

Digital Twins in Agriculture: implementation challenges for the North Wyke Farm Platform

Ensuring food insecurity, in the context of climate change, is a major challenge of the 21st century. As a component to this challenge, it is necessary to monitor and control productivity from agriculture, while at the same time balance ecological priorities with those of food security. Timely decisions to achieve this need to be taken with coherence across local (the farmer) and global (policy) scales, where farming needs to be both sustainable and resilient. Typically, agroecosystem models provide a means to objectively inform decisions, where for improving resilience, simulated impacts due to consecutive droughts, increased incidence of extreme rainfall, increased incidence of pest or disease outbreaks can be generated. This virtual environment can be taken a step further where the (physical) agroecosystem models are hybridised with statistical and machine learning models, that are in turn dynamically informed (evaluated and refined) with real-time IoT data. This constitutes a digital twin of the system, where uncertainties associated with the data and those associated with model parameterisation are captured throughout, so that for any given simulation scenario, realistic estimates of error and risk are captured.

Set within an interactive visual environment, the digital twin enables insight and discovery. Core to this endeavour is the digital infrastructure underpinning the virtual representation of the real-world farm system at different stages of its life cycle. The North Wyke Farm Platform at Rothamsted Research serves as an ideal resource for implementing digital twins at the farm scale. The platform is a globally unique facility set up to research pasture-based livestock production systems and optimal land use. It provides an extensive range of in situ instrumentation that generates big data from three outdoor farms; two sheep / cattle grazed, the third arable; and a fourth indoor cattle farm. Since its establishment in 2010, the platform has openly delivered 74.7 million measurements of mixed resolution data on farm inputs, outputs and events, coupled with a wealth of research outputs (<https://nwfp.rothamsted.ac.uk/>).

To implement the platform's digital twin significant challenges are present. These are multidisciplinary with the following interlinked themes considered core: (i) conceptual frameworks for digital twins; (ii) system-scale agricultural research through expertise in soils, crops, livestock, biodiversity, gaseous emissions, water emissions; (iii) digital workflows for data collection (non-IoT and IoT) and (ground and remote) sensing; (iv) digital workflows for data management, processing (quality control, infilling, anomaly detection) and fusion (given varying scales of support and process); (v) development of hybrid models and ensembles; (vi) software design for digital twin platforms / applications; and (vii) co-development with stakeholders from research to farm advisors to policy.

For this talk, emphasis will be placed on themes (iii) to (v).