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USING THE EXTENDED KALMAN FILTER TO IMPROVE THE EFFICIENCY OF GREENHOUSE CLIMATE CONTROL

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Abstract. *The efficiency of plant production in greenhouses relies on the measurements provided by several electronic sensors located inside and outside the greenhouse. Environmental conditions such as the direct exposure of sensors to sunlight and the deterioration of connections between sensors and the controllers could result in very noisy and incomplete measurements which may impair the greenhouse operation. It may also increase the number of false alarms received from fault detection and isolation (FDI) systems and reduce its detection capability which, in turn, may result in significant financial losses to the grower. The objective of this paper is to explore the ability of the Extended Kalman Filter (EKF) for improving the efficiency of the greenhouse climate controller by using the on-line estimated air temperature and humidity ratio inside the greenhouse as the controlled variables instead of the observed noisy states. The result suggests that the EKF is able to improve the efficiency of the greenhouse climate control and also increase the sensitivity of failure detectability. This approach is not limited to greenhouses but it is also applicable to any control system installed in a noisy environment.*
Keywords: Online estimation, Uncertainty, Fault detection and isolation, State feedback, Climate control

1. **Introduction.** The greenhouse climate control (GCC) problem is to create a favorable environment to improve the development of plantations and to minimize the price of production in terms of raw materials and energy consumption. The creation of a favorable environment inside a greenhouse requires the regulation of all relevant variables in the development of the plant; notably air temperature and humidity ratio. Optimal air temperature and humidity conditions could be obtained by the application of advanced controllers and highly sophisticated models. These in turn require regular attention from the user due to the continuously changing circumstances in terms of plant growth, changing material prosperities and modifications in greenhouse design and layout. Moreover, the uncertainty in sensory measurements due to accumulated wear and tear could impair the greenhouse operation. In an attempt to improve the efficiency of the greenhouse climate control, the Extended Kalman Filter (EKF) is proposed to handle such measurement and modeling uncertainties.

Over the last few decades, the control design of the climatic conditions in greenhouses has seen considerable interest. Several authors have contributed to the development of greenhouse modeling and identification [1-6], intelligent greenhouse climate control [7-14] and fault detection and isolation in greenhouses [15-20]. Recently, measurement and modeling uncertainties in greenhouses have been addressed and a solution based on using type-2 fuzzy logic controller has been proposed [21]. The number of studies that investigate the use of EKF in greenhouse climate control is fairly limited. In other fields