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Digital Services for Farmers based on Sentinel-2 Satelllite Images and Advanced Machine Learning

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INTRODUCTION:

The world's growing population is putting an immense pressure on agriculture to produce more with less. In the context of conflicting economic, environmental and societal demands, decision-making across the whole supply chain needs to be optimised. In order to make informed decisions, data coming from satellites, drones, sensors and other sources needs to be analysed. However, due to complexity and magnitude of data, advanced machine learning and data analytics algorithms need to be employed.

OBJECTIVES:

This paper tackles two critical tasks in precision agriculture – management zone delineation and yield prediction. Management zones are regions in the field that have large inter-region and small intra-region variability, meaning that their boundaries divide the field into homogeneous zones for which the agronomic operations should be separately adjusted. Secondly, yield prediction is essential for fertiliser optimisation and post-harvest logistics. Fertiliser type and amount are tied to the amount of nutrients extracted from the soil and in order to compensate for this, nutrients need to be replenished. The information about the yield is also key for optimising harvesting, logistics, storage and sales.

METHOD / DESIGN:

The choice of input data depends on the use-case, but generally, there is a trade-off between precision and scalability. Within the scope of image processing, drones may provide high-resolution data, but their use is limited by the need of physical presence of the human operator in regular intervals during the season. Sentinel-2 satellites on the other hand provide images at a 10 m resolution, but cover the whole globe every 5 days on average. For this reason, we chose them as the input data source. For management zone delineation, we calculated different spectral vegetation indices from satellite images and applied the k-means algorithm. The resulting maps were post-processed so that the resolution of the zones fits the width of the fertiliser/pesticide spreader. Yield prediction was set on a per pixel basis. We used the soya yield maps from combine harvesters acquired in the years 2018-2020 for model training (411 ha in total) and a number of machine learning models were implemented, such as: random forest, artificial neural networks, XGBoost and stochastic gradient descent.

RESULTS:

Proposed yield prediction algorithms were evaluated on the test set which included 14 out of 142 soya fields from the database. With the Pearson correlation coefficient of 0.74 and mean absolute error of 0.49 t/ha, stochastic gradient descent achieved the best performance. As for management zone delineation, the tool cannot be validated on a similar basis, as there is no objective division of the field into zones. Rather than that, we left the algorithm parameters, such as choice of the spectral index (from a number of soil and plant-based indices), the number of zones and the width of the machine, to the user to decide on, according to his/her preference, experience and the desired output.

CONCLUSIONS:

The aforementioned machine learning models are essential tools for monitoring crop growth. The resulting maps provide precious information to the farmers, who can optimise their decisions based on them. In order to facilitate rapid transfer of technology from academia to industry, we implemented a management zone delineation module within AgroSense. With more than 20,000 users, and ¼ of all Serbian farmland managed through the system, this technology transfer signifies an important step in digital transformation of agriculture.

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