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Internet of things-based smart system for apple orchards monitoring and management

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ABSTRACT

In this pilot research, a smart monitoring and management system based on Internet of Things (IoT) was developed and realized for apple orchards to monitor the orchard environmental conditions and to forecast the most important disease and pest, as well as to manage irrigation and fertilization. The architecture of the IoT was considered as four layers including perception layer, transport layer, processing layer and application layer. Environmental data in apple orchard was collected on-line with wireless weather and soil sensors (perception layer) and sent to gateway through LoRa radio protocol and then from the gateway to the network server (transport layer) and provided to the software for users. Methods for forecasting apple powdery mildew disease and apple codling moth, as well as thresholds for starting and stopping irrigation were determined and used as bases for decision-making in the system software. Moreover, data processing and required analysis were carried out in the system software along with the presentation of meteorological information, phenology of apple fruit growth stages, and scientific and technical instructions for fertilization in apple orchards (processing layer). A dashboard was also created to visually display the results (application layer). The results showed that the smart system is able to inform the user for the best spraying times and practical recommendations to control the biological threats. Therefore, the losses caused by the disease and pest will be reduced and consequently, the yield will be improved. Evaluation results indicated that the system based on the determined forecasting methods can reduce the number of spraying times (twice instead of at least three times to control apple powdery mildew, and twice instead of four times to control apple codling moth). Therefore, the consumption of fungicides and pesticides is reduced (>33 % and up to 50 %, respectively) which will improve the quality of apples in terms of chemical residues. Moreover, this smart system can help for optimal use of agricultural water according to the tree need with optimal management and irrigation scheduling based on the set thresholds for starting and stopping irrigation. On the other hand, applying fertilization recommendations provided in the system is based on different stages of phenology that helps for optimal fertilizer consumption. In conclusion, the use of this system can help the user to reduce production costs and to increase the quantity and quality of the product by providing timely warnings and practical recommendations regarding spraying, irrigation and fertilization. Considering the effectiveness and technical capabilities, it is recommended to implement the smart monitoring and management system in apple orchards and develop it to manage other basic challenges in such orchards.

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