Optimising Blueberry Production using Aerial and Ground Robots

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Blueberries are perennial crops usually grown on ridges, on a slightly hilly terrain, such as the one found in Central Serbia. Serbia possesses a huge potential for growing this high-value crop, as it is located on the southernmost part of Europe where the Northern highbush variety can be cultivated. This means that the fruits arrive weeks before they do in the rest of Europe, allowing Serbian farmers to achieve higher prices. However, blueberries require a lot of human labour and optimal decision-making based on the state of the crops. The research being conducted is part of Flexigrobots, an H2020 project directed towards applicability of robots in agriculture. The research is split into three parts.

1. **Detection.** The first goal of the project is detection of weeds and diseases. We use the DJI P4 Multispectral UAV imagery in conjunction with convolutional neural networks such as U-net and ResNet, to detect weeds and areas affected by pests and diseases. We also developed a management zone delineation algorithm that uses K-means clustering to detect homogeneous areas inside the field that should have separate strategies for application of irrigation, fertiliser and other operations.
2. **Assessment.** Upon receiving the spatial information about the areas of interest, a UGV will be sent to the spot to detect the presence of weeds and diseases at a high resolution. Moreover, based on the management zones detected in the previous step, the UGV will perform soil analysis. The soil analysis module contains a soil probe for soil sampling at a 30cm depth. The sample is then mixed with water and analysed using the sensor based on a multi-ion selective probe for detecting the following ions NH4+, NO3-, P[HPO42-],K+,Ca2+,Na+. Besides that, UGV is equipped with probes for pH and electrical conductivity measurements, since both of them are very important parameters in blueberry production.
3. **Action.** Based on information acquired by the UAV and UGV, farmers can optimise their decision-making. Firstly, they can adjust the appropriate level and timing of irrigation, thus making cuts in the water spent and reducing the harmful effects of nitrogen leaching. Secondly, based on the level of nitrogen found in the soil, farmers can optimise fertiliser application, thus providing optimal conditions for the growth of crops. Last but not least, the UGV is equipped with a module for precise weed spraying. The module consists of precise ultra low volume (ULV) target-sprayers for weeds, mechanical construction that enable precise positioning of the sprayers. With such a module, the amount of pesticides is minimised, according to the principles of *precision agriculture*.

This research has got a huge potential to optimise blueberry production and substitute manual, tedious tasks of spraying and soil sampling that usually require up to 30 working days per hectare in the hot summer months. It will also contribute to solving the problem of labour shortage and allow farmers to produce more with less.