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Machine Learning-based inference system to detect the phenological stage of a citrus crop for helping deficit irrigation techniques to be automatically applied.

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This paper presents a system that helps farmers to irrigate crops, minimizing water consumption, while productivity is kept, when deficit irrigation techniques are applied, according to the phenological stage of such crop. Such stage is automatically inferred by using a Machine Learning-based technique, which uses single images, which can be acquired by simply using a low cost commercial camera (even the one embedded in a smartphone), as inputs. Specifically, this work compares several Machine Learning approaches, in particular, classical and deep neural networks trained with a dataset obtained from taking multiple real images from a citrus crop. Such images represent different growing stages of the citrus associated to different phenological stages. Since, according to the deficit irrigation approach, the amount of water that can be reduced without affecting the yield depends on the phenological stage of the crop, once such stage is inferred, a Decision Support System uses such information for automatically programming irrigation. The paper also remarks the main advantages of using a single camera as unique sensor in terms of low economic cost as opposed to other systems that uses more expensive and invasive sensors in the crop. In addition, as a smartphone camera could be used as sensor, the smartphone itself could be used as computing device to run the phenological stage detector in real time, and to interact with the Decision Support System by using Cloud and Edge computing technologies. Finally, a set of experiments show the main results obtained after testing different Machine Learning approaches. After comparing such approaches, the best choice is selected to be integrated as a part of the mentioned Decision Support System.