UNIVERSITY OF SALERNO

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APPLICATION OF DIGITAL TWIN MODELS IN THE FRUIT SUPPLY CHAIN

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Abstract

The goal of this study is to investigate the fundamental principles underlying the use of the digital twin in common industrial operations and the agri-food supply chain, as well as the development of methodologies and frameworks for the digital twin to reduce the waste of fresh produce, particularly fruits. Thus, the study began with the identification of basic concepts related to the digital twin and its advances in the agri-food supply chain. Moreover, methodologies and a general framework for implementation have been suggested based on the operating model of the Italian food bank (Banco Alimentare Campania Onlus), which includes fruit donors, the food bank, and local charity groups as supply chain actors.

First, a detailed review has been performed to explore the fundamental concepts of the digital twin application in the main industrial activities, including production, predictive maintenance, and after-sales services. This is followed by a section with an analysis of existing literature on the use of digital twins in the agri-food supply chain, which has recently attracted the attention of many research institutes and companies. In this sector, digital twin could be used to monitor the real-time status of fresh produce as well as supply chain activities, although the approaches are not specified. In the third chapter, a machine learning-based digital twin technique was devised and applied to track the evolution of fruit quality changes throughout storage, and good prediction accuracy was achieved to develop product twin. The fourth part of the study has focused on the creation of a cloud analytics-based digital twin capable of efficiently reducing fruit loss at the inventory level using historical time-series data. The fifth section of the study demonstrates the possible use of digital twins for near-real-time optimization of fruit deliveries from the food bank to local charity organizations, which is also regarded to have a considerable improvement in fruit waste reduction, which is mostly driven by limited fleet size and long routes during transportation. The last section presents a general framework of a fruit supply chain digital twin model, which includes an integrated solution for monitoring fruit quality status, inventory planning, and delivery optimization.

According to this research, despite a lack of common understanding of the concept, digital twin applications could enhance operational performance in many industrial sectors, including the agri-food supply chain. The proposed methods could also increase visibility in the fruit supply chain, reducing waste and meeting additional sustainability goals.