and robot positions while filtering out disturbances. Secondly, our ball out of play function determines the ball's location within the field, aiding in identifying the last robot to interact with it. Thirdly, our last touch function employs a random forest classifier to detect robot-ball interactions, optimizing performance through meticulous data pre-processing and hyper-parameter adjustments. Lastly, our communication system employs a straightforward user interface to relay decisions to the referee and receive real-time updates on the game state, ensuring seamless and accurate officiating.

The validation process for the Assistant Referee System involves thorough preparation to ensure seamless integration and functionality before real-world testing. This includes configuring the system

on the Tech United field, calibrating all components for optimal performance, and conducting controlled scenarios to validate its ability to receive and interpret live game data accurately. Validation also confirms that the system receives data only from independent sensors, ensuring autonomy and impartiality during gameplay. Collaborative testing in simulated game scenarios evaluates responsiveness and decision-making capabilities, aiming to refine system performance. Additionally, a match of 2 vs. 2 robots is played, with human referees and the Assistant Referee System used simultaneously, and decisions recorded to meet specified requirements such as distinguishing the last team to touch the ball and making real-time combined decisions. Moreover, the system's ability to communicate decisions when the ball is out of play and demonstrate its decision-making process as needed is showcased.

For future work, it is recommended to scale the OptiTrack system to cover the whole field instead of only half the field and looking into increasing the ball tracking accuracy. Furthermore, increasing the accuracy and robustness of our machine learning model to get closer to human-level performance is recommended. Moreover, it is recommended to extent the algorithm in order to determine which team gets the trow-in, corner or goal kick.