Applying non-invasive technology and machine learning to assess surface properties relevant to player-surface interaction.

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Abstract: Playing surface conditions affect injury risk and performance of players. 91 % of footballers relate risk of injury to the pitch type and conditions (Mears et al., 2018) and there can be a 2.5 x higher injury risk if the rotational traction of the shoe-surface interface is too high (Thomson et al., 2015). Spatiotemporal variability of pitch properties further affects player-surface interaction (Straw & Henry, 2018). Typically, individual soil properties are measured at relatively few points across an entire pitch with several manual tools being used, including a Clegg Impact Soil Tester (CIST) for measuring surface hardness and moisture probes for measuring volumetric water content (VWC). Such measurements give an incomplete assessment of the spatiotemporal varying pitch conditions, can be affected by inter-user variability, change the local pitch properties due to their invasiveness and the laborious nature of testing results in sports grounds pitch being tested too infrequently. A promising alternative means to measure soil properties is use of non-invasive soil sensing methods to create digital soil maps. These methods can non-invasively scan an entire pitch, do not rely on manual operation, and have the potential to predict several soil properties from one scan. To evaluate the potential of data collected with a non-invasive soil sensing method to accurately predict soil properties relevant to player-surface interaction. Pitch data were collected on the training grounds of a professional football club playing in the 1. Bundesliga in Germany. Data collection consisted of manual, sample point measurements of surface hardness with a CIST (2.25kg Type CIST/883) and VWC using a soil moisture probe (POGO Pro). Data collection was performed across multiple days, in varying weather conditions and pitch states. Data were subsequently cleaned to remove outliers. Manual measurements were interpolated to form a grid and each point is matched with non-invasive soil sensing measurements. Weather parameters, such as temperature and cumulative precipitation were used as auxiliary features to improve model performance. Classical machine learning and neural network models were trained in regression tasks. Regression was performed against surface hardness (Gm) displaying an R^2 of 0.915 and RMSE of 3.9 Gm as well as against VWC (%) showing an R^2 of 0.554 and RMSE of 2.6 %. Non-invasive soil sensors allow for easy and quick data collection and show encouraging results for creating predictive digital soil maps for properties that are to-date measured with manual and invasive tools, thus obviating issues associated with these conventional methods. Overall, this facilitates incorporating pitch conditions in informed decision and offers the opportunity to generate novel insights into player-surface interaction.

Keywords: Artificial Intelligence, Soil Sensors, Football, Injury Prevention, Playing Surface Quality.