A Case Study of Digital Twin for Greenhouse Horticulture Production Flow

温室园艺生产流程中的数字双胞胎案例研究2022

Abstract: Greenhouse horticulture production is associated with high uncertainty and a long learning process due to its high dependency on the outdoor & indoor environment and plant types. Digital Twin (DT) technology enables a faster understanding of greenhouse horticulture facilities, obtaining insight into the production process flow and investigating the consequences of production decisions. However, no digital twin has been developed in this field due to the complexity of greenhouse production. Therefore, this paper presents a case study of a DT development for a Danish greenhouse production flow using multi-method modeling and multi-agent simulation. The results show that the developed DT can accurately represent the greenhouse production process and estimate the plant growth state with an absolute error of 0.31 days compared to the observed production. Furthermore, the developed DT can accurately predict deviations to the plant growth state corresponding to previously observed behavior at the facility. To capture the greenhouse production process flow at the top-level greenhouse DT agent, the underlying physical agents developed included: compartments, growth climate, conveyors, staff, tables, plants, soil machine, table loading, and packing station as well as the packing station. Lastly, the developed DT method supports agent re-usability for other case studies.

摘要：温室园艺生产由于高度依赖室外和室内环境以及植物类型，因此具有高度的不确定性和漫长的学习过程。数字双胞胎（DT）技术能够更快地了解温室园艺设施，深入了解生产流程，调查生产决策的后果。然而，由于温室生产的复杂性，在这一领域还没有开发出数字双胞胎。因此，本文介绍了一个使用多方法建模和多代理仿真对丹麦温室生产流程进行DT开发的案例研究。结果表明，开发的DT可以准确地表示温室生产过程，并估计植物生长状态，与观察到的生产情况相比，绝对误差为0.31天。此外，开发的DT可以准确地预测植物生长状态的偏差，与之前观察到的设施行为相对应。为了捕捉顶级温室DT代理的温室生产流程，所开发的基础物理代理包括：隔间、生长气候、传送带、工作人员、桌子、植物、土壤机、装台、包装站以及包装站。最后，所开发的DT方法支持代理人在其他案例研究中的可重复使用。

D. A. Howard, Z. Ma and B. N. Jørgensen, "A Case Study of Digital Twin for Greenhouse Horticulture Production Flow," 2022 IEEE 2nd International Conference on Digital Twins and Parallel Intelligence (DTPI), Boston, MA, USA, 2022, pp. 1-6, doi: 10.1109/DTPI55838.2022.9998914.

Data Architecture for Digital Twin of Commercial Greenhouse Production2020

商业温室生产的数字双胞胎的数据架构

There is an increasing demand for industry-specific solutions for optimizing production processes with the transitions towards Industry 4.0. The commercial greenhouse sector relies heavily on optimal use of energy with multiple new concepts introduced in recent years e.g. vertical farming and urban agriculture. Digital twins allow utilizing the Internet of Things and big data to simulate the alternative operation strategies without compromising current operation. This paper aims to present the development of a digital twin of the commercial greenhouse production process as a part of the recently launched EUDP funded project Greenhouse Industry 4.0 in Denmark. This digital twin allows using big data and the Internet of Things to optimize the greenhouse production process and communicate with other digital twins representing essential areas in the greenhouse (climate and energy). This digital twin can estimate future states of the greenhouse by using past and real-time data inputs from databases, sensors, and spot markets. This paper also introduces a Smart Industry Architecture Model Framework for the discussion of the required data architecture of the digital twin for the greenhouse production flow which ensures a correct data architecture for the data exchange across all entities in the system.

随着向工业4.0的过渡，对优化生产过程的特定行业解决方案的需求越来越大。商业温室领域在很大程度上依赖于能源的优化利用，近年来引入了多种新概念，如垂直耕作和城市农业。数字双胞胎允许利用物联网和大数据来模拟替代的操作策略，而不影响当前的操作。本文旨在介绍商业温室生产过程的数字双胞胎的发展，作为最近在丹麦启动的欧盟发展计划资助的温室工业4.0项目的一部分。这个数字孪生体允许使用大数据和物联网来优化温室生产过程，并与代表温室重要领域（气候和能源）的其他数字孪生体沟通。这个数字孪生体可以通过使用来自数据库、传感器和现货市场的过去和实时数据输入来估计温室的未来状态。本文还介绍了一个智能产业架构模型框架，用于讨论温室生产流程所需的数字孪生体的数据架构，确保系统中所有实体的数据交换有一个正确的数据架构。

D. Anthony Howard, Z. Ma, J. Mazanti Aaslyng and B. Nørregaard Jørgensen, "Data Architecture for Digital Twin of Commercial Greenhouse Production," 2020 RIVF International Conference on Computing and Communication Technologies (RIVF), Ho Chi Minh City, Vietnam, 2020, pp. 1-7, doi: 10.1109/RIVF48685.2020.9140726.

Smart Autonomous Greenhouse Design Modeling and Simulation as a Variable Structure Automatic System2021

作为可变结构自动系统的智能自主温室设计建模和模拟

This paper describes our project to design a Smart Autonomous Greenhouse (SAG) and proposes a methodology of modeling suitable for simulation, analysis and control. This kind of Systems permanently interact with its environment. The smart greenhouse is equipped with a distributed control system using IoTs, wireless-sensors and actuators. We propose a Variable Structure and Switched System Models (VSAS) class for a robust modeling and control approach. VSAS models allow us to develop a Virtual Twin of the Smart Connected Greenhouse.

本文描述了我们设计智能自主温室（SAG）的项目，并提出了一种适合模拟、分析和控制的建模方法。这种系统与它的环境长期互动。该智能温室配备了一个使用物联网、无线传感器和执行器的分布式控制系统。我们提出了一个可变结构和开关系统模型（VSAS）类，以实现强大的建模和控制方法。VSAS模型使我们能够开发一个智能互联温室的虚拟双胞胎。

N. K. M’Sirdi, F. Aubepart and A. Belhani, "Smart Autonomous Greenhouse Design Modeling and Simulation as a Variable Structure Automatic System," 2021 9th International Renewable and Sustainable Energy Conference (IRSEC), Morocco, 2021, pp. 1-7, doi: 10.1109/IRSEC53969.2021.9741159.

Proposal of an IoT Architecture for Greenhouse Monitoring2022

用于温室监测的物联网架构的建议

Agriculture is an industry that is essential for the food supply for the world population. Although this industry is so important, there are many challenges associated with it, such as the pollution/waste present in the agricultural practices and the aging of the farmers. The application of technological solutions can provide a way to solve these challenges, by retrieving data from the physical environment, based on which future decisions can be taken, using actuators. The goal of this work is to present an architecture through which the different layers can communicate with each other’s, and then based on this architecture develop a system that can help monitor the agricultural fields. The project is applied in a controlled environment (a greenhouse), and the objective is to verify both the waste of water within the cultures, and if there are benefits in changing the plastics used on top of the soil in terms of production, from the traditional one (black), to a plastic that is white and thicker.

农业是一个对世界人口的食物供应至关重要的行业。虽然这个行业如此重要，但也有许多相关的挑战，如农业实践中存在的污染/废物和农民的老化。技术解决方案的应用可以提供一种解决这些挑战的方法，通过从物理环境中检索数据，在此基础上，可以利用执行器做出未来的决定。这项工作的目标是提出一个架构，通过这个架构，不同的层可以相互沟通，然后基于这个架构开发一个可以帮助监测农田的系统。该项目应用于受控环境（温室），目的是验证培养物中水的浪费情况，以及从传统的塑料（黑色）到白色和更厚的塑料，改变土壤顶部使用的塑料是否对生产有好处。

V. Lisnic, F. Ferrada and P. Correia, "Proposal of an IoT Architecture for Greenhouse Monitoring," 2022 International Young Engineers Forum (YEF-ECE), Caparica / Lisbon, Portugal, 2022, pp. 45-51, doi: 10.1109/YEF-ECE55092.2022.9850210.

Guidelines for Digital Twins in 5G Agriculture2022

5G农业中的数字双胞胎指南

New devices for the Internet of Things (IoT) and 5G enable monitoring and controlling of environments and objects in agriculture and other areas. Digital Twins is a growing concept connecting IoT with applications to automate agriculture, predicting crop behavior through data analysis. However, there is a conceptual gap between the digital twin concept and its application to real development. This work proposes a novel meta classes model to guide designs on digital twins in agriculture based on a bibliometric analysis to identify the current works in the area. The proposed design considers several meta classes such as communication devices, sensors, actuators, historical sensing, visualization, Human-Machine Interfaces, decisions, physical objects, and physical sectors. These meta-classes can work on a Jetson nano processor or a Raspberry Pi because they can be implemented in several languages and frameworks.

物联网（IoT）和5G的新设备能够对农业和其他领域的环境和物体进行监测和控制。数字双胞胎是一个不断增长的概念，将物联网与应用连接起来，实现农业自动化，通过数据分析预测农作物行为。然而，在数字孪生的概念和它在实际发展中的应用之间存在着概念上的差距。这项工作提出了一个新的元类模型，以指导农业中的数字双胞胎设计，该模型基于文献计量分析，以确定该领域的当前工作。拟议的设计考虑了几个元类，如通信设备、传感器、执行器、历史感应、可视化、人机界面、决策、物理对象和物理部门。这些元类可以在Jetson nano处理器或Raspberry Pi上工作，因为它们可以用几种语言和框架实现。

D. Fuentealba, C. Flores, I. Soto, R. Zamorano and S. Reid, "Guidelines for Digital Twins in 5G Agriculture," 2022 13th International Symposium on Communication Systems, Networks and Digital Signal Processing (CSNDSP), Porto, Portugal, 2022, pp. 613-618, doi: 10.1109/CSNDSP54353.2022.9907935.

A digital twin for smart farming2019

智能农业的数字双胞胎

This paper presents a digital twin in the agriculture domain by leveraging the technologies developed by Sensing Change and the Smart Water Management Platform projects. The Sensing Change project developed a soil probe whereas the SWAMP project is currently developing an Internet of Things platform for water management in farms. This paper leverages the technologies developed by those projects by building an initial digital environment to create a cyber-physical-system (CPS) so farmers can better understand the state of their farms regarding the use of resources and equipment. We conclude that our system can gather data from the soil probe and display its information in a dashboard which enables for further deployment of more soil probes and other monitoring and controlling devices to create a fully operating digital twin.

本文通过利用 "传感变革 "和 "智能水管理平台 "项目开发的技术，介绍了农业领域的数字双胞胎。Sensing Change项目开发了一个土壤探测器，而SWAMP项目目前正在为农场的水管理开发一个物联网平台。本文利用这些项目开发的技术，建立了一个初步的数字环境，以创建一个网络物理系统（CPS），使农民能够更好地了解他们农场的资源和设备的使用状况。我们的结论是，我们的系统可以从土壤探测器中收集数据，并将其信息显示在一个仪表板上，从而可以进一步部署更多的土壤探测器和其他监测和控制设备，以创建一个完全运行的数字双胞胎。

R. G. Alves et al., "A digital twin for smart farming," 2019 IEEE Global Humanitarian Technology Conference (GHTC), Seattle, WA, USA, 2019, pp. 1-4, doi: 10.1109/GHTC46095.2019.9033075.

The Development of AgriVerse: Past, Present, and Future2023

AgriVerse的发展： 过去、现在和未来

Abstract:Agricultural metaverse (AgriVerse) aims to optimize the production chain by saving costs, increasing efficiencies, and breaking information silos, in order to achieve sustainable agriculture. While AgriVerse is featured by the virtual-real interaction of the agriculture-related processes based on heterogeneous data, knowledge, and models, the link between AgriVerse and the intensively studied plant modeling is vague. This article presents briefly the research contents of plant modeling, analyzes the ongoing transition at the age of artificial intelligence (AI), and envisions future AgriVerse with the support of the agricultural foundation model, the decentralized agricultural organization (DAO) and the decentralized science (DeSci) of the plant model. Three AgriVerse application scenarios are presented. The opportunities and challenges of AgriVerse are discussed. This work is expected to identify the key research issues of AgriVerse and bring practitioners of diverse backgrounds together into the AgriVerse community.

摘要：农业元空间（AgriVerse）旨在通过节约成本、提高效率和打破信息孤岛来优化生产链，以实现可持续农业。虽然AgriVerse的特点是基于异质数据、知识和模型的农业相关过程的虚拟-真实交互，但AgriVerse与深入研究的植物建模之间的联系是模糊的。本文简要介绍了植物建模的研究内容，分析了人工智能（AI）时代正在进行的转型，并设想了在农业基础模型、分散的农业组织（DAO）和植物模型的分散科学（DeSci）支持下的未来AgriVerse。介绍了三种AgriVerse的应用场景。讨论了AgriVerse的机遇和挑战。这项工作有望确定AgriVerse的关键研究问题，并将不同背景的从业者聚集到AgriVerse社区中。

M. Kang, X. Wang, H. Wang, J. Hua, P. d. Reffye and F. -Y. Wang, "The Development of AgriVerse: Past, Present, and Future," in IEEE Transactions on Systems, Man, and Cybernetics: Systems, vol. 53, no. 6, pp. 3718-3727, June 2023, doi: 10.1109/TSMC.2022.3230830.

Agricultural Metaverse: Key Technologies, Application Scenarios, Challenges and Prospects

农业生态圈： 关键技术、应用场景、挑战和前景

As an emerging concept, metaverse has attracted extensive attention from industry, academia and scientific research field. The combination of agriculture and metaverse will greatly promote the development of agricultural informatization and agricultural intelligence, provide new impetus for the transformation and upgrading of agricultural intelligence. Firstly, to expound feasibility of the application research of metaverse in agriculture, the basic principle and key technologies of agriculture metaverse were briefly described, such as blockchain, non-fungible token, 5G/6G, artificial intelligence, Internet of Things, 3D reconstruction, cloud computing, edge computing, augmented reality, virtual reality, mixed reality, brain computer interface, digital twins and parallel system. Then, the main scenarios of three agricultural applications of metaverse in the fields of virtual farm, agricultural teaching system and agricultural product traceability system were discussed. Among them, virtual farm is one of the most important applications of agricultural metaverse. Agricultural metaverse can help the growth of crops and the raising of livestock and poultry in the field of agricultural production, provide a three-dimensional and visual virtual leisure agricultural experience, provide virtual characters in the field of agricultural product promotion. The agricultural metaverse teaching system can provide virtual agricultural teaching similar to natural scenes, save training time and improve training efficiency by means of fragmentation. Traceability of agricultural products can let consumers know the production information of agricultural products and feel more confident about enterprises and products. Finally, the challenges in the development of agricultural metaverse were summarized in the aspects of difficulties in establishing agricultural metaverse system, weak communication foundation of agricultural metaverse, immature agricultural metaverse hardware equipment and uncertain agricultural meta universe operation, and the future development directions of agricultural metaverse were prospected. In the future, researches on the application of metaverse, agricultural growth mechanism, and low power wireless communication technologies are suggested to be carried out. A rural broadband network covering households can be established. The industrialization application of agricultural meta universe can be promoted. This review can provide theoretical references and technical supports for the development of metaverse in the field of agriculture.

作为一个新兴的概念，元空间已经引起了产学研领域的广泛关注。农业与元空间的结合将极大地促进农业信息化和农业智能化的发展，为农业智能化的转型升级提供新的动力。首先，为了阐述元数据在农业领域应用研究的可行性，简要介绍了农业元数据的基本原理和关键技术，如区块链、不可伪造代币、5G/6G、人工智能、物联网、三维重建、云计算、边缘计算、增强现实、虚拟现实、混合现实、脑机接口、数字双胞胎和并行系统。然后，讨论了元空间在虚拟农场、农业教学系统和农产品溯源系统等领域的三个农业应用的主要场景。其中，虚拟农场是农业元数据的最重要应用之一。农业元数据可以帮助农业生产领域的农作物生长和畜禽饲养，提供立体化、可视化的虚拟休闲农业体验，在农产品推广领域提供虚拟人物。农业元数据教学系统可以提供类似于自然场景的虚拟农业教学，缩短培训时间，提高培训效率。 通过碎片化的方式缩短培训时间，提高培训效率。农产品的可追溯性可以让消费者了解农产品的生产信息，对企业和产品更加放心。最后，从农业元宇宙系统建立困难、农业元宇宙通信基础薄弱、农业元宇宙硬件设备不成熟、农业元宇宙运行不确定等方面总结了农业元宇宙发展中的挑战，并展望了农业元宇宙的未来发展方向。建议今后开展元宇宙的应用、农业增长机制、低功耗无线通信技术等方面的研究。可以建立一个覆盖家庭的农村宽带网络。可以推动农业元宇宙的产业化应用。本综述可以为元宇宙在农业领域的发展提供理论参考和技术支撑。

# The Possible Future for Agricultural Products and Medicinal plants in Metaverse2022

农产品和药用植物在Metaverse的可能前景

Metaverse的新概念试图创造一种与现实生活目标相似的虚拟生活。虽然它的机制到目前为止还没有得到很好的确认，但根据目前的数据，显然，一些设施，如VR和AR可以为农业和药用植物方面提供一个多元的空间。这种第四代技术将在农业价值链的环环相扣中发挥重要作用，并在用户和产业链之间，以及在地球和生产及消费领域之间建立一种新的理解。从理论上讲，本文试图定义一些与Metaverse技术有关的共同特征，然后说明这一未来工具如何监测人类及其农产品从生产前阶段到消费后阶段的情况；然后阐明人类如何能够成为周围生态系统其他部门的旅行者，深入了解每个决定和行动对地球其他地区的影响。最后，为了解决人类面临的问题，将描述在元空间中创建 "个人用户元数据 "的重要性，尽管底层的方法很复杂，但却产生了一个简单的解决方案，就像我们在自然界的土壤机制中可能看到的那样。

DeCASA in AgriVerse: Parallel Agriculture for Smart Villages in Metaverses

AgriVerse中的DeCASA： Metaverses中智能村庄的平行农业

Briefing: The demand for food is tremendously increasing with the growth of the world population, which necessitates the development of sustainable agriculture under the impact of various factors, such as climate change. To fulfill this challenge, we are developing Metaverses for agriculture, referred to as AgriVerse, under our Decentralized Complex Adaptive Systems in Agriculture (DeCASA) project, which is a digital world of smart villages created alongside the development of Decentralized Sciences (DeSci) and Decentralized Autonomous Organizations (DAO) for Cyber-Physical-Social Systems (CPSSs). Additionally, we provide the architectures, operating modes and major applications of DeCASA in Agri-Verse. For achieving sustainable agriculture, a foundation model based on ACP theory and federated intelligence is envisaged. Finally, we discuss the challenges and opportunities.

简讯： 随着世界人口的增长，对食物的需求也在极大地增加，这就需要在气候变化等各种因素的影响下发展可持续的农业。为了应对这一挑战，我们正在开发农业的Metaverses，简称AgriVerse，在我们的分散式复杂适应性农业系统（DeCASA）项目下，这是一个智能村庄的数字世界，与分散式科学（DeSci）和分散式自治组织（DAO）的网络-物理-社会系统（CPSS）的发展同时创建。此外，我们还提供了DeCASA在Agri-Verse中的架构、运行模式和主要应用。为了实现可持续农业，我们设想了一个基于ACP理论和联合智能的基础模型。最后，我们讨论了挑战和机遇。

X. Wang, M. Kang, H. Sun, P. de Reffye and F. -Y. Wang, "DeCASA in AgriVerse: Parallel Agriculture for Smart Villages in Metaverses," in IEEE/CAA Journal of Automatica Sinica, vol. 9, no. 12, pp. 2055-2062, December 2022, doi: 10.1109/JAS.2022.106103.

IoT based Data Sensing System for AutoGrow, an Autonomous greenhouse System for Precision Agriculture

基于物联网的数据传感系统，用于精准农业的自主温室系统AutoGrow

Abstract:Rising global average temperature is associated with widespread changes in weather patterns. India is identified as one of the highly vulnerable countries to climate change. Climate change poses a significant threat to Indian agriculture and food security, it also affects nutritional value within the crop. Paradoxically, Agriculture generates 19-29% of total greenhouse gas (GHG) emissions. Precision farming using an instrumented greenhouse which falls under the ambit of Controlled Environment Agriculture (CEA) presents a plausible solution option for climate resilient agriculture.Artificial Intelligence has reached breakthroughs in several areas but in agriculture artificial intelligence could be applied easily with data collection from various types of sensors. It is obvious to use AI also for agricultural purposes. The twin levers of an instrumented Greenhouse using IoT and AI provides interesting options for autonomous food production in CEA. We envisage AutoGrow, a Greenhouse system that incorporates AI/ML to perform the control function of optimizing the use of resources. Data for AI/ML is acquired through an IoT system with a multitude of sensors. In this work, we present an IoT based data sensing and data logging subsystem. The sub-system includes sensing a multitude of parameters that includes temperature, moisture, humidity, pH and the big 3 primary nutrients (NPK). Further, the solenoid valves are incorporated as actuators for the control operation of administering irrigation and water soluble nutrients. A prototype lab system is successfully built and tested. The lab prototype showcases all the features to sense, communicate, and perform effective irrigation and controlled supply of nutrients.

摘要：全球平均气温的上升与天气模式的广泛变化有关。印度被认为是极易受到气候变化影响的国家之一。气候变化对印度的农业和食品安全构成了重大威胁，它还影响到作物的营养价值。矛盾的是，农业产生的温室气体（GHG）排放总量占19-29%。使用属于可控环境农业（CEA）范围内的仪器化温室的精准农业为气候适应性农业提供了一个可信的解决方案。显然，将人工智能也用于农业目的。使用物联网和人工智能的仪器化温室的双重杠杆，为CEA的自主食品生产提供了有趣的选择。我们设想了AutoGrow，一个结合了人工智能/ML的温室系统，执行优化资源使用的控制功能。AI/ML的数据是通过一个拥有众多传感器的物联网系统获得的。在这项工作中，我们提出了一个基于物联网的数据感应和数据记录子系统。该子系统包括感应大量的参数，包括温度、水分、湿度、pH值和三大主要营养素（NPK）。此外，电磁阀作为执行器被纳入，用于控制灌溉和水溶性营养物质的操作。一个实验室原型系统已经成功建立并测试。该实验室原型展示了感应、通信和执行有效灌溉和控制营养供应的所有功能。

Toward agriculture 4.0: Smart farming environment based on robotic and IoT

迈向农业4.0： 基于机器人和物联网的智能耕作环境

The Agriculture 4.0 is the agriculture that integrates a series of innovations in order to produce and improve agricultural product. These innovations include precision farming, IoT and big data in order to achieve greater production efficiency. Our vision in this work is a new generation of smart, flexible, robust, compliant, interconnected robotic and autonomous systems working seamlessly alongside their human co-workers in farms and food factories. For this objective, we proposed a solution based on robotic and IoT technologies for smart greenhouse's management which offers the farmer the ability to monitor, supervise and control an important number of greenhouses without the need to physically intervene each time for regular actions like irrigation, nebulization and aeration depending on the foods and plant's needs.

农业4.0是整合了一系列创新的农业，以生产和改善农产品。这些创新包括精准农业、物联网和大数据，以实现更大的生产效率。我们在这项工作中的愿景是新一代的智能、灵活、坚固、合规、相互连接的机器人和自主系统，在农场和食品工厂中与人类同事无缝协作。为了这个目标，我们提出了一个基于机器人和物联网技术的智能温室管理解决方案，为农民提供监测、监督和控制重要数量的温室的能力，而不需要每次都根据食品和植物的需要，对灌溉、雾化和通气等常规行动进行物理干预。

Soheyb, T. Abdelmoutia and T. S. Labib, "Toward agriculture 4.0: Smart farming environment based on robotic and IoT," 2021 4th International Symposium on Advanced Electrical and Communication Technologies (ISAECT), Alkhobar, Saudi Arabia, 2021, pp. 1-5, doi: 10.1109/ISAECT53699.2021.9668490.

IoT-enabled controlled environment agriculture

基于物联网的可控环境农业

Abstract:Wireless communications, with the emerging technologies of cloud computing, ubiquitous sensing and big data, had the impact of changing all aspects of our lives. The aim of this paper is to discuss the possibility of enhancing greenhouse agricultural activities in an arid climate using Internet of Things (IoT) and other computational technologies, especially as an enablers of Controlled Environment Agriculture (CEA). The utilization of CEA practices and the efficiency and effectiveness of agricultural big data are highly affected by the availability of wireless connectivity. In this paper we propose a framework that utilizes emerging computational technologies to monitor and control a CEA.

摘要：无线通信与云计算、无处不在的传感和大数据等新兴技术，对我们生活的各个方面都产生了影响。本文旨在讨论利用物联网和其他计算技术，特别是作为可控环境农业（CEA）的推动者，在干旱气候下加强温室农业活动的可能性。CEA实践的利用以及农业大数据的效率和效果受到无线连接可用性的高度影响。在本文中，我们提出了一个利用新兴计算技术来监测和控制CEA的框架。

S. AlKameli and W. M. ElMedany, "IoT-enabled controlled environment agriculture," 3rd Smart Cities Symposium (SCS 2020), Online Conference, 2020, pp. 296-301, doi: 10.1049/icp.2021.0858.

Design and Manufacture of a Smart Greenhouse with Supervisory Control of Environmental Parameters Using Fuzzy Inference Controller

使用模糊推理控制器对环境参数进行监督控制的智能温室的设计和制造2020

The Internet of Things (IoT) is an Internet network consisting of a set of objects through which they can communicate with each other. Anything that can collect data, be controlled, or communicate remotely is subject to the definition of objects in this network. New research in the field of IoT and artificial intelligence has been working in the world, including IoT applications in agriculture. The Internet of Things and artificial intelligence can be used to optimize water, energy consumption, more and better production of agricultural products. In this paper, an IoT-based smart greenhouse is designed and implemented with a monitoring controller to check data and prevent plant damage, and a fuzzy controller to intelligently control parameters such as temperature, light, soil moisture, and Greenhouse environment is used. The design created in this paper allows the user to monitor and adjust the greenhouse parameters remotely and via internet.

物联网（IoT）是一个由一组物体组成的互联网网络，通过这个网络，这些物体可以相互通信。任何可以收集数据、被控制或远程通信的东西都要服从这个网络中物体的定义。物联网和人工智能领域的新研究已经在世界范围内开展，包括物联网在农业中的应用。物联网和人工智能可以用来优化水、能源消耗，更多更好地生产农产品。在本文中，设计并实现了一个基于物联网的智能温室，用监测控制器检查数据并防止植物受损，用模糊控制器来智能控制温度、光照、土壤湿度和温室环境等参数。本文创建的设计允许用户通过互联网远程监控和调整温室的参数。

Y. Alaviyan, M. Aghaseyedabdollah, M. Sadafi and A. Yazdizade, "Design and Manufacture of a Smart Greenhouse with Supervisory Control of Environmental Parameters Using Fuzzy Inference Controller," 2020 6th Iranian Conference on Signal Processing and Intelligent Systems (ICSPIS), Mashhad, Iran, 2020, pp. 1-6, doi: 10.1109/ICSPIS51611.2020.9349619.

Sensor Based Smart Agriculture with IoT Technologies: A Review

基于传感器的物联网技术的智能农业： 回顾

The IoT is a new technology trend used in almost every area thing, when connected to the internet and to each other, when you connect to the internet or interconnect, your entire system will be smarter. We have used IoT in all areas of our lives, including smart cities, smart homes, and smart retail. Much more. From 9.6 billion by 2050, agriculture needs to deliver even faster to meet this type of demand. This is possible with the latest technology, especially the IoT. The IoT enables labour free farms. Not only can it be used for large-scale agriculture, but it can also be used for livestock, greenhouse management, and agricultural land management. The most significant tool for the IoT is the sensor. A sensor is a device that collects important data that is interpreted to obtain the required analysis. The important objective of sensors are used to determine the soil's physical qualities and the environment. The main applications of sensors are control and supervise, safety, alarm, diagnostics, and analytics. Sensors make innovative agriculture more effective and trouble-free. In agriculture, the sensor is mainly used for measuring, measuring NPK (Nitrogen, Phosphorus, Potassium) levels, and detecting disease and soil moisture content. The main solution to this problem is smart farming, which modernizes traditional farming practices. This paper narrates the role of IoT application in smart agriculture. Smart farming is also known as precision farming hence it uses accurate information to draw outcomes. It demonstrates the different sensors, applications, challenges, strengths and weaknesses that support the IoT and agriculture.

物联网是一种新的技术趋势，几乎应用于每一个领域的事物，当你连接到互联网和相互之间，当你连接到互联网或互连，你的整个系统将变得更加智能。我们已经将物联网应用于我们生活的各个领域，包括智能城市、智能家居、智能零售。还有很多。从2050年的96亿，农业需要提供更快，以满足这种类型的需求。有了最新的技术，特别是物联网，这是有可能的。物联网实现了无劳动力的农场。它不仅可以用于大规模农业，还可以用于畜牧业、温室管理和农业土地管理。物联网的最重要工具是传感器。传感器是一个收集重要数据的设备，通过解释获得所需的分析。传感器的重要目标是用来确定土壤的物理质量和环境。传感器的主要应用是控制和监督、安全、报警、诊断和分析。传感器使创新农业更加有效和无故障。在农业中，传感器主要用于测量，测量氮磷钾水平，检测疾病和土壤水分含量。解决这个问题的主要办法是智能农业，它使传统的农业实践现代化。本文叙述了物联网应用在智能农业中的作用。智能农业也被称为精准农业，因此它使用准确的信息来得出结果。它展示了支持物联网和农业的不同传感器、应用、挑战、优势和劣势。

M. Pyingkodi et al., "Sensor Based Smart Agriculture with IoT Technologies: A Review," 2022 International Conference on Computer Communication and Informatics (ICCCI), Coimbatore, India, 2022, pp. 1-7, doi: 10.1109/ICCCI54379.2022.9741001.

Development of an Intelligent LED Lighting Control Testbed for IoT-based Smart Greenhouses

为基于物联网的智能温室开发智能LED照明控制测试平台

The aim of our study is to develop an intelligent control system for mixing color ratios using LED lights in a greenhouse environment. To this end, different components of an experimental testbed is presented for achieving the desired light requirements for plant growth in a greenhouse environment. The proposed testbed provides a easy-to-use plant growth system with IoT-enabled control and monitoring features. To testify the features mentioned above, a feedback lighting control method to achieve a desired photosynthetic photon flux density (PPFD) set point is implemented. A two-week experiment was conducted on microgreen kale which was planted in the testbed and harvested at the end of the experiment. The experimental results has shown that the tested microgreen kale grew with a healthy condition in the proposed testbed and lighting environment.

我们研究的目的是开发一个智能控制系统，用于在温室环境中使用LED灯混合颜色比例。为此，我们提出了一个实验测试平台的不同组成部分，以实现温室环境中植物生长的理想光照要求。拟议的测试平台提供了一个易于使用的植物生长系统，具有物联网控制和监测功能。为了证明上述功能，实施了一种反馈照明控制方法，以实现理想的光合光子通量密度（PPFD）设定点。对微型绿色甘蓝进行了为期两周的实验，该甘蓝被种植在测试床上，并在实验结束时进行了收获。实验结果表明，被测试的微型甘蓝在拟议的试验床和照明环境下生长健康。

J. Jiang and M. Moallem, "Development of an Intelligent LED Lighting Control Testbed for IoT-based Smart Greenhouses," IECON 2020 The 46th Annual Conference of the IEEE Industrial Electronics Society, Singapore, 2020, pp. 5226-5231, doi: 10.1109/IECON43393.2020.9254993.

Data Communication Design Based on Internet of Things Architecture for Smart Greenhouse Monitoring and Controlling System

基于物联网架构的智能温室监控系统数据通信设计

Agriculture is an important economic sector in an agricultural country, such as Indonesia. In developing agricultural potential, there are many modern agricultural systems, one of which is the greenhouse system. The greenhouse is a planting system that can prevent plants from several factors that can cause damage to growth. Greenhouses interact with the surrounding environment and create a microclimate in the greenhouse. Changes in the microclimate are very influential for greenhouse cultivation plants. This paper provides a design of a two-way data communication system based on the Internet of Things (IoT) for monitoring and controlling smart greenhouses. Smart nodes can send microclimate readings to a remote database every 15 minutes. Users can control the actuators in the smart greenhouse remotely. Analysis and testing of the design of a smart greenhouse-based two-way data communication system were carried out by calculating the latency and packet loss data values. The average response latency of remote actuator control is 14.83 seconds. In sending microclimate data, smart greenhouses have an average latency of 14 minutes and 56 seconds with a packet loss percentage of 0%.

在印度尼西亚这样的农业国家，农业是一个重要的经济部门。在开发农业潜力方面，有许多现代农业系统，其中之一就是温室系统。温室是一种种植系统，可以防止植物受到一些可能导致生长受损的因素影响。温室与周围的环境相互作用，在温室中形成小气候。小气候的变化对温室栽培植物有很大的影响。本文提供了一个基于物联网的双向数据通信系统的设计，用于监测和控制智能温室。智能节点可以每15分钟向远程数据库发送微气候读数。用户可以远程控制智能温室中的执行器。通过计算延迟和丢包数据值，对基于智能温室的双向数据通信系统的设计进行了分析和测试。远程执行器控制的平均响应延时为14.83秒。在发送微气候数据时，智能温室的平均延迟为14分56秒，丢包率为0%。

A. Vishwakarma, A. Sahu, N. Sheikh, P. Payasi, S. K. Rajput and L. Srivastava, "IOT Based Greenhouse Monitoring And Controlling System," 2020 IEEE Students Conference on Engineering & Systems (SCES), Prayagraj, India, 2020, pp. 1-6, doi: 10.1109/SCES50439.2020.9236693.

LoRa-based smart greenhouse control system

基于LoRa的智能温室控制系统

With the continuous development of the intelligent society, smart greenhouses are also developing rapidly in the direction of intelligence and precision, realizing intelligent monitoring of the growth environment of each crop in the greenhouse, and making up for the high labor cost, high labor intensity and high labor intensity of traditional greenhouse planting. Disadvantages such as low production efficiency. The LoRa-based smart greenhouse control system adopts wireless communication technology, uses a variety of sensor modules to realize real-time monitoring of the growth environment, and combines the terminal display of various webpages and small programs to realize remote monitoring and intelligent monitoring of various environmental factors in the greenhouse. Management, early warning reminders and other functions, so as to achieve the purpose of increasing crop yield, improving product quality, and improving production efficiency, thereby greatly improving the economic benefits of smart agriculture.

随着智能化社会的不断发展，智能温室也在向智能化、精准化方向快速发展，实现了对温室内每种作物生长环境的智能监控，弥补了传统温室种植的高劳动成本、高劳动强度、高劳动强度 生产效率低等劣势。基于LoRa的智能温室控制系统采用无线通信技术，利用各种传感器模块实现对生长环境的实时监测，并结合各种网页和小程序的终端显示，实现对温室内各种环境因子的远程监控和智能监测。管理、预警提醒等功能，从而达到增加作物产量、改善产品质量、提高生产效率的目的，从而大大提高了智慧农业的经济效益。

C. Zhang and J. Yang, "LoRa-based smart greenhouse control system," 2023 IEEE 2nd International Conference on Electrical Engineering, Big Data and Algorithms (EEBDA), Changchun, China, 2023, pp. 948-952, doi: 10.1109/EEBDA56825.2023.10090493.

IoT Based Smart Greenhouse Framework and Control Strategies for Sustainable Agriculture

基于物联网的智能温室框架和可持续农业的控制策略2022

In recent years, the Internet of Things (IoT) has become one of the most familiar names creating a benchmark and scaling new heights. IoT an indeed future of the communication that has transformed the objects (things) of the real world into smarter devices. With the advent of IoT technology, this decade is witnessing a transformation from traditional agriculture approaches to the most advanced ones. In perspective to the current standing of IoT in agriculture, identification of the most prominent application of IoT-based smart farming i.e. greenhouse has been highlighted and presented a systematic analysis and investigated the high quality research work for the implementation of greenhouse farming. The primary objective of this study is to propose an IoT-based network framework for a sustainable greenhouse environment and implement control strategies for efficient resources management. A rigorous discussion on IoT-based greenhouse applications, sensors/devices, and communication protocols have been presented. Furthermore, this research also presents an inclusive review of IoT-based greenhouse sensors/devices and communication protocols. Moreover, we have also presented a rigorous discussion on smart greenhouse farming challenges and security issues as well as identified future research directions to overcome these challenges. This research has explained many aspects of the technologies involved in IoT-based greenhouse and proposed network architecture, topology, and platforms. In the end, research results have been summarized by developing an IoT-based greenhouse farm management taxonomy and attacks taxonomy.

近年来，物联网（IoT）已经成为最熟悉的名字之一，创造了一个标杆，并攀登了新的高度。物联网确实是一种未来的通信方式，它将现实世界的物体（事物）转变为更智能的设备。随着物联网技术的出现，这十年正见证着从传统农业方法到最先进方法的转变。从物联网在农业中的现状来看，基于物联网的智能农业最突出的应用即温室的识别已经被强调，并提出了一个系统的分析，调查了实施温室农业的高质量的研究工作。本研究的主要目的是为可持续的温室环境提出一个基于物联网的网络框架，并实施高效资源管理的控制策略。对基于物联网的温室应用、传感器/设备和通信协议进行了严谨的讨论。此外，这项研究还对基于物联网的温室传感器/设备和通信协议进行了全面的回顾。此外，我们还对智能温室农业的挑战和安全问题进行了严格的讨论，并确定了克服这些挑战的未来研究方向。这项研究已经解释了基于物联网的温室所涉及的技术的许多方面，并提出了网络架构、拓扑结构和平台。最后，通过制定基于物联网的温室农场管理分类法和攻击分类法，总结了研究成果。

M. S. Farooq, R. Javid, S. Riaz and Z. Atal, "IoT Based Smart Greenhouse Framework and Control Strategies for Sustainable Agriculture," in IEEE Access, vol. 10, pp. 99394-99420, 2022, doi: 10.1109/ACCESS.2022.3204066.

Managing Traditional Solar Greenhouse With CPSS: A Just-for-Fit Philosophy2018

用CPSS管理传统的太阳能温室：一种适合的理念

The profit of greenhouse production is influenced by management activities (e.g., environmental control and plantation scheduling) as well as social conditions (e.g., price fluctuation). In China, the prevailing horticultural facility is the traditional solar greenhouse. The key existing problem is the lack of knowledge of growers, which in turn leads to inefficient management, low production, or unsalable products. To secure effective greenhouse management, the production planning system must account for the crop growing environment, grower's activities, and the market. This paper presents an agricultural cyber-physical-social system (CPSS) serving agricultural production management, with a case study on the solar greenhouse. The system inputs are derived from social and physical sensors, with the former collecting the price of agricultural products in a wholesale market, and the latter collecting the necessary environmental data in the solar greenhouse. Decision support for the cropping plan is provided by the artificial system, computational experiment, and parallel execution-based method, with description intelligence for estimating the crop development and harvest time, prediction intelligence for optimizing the planting time and area according to the expected targets (stable production or maximum gross profit), and prescription intelligence for online system training. The presented system fits the current technical and economic situation of horticulture in China. The application of agricultural CPSS could decrease waste in labor or fertilizer and support sustainable agricultural production.

温室生产的利润受到管理活动（如环境控制和种植安排）以及社会条件（如价格波动）的影响。在中国，普遍的园艺设施是传统的日光温室。现有的关键问题是种植者缺乏知识，这反过来又导致管理效率低下，产量低，或产品无法销售。为了保证有效的温室管理，生产计划系统必须考虑到作物生长环境、种植者的活动和市场。本文介绍了一个服务于农业生产管理的农业网络-物理-社会系统（CPSS），并对日光温室进行了案例研究。系统的输入来自社会和物理传感器，前者收集批发市场的农产品价格，后者收集日光温室的必要环境数据。种植计划的决策支持由人工系统、计算实验和基于并行执行的方法提供，其中描述智能用于估计作物发育和收获时间，预测智能用于根据预期目标（稳定产量或最大毛利）优化种植时间和面积，处方智能用于在线系统培训。所提出的系统符合中国当前园艺的技术和经济状况。农业CPSS的应用可以减少劳动力或肥料的浪费，支持可持续的农业生产。

M. Kang, X. -R. Fan, J. Hua, H. Wang, X. Wang and F. -Y. Wang, "Managing Traditional Solar Greenhouse With CPSS: A Just-for-Fit Philosophy," in IEEE Transactions on Cybernetics, vol. 48, no. 12, pp. 3371-3380, Dec. 2018, doi: 10.1109/TCYB.2018.2858264.

Internet of Things Empowered Smart Greenhouse Farming

物联网赋能智能温室农业

The rapid change of climate, population explosion, and reduction of arable lands are calling for new approaches to ensure sustainable agriculture and food supply for the future. Greenhouse agriculture is considered to be a viable alternative and sustainable solution, which can combat the future food crisis by controlling the local environment and growing crops all year round, even in harsh outdoor conditions. However, greenhouse farms persist many challenges for efficient operation and management. The evolving Internet of Things (IoT) technologies, which encompass the smart sensors, devices, network topologies, big data analytics, and intelligent decision is believed to be the solution in addressing the key challenges facing the greenhouse farming, such as greenhouse local climate control, crop growth monitoring, crop harvesting and etc. This paper reviews the current greenhouse cultivation technologies as well as the state-of-the-art of IoT technologies for smart greenhouse farms. The paper also highlights the major challenges that need to be addressed.

气候的迅速变化、人口的爆炸和可耕地的减少都要求采取新的方法来确保未来的可持续农业和粮食供应。温室农业被认为是一个可行的替代和可持续的解决方案，它可以通过控制当地环境和全年种植作物，甚至在恶劣的室外条件下，来对抗未来的粮食危机。然而，温室农场在高效运营和管理方面一直存在许多挑战。不断发展的物联网（IoT）技术，包括智能传感器、设备、网络拓扑结构、大数据分析和智能决策，被认为是解决温室种植面临的关键挑战的解决方案，如温室本地气候控制、作物生长监测、作物收获等。本文回顾了当前的温室栽培技术，以及智能温室农场的物联网技术的最新进展。本文还强调了需要解决的主要挑战。

R. Rayhana, G. Xiao and Z. Liu, "Internet of Things Empowered Smart Greenhouse Farming," in IEEE Journal of Radio Frequency Identification, vol. 4, no. 3, pp. 195-211, Sept. 2020, doi: 10.1109/JRFID.2020.2984391.

Toward Implementing Interoperability in Pervasive Healthcare Systems for Chronic Diseases By Decentralization and Modularity

通过分散和模块化在慢性病的普适性医疗系统中实现互操作性

Chronic disease is a major problem that does not have a clear treatment. Several researchers from other fields than health, such as information systems and artificial intelligence, focus on presenting a system to help these patients. Designing a system to monitor chronic diseases presents designers with several obstacles. Studying possible design techniques and common functionalities prolong the design process. This research focuses on helping designers to decreases the primary design steps by presenting some common functionalities and techniques. We focused on creating an understanding of Decentralization and modularity in the pervasive healthcare systems as a method to increase Interoperability in healthcare software’s for chronic diseases. We focused on these two quality attributes (Modularity and Decentralization) because the nature of chronic disease needs monitoring and continuous surveillance. Additionally, New technologies and innovation emerge for chronic disease everyday. Decentralization can be implemented by combining Blockchain and IPFS technologies and Modularity can be implemented by list of features (functionalities). We have reviewed several published healthcare systems and frameworks in this domain to do a comparative analysis of the functionality on the proposed systems and frameworks based on their similarities and differences. Therefore, we identify functionalities by using a comparative analysis of the architectural elements of each existing system and framework. Afterward, the analysis results aggregated into features list. System designers can propose new systems for chronic diseases more timely with having a list of proposed features and techniques as their feasible options. The results of this research facilitate the design and reduce the time of the design process.

慢性病是一个没有明确治疗方法的主要问题。一些来自健康以外的其他领域的研究人员，如信息系统和人工智能，专注于提出一个系统来帮助这些病人。设计一个监测慢性病的系统给设计师带来了一些障碍。研究可能的设计技术和共同的功能会延长设计的过程。这项研究的重点是通过介绍一些常见的功能和技术来帮助设计师减少主要的设计步骤。我们专注于在普适性医疗系统中建立对分散化和模块化的理解，以此来提高慢性病医疗软件的互操作性。我们专注于这两个质量属性（模块化和分散化），因为慢性病的性质需要监测和持续监控。此外，每天都有针对慢性病的新技术和创新出现。分散化可以通过结合区块链和IPFS技术来实现，而模块化可以通过特征（功能）的清单来实现。我们已经审查了这个领域的几个已发表的医疗系统和框架，根据它们的相似性和差异，对拟议的系统和框架的功能进行了比较分析。因此，我们通过对每个现有系统和框架的架构要素的比较分析来确定功能。之后，分析结果汇总成功能列表。系统设计者可以通过拥有建议的功能和技术清单作为其可行的选择，更及时地提出治疗慢性病的新系统。这项研究的结果促进了设计并减少了设计过程的时间。

M. Ali Saberi, H. Mcheick, M. Adda and H. Ibrahim, "Toward Implementing Interoperability in Pervasive Healthcare Systems for Chronic Diseases By Decentralization and Modularity," 2022 3rd International Conference on Human-Centric Smart Environments for Health and Well-being (IHSH), Lévis, QC, Canada, 2022, pp. 64-72, doi: 10.1109/IHSH57076.2022.10092028.

Reference design model for a patient-centric data exchange healthcare environment以病人为中心的数据交换医疗环境的参考设计模型

医疗保健行业目前正经历着从以提供者为中心的环境向以病人为中心的环境的范式转变，这是现代世界中电子医疗技术快速扩张的直接结果。在这篇文章中，我们探讨了为了达到发展以病人为中心的安全的医疗环境的目的而需要考虑的各种设计因素。我们讨论了医疗系统背景下的互操作性的概念，以及可以使用FHIR将这一想法变成现实的各种方式。除此之外，本文还调查了四种不同的以病人为中心的数据共享机制的使用情况。最后，将使用其中一种数据交换机制来详细描述用于使环境更加以病人为中心的参考设计模型。

The healthcare industry is currently undergoing a paradigm shift from a provider-centric environment to a patient-centric one as a direct result of the fast expansion of eHealth technologies in the modern world. In this article, we explore the various design considerations that need to be taken into account in order to accomplish the purpose of developing a patient-centered and safe healthcare environment. We discuss the concept of interoperability in the context of the healthcare system, as well as the various ways in which FHIR could be used to turn this idea into a practical reality. In addition to that, this article investigates the use of four different patient-centric data sharing mechanisms. In conclusion, the reference design model that will be used to make the environment more patient-centric will be described in detail using one of the data exchange mechanism.

P. Khatiwada, B. Yang and A. Skjelvik, "Reference design model for a patient-centric data exchange healthcare environment," 2022 3rd International Conference on Human-Centric Smart Environments for Health and Well-being (IHSH), Lévis, QC, Canada, 2022, pp. 49-56, doi: 10.1109/IHSH57076.2022.10092114.

Human centric platforms for personalized value creation in metaverse

以人为本的平台，在元空间中创造个性化的价值

The term “Metaverse” first used in Neal Stephenson's sci-fi book Snow Crash in 1992, refers to a fusion of virtual and real existence. Nearly 30 years later, that definition is taking shape and promises to alter how people live and operate. This next evolution of Internet also known as Web3.0 will combine digital and physical elements. Multiple definitions can be found in the literature, with the most prevalent being the “new internet”, among others such as “democratized virtual society”, “persistent virtual spaces”, “a digital twin of our own world for personalized value creation”. Consequently, the common consensus dictates that Metaverse can be realized as a new form of the Internet, totally reshaped from what is already known. As we are heading towards the coexistence of Industry 5.0 and Society 5.0 (super smart and intelligent society), this paper attempts to present the definition of Metaverse, its evolution, the advantages and disadvantages, the pillars for the technological advancement which could be the fuel to spark future investigation and discussion as well as to accelerate the development of Metaverse towards the human centric and personalized society. Furthermore, in this manuscript, challenges and opportunities are presented (including Manufacturing), a brief comparison is performed versus Virtual Reality, and a conceptual framework for integrating Metaverse in Manufacturing is also presented.

1992年尼尔-斯蒂芬森（Neal Stephenson）的科幻小说《雪崩》（Snow Crash）中首次使用了 "Metaverse "一词，指的是虚拟和现实存在的融合。近30年后，这一定义正在形成，并有望改变人们的生活和工作方式。这种互联网的下一次演变也被称为Web3.0，将结合数字和物理元素。文献中可以找到多种定义，最普遍的是 "新互联网"，还有其他一些定义，如 "民主化的虚拟社会"、"持久的虚拟空间"、"我们自己世界的数字双胞胎，用于创造个性化的价值"。因此，共同的共识决定了Metaverse可以作为互联网的一种新形式来实现，完全重塑已知的东西。由于我们正朝着工业5.0和社会5.0（超级智能和智慧社会）并存的方向发展，本文试图介绍Metaverse的定义、其演变、优势和劣势、技术进步的支柱，这可能是引发未来调查和讨论的燃料，以及加速Metaverse向以人为本和个性化社会的发展。此外，本稿件还提出了挑战和机遇（包括制造业），与虚拟现实进行了简单的比较，并提出了将Metaverse融入制造业的概念框架。(Mourtzis, Panopoulos et al. 2022)

Mourtzis, D., et al. (2022). "Human centric platforms for personalized value creation in metaverse." Journal of Manufacturing Systems 65: 653-659.

Industrial wearable system: the human-centric empowering technology in Industry 4.0

工业可穿戴系统：工业4.0中以人为本的赋能技术

The Industry 4.0 program and corresponding international initiatives continue to transform the industrial workforce and their work. The service-oriented, customer-centric and demand-driven production is pushing forward the progress of industrial automation. Even though, it does not mean that human can be fully replaced by machines/robots. There is an increasing awareness that human presence is not only one type of manufacturing capability, but also contributes to the overall system’s fault tolerant. How to achieve the seamless integration between human and machines/robots and harness human’s full potential is a critical issue for the success of Industry 4.0. In this research, a human-centric empowering technology: industrial wearable system is proposed. The aim of this system is to establish a human–cyber–physical symbiosis to support real time, trusting, and dynamic interaction among operators, machines and production systems. In order to design a substantial framework, three world-leading R&D groups in this field are investigated. Five design considerations have been identified from real-life pilot projects. The future trends and research opportunities also show great promise of industrial wearable system in the next generation of manufacturing.

工业4.0计划和相应的国际倡议继续改变着工业劳动力和他们的工作。以服务为导向，以客户为中心，以需求为导向的生产正在推动工业自动化的进步。即使如此，这并不意味着人类可以完全被机器/机器人取代。人们越来越意识到，人的存在不仅是一种制造能力，而且还有助于整个系统的容错性。如何实现人与机器/机器人的无缝整合，并充分发挥人的潜力，是工业4.0成功的关键问题。在这项研究中，提出了一种以人为本的赋能技术：工业可穿戴系统。该系统的目的是建立一个人-网络-物理的共生关系，以支持操作员、机器和生产系统之间的实时、信任和动态互动。为了设计一个实质性的框架，我们调查了该领域的三个世界领先的研发小组。从现实生活中的试点项目中确定了五个设计考虑因素。未来的趋势和研究机会也显示了工业可穿戴系统在下一代制造业中的巨大前景。

Kong, X.T.R., Luo, H., Huang, G.Q. et al. Industrial wearable system: the human-centric empowering technology in Industry 4.0. J Intell Manuf 30, 2853–2869 (2019). https://doi.org/10.1007/s10845-018-1416-9

A Reference Human-centric Architecture Model: a skill-based approach for education of future workforce

以人为本的参考架构模型：基于技能的未来劳动力教育方法

As Industry 4.0 sets foot as the next Industrial Revolution, it is necessary to bear in mind the new challenges from the human workforce perspective. There is a need for such challenges to inform educational and training programs, for them to enable skill development from a holistic viewpoint. Yet, most of the educational programs seem to be technological or subject-based, i.e. not skilled-based. There is an opportunity for a new approach to support and create educational programs and training for both university graduates and industry workers. This paper presents a human-centric model based on competences, age groups, and environment scenarios. The proposal supports the development of more robust means to look at educational gaps by visualizing and adapting a competency-based scenario. The aim is to provide a novel approach that is holistic, inclusive, and flexible in better preparing the future workforce.

随着工业4.0作为下一次工业革命的到来，有必要从人类劳动力的角度牢记新的挑战。有必要将这些挑战告知教育和培训计划，使其能够从整体角度进行技能开发。然而，大多数教育计划似乎是以技术或学科为基础的，也就是说，不是以技能为基础。现在有机会采用一种新的方法来支持和创建大学毕业生和产业工人的教育计划和培训。本文提出了一个基于能力、年龄组和环境情景的以人为本的模型。该建议支持开发更强大的手段，通过可视化和调整基于能力的场景来观察教育差距。其目的是提供一种新颖的方法，在更好地准备未来的劳动力方面具有整体性、包容性和灵活性。

Flores, E., et al. (2020). "A Reference Human-centric Architecture Model: a skill-based approach for education of future workforce." Procedia Manufacturing 48: 1094-1101.

Applications of IoT for optimized greenhouse environment and resources management

物联网在优化温室环境和资源管理方面的应用

最近的研发项目、不断增长的物联网基础设施的商业化以及相关技术，如卫星、人工智能、传感器、执行器、无人驾驶航空器、大数据分析、智能机器和射频识别装置，都加强了物联网在精准农业和智能温室中的作用。尽管智能技术的整合为精准商业农业提供了无限的潜力，但考虑到物联网基础设施在全球的分布不均，且集中在高收入国家，优化资源管理仍是一项挑战。在智能温室中利用物联网技术往往涉及农业生产成本、环境保护、生态退化和可持续性之间的权衡。物联网基础设施的安装是资本密集型的，往往会转化为更高的能源需求，从而提高了气候变化的风险。物联网传感器和网络的广泛使用也增加了电子废物管理的新挑战，耗尽有限的资源，破坏脆弱的生态系统，导致气候变化。温室中物联网系统的整合将通过全球部署先进的5G技术和低地球轨道（LEO）星座宽带互联网的低延迟和高速度得到加强。农用化学品的智能应用可以产生巨大的节约（500美元/英亩或更多），而基于需求的灌溉和施肥将有助于提高作物产量。在全球范围内，到2030年，物联网基础设施的部署将为国内生产总值产生约5000亿美元的附加值。预测的经济效益肯定了物联网在优化温室环境和资源管理方面的应用是可持续的，任何潜在的风险都是商业农业的长期利益所无法比拟的。这篇评论文章对物联网在农业4.0中的作用、挑战和发展中国家的未来前景提出了新的见解，这些国家缺乏投资于精准农业技术的资源。

Optimal smart contract for autonomous greenhouse environment based on IoT blockchain network in agriculture

基于物联网区块链网络的农业自主温室环境的最佳智能合约