

# Human-centric interoperability Method for Greenhouse Digital Twins in Metaverse era

Lin Yang *IEEE member*  
College of Engineering  
Huazhong Agricultural University  
Wuhan, China  
lin.yang@hzau.edu.cn

Tong Pang  
College of Engineering  
Huazhong Agricultural University  
Wuhan, China  
pangtong@webmail.hzau.edu.cn

Giancarlo Fortino *IEEE Fellow*  
Department of IMES  
University of Calabria  
Rende, Italy  
giancarlo.fortino@unical.it

Qing Yang  
Department of IMES  
University of Calabria  
Rende, Italy  
yngqng81p14z210d@studenti.unical.it

Xin Yang  
Leibniz Centre for Agricultural  
Landscape Research  
Müncheberg, Germany  
isyang\_xin@163.com

Claudio Savaglio  
Department of IMES  
University of Calabria  
Rende, Italy  
csavaglio@dimes.unical.it

**Abstract**—With the emerging of Digital twins (DT) and Internet of Things technologies in the field of smart agriculture, the agricultural metaverse (AM) is becoming a research hotspot currently. Massive networked and intelligent sensors and agricultural robots are deployed in greenhouses, and factory greenhouses have become one of the most potential AM application scenarios. Moreover, the interoperations feature of multi-robots leads the AM agricultural production system to be more complex, such as self-organization and autonomous collaboration of greenhouse facilities and robots. On the one hand, in unmanned or less-manned greenhouse indoor production, it is needed the agricultural machines/robots controlling to match the crop growth rhythms; on the other hand, in greenhouse outdoor production, it is preferred crop production rhythms to match the social disturbances, such as dynamic social factors of agricultural product transportation, customer customization, and agricultural order changes in socialized greenhouses etc. Such rhythms and beat consistency problems are close related to the interoperability between humans and the Internet of Things. However, the current research of agricultural DT or agricultural metaverse rarely reports on these issues. To this end, this paper explores a human-centric interoperability method for the greenhouse DT, in the era of the future agricultural metaverse. First, a smart greenhouse DT model is built, including greenhouse digital twins, crop growth models, and facility control modules; Second, based on the greenhouse DT, a human-centered interoperability framework is proposed for socialized greenhouses. Finally, a prototype system of greenhouse DT is designed, to verify the feasibility of the human-centered interoperability method.

**Keywords**—Smart Agriculture, Greenhouse, Agricultural Metaverse, Human-centric interoperability, Digital Twin

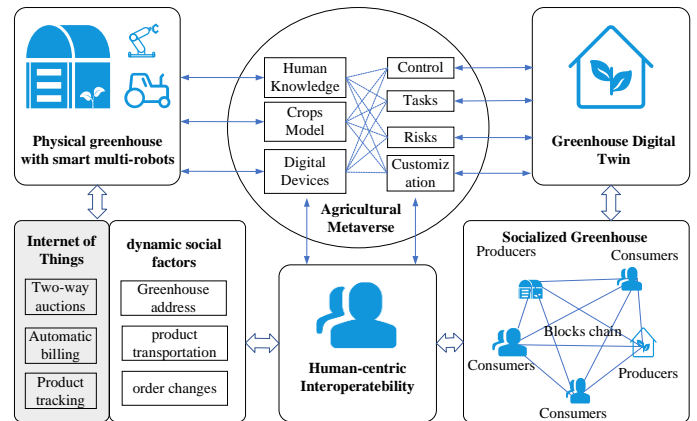


Figure 2 A human-centric interoperability framework

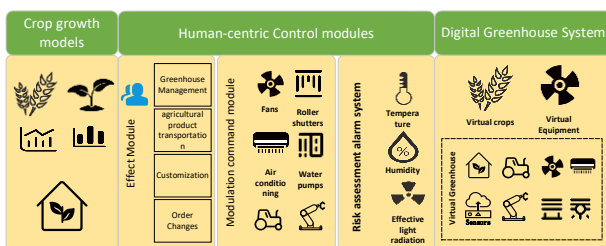


Figure 1 Greenhouse digital twin