Digital Twin Technology in Greenhouse

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***Abstract*— A digital twin is a digital representation of a real-world entity or system.Digital twins are being adopted increasingly by more industries, transforming them and bringing new opportunities. Digital twins provide previously unheard levels of control over physical entities and help to manage complex systems by integrating an array of technologies. Our project aims to create digital twin system of greenhouse for analyzing various features like humidity, carbondioxide,light intensity,pH, water content.It monitors the growth of the plant.Digital twin concept evaluates the physical greenhouse facilitiy's performance and the production processes through digital model and simulations. The developed digital twin will predict how the physical twin will perform under different operational conditions .It provide intelligent,adaptive,and dynamic facility management and farming decision making suggestion.The contribution of the project is to develop an ecosystem of digital twins that collectively capture the behavior of an greenhouse facility.**

Keywords— : Digital Twin,Greenhouse,Physical Twin

I. INTRODUCTION

We live in a world where everything can be controlled and operated automatically, but there still a few important sectors in our country where automation has not been adopted or not been put to a full-fledged use, perhaps because of several reasons one such reason is cost. One such field is that of agriculture. Agriculture has been one of the primary occupations of man since early civilizations and even today manual interventions in farming are inevitable. Greenhouses form an important part of the agriculture and horticulture sectors in our country as they can be used to grow plants under controlled climatic conditions for optimum produce. Automating a greenhouse envisages monitoring and controlling of the climatic parameters which directly or indirectly govern the plant growth and hence their produce. Automation is process control of industrial machinery and processes, thereby replacing human operators. Agriculture plays a vital role in developing countries in many ways.Greenhouse is one of the agricultural method that is used for growing plants in an artificially created suitable climatic conditions.This way of farming avoids problems caused by seasonal changes.So that we can raise the amount of food production in our farms. A digital twin is a virtual representation that acts as a realtime digital counterpart of a physical object or system.By producing a virtual replica of the physical assets of a product or system using digital twin technology helps in analyzing the data, paves a way to check the functioning beforehand so as to develop a solution for any potential issues. This paper becomes novel because the existing system contains climate control software, pH sensors, automated irrigated systems, temperature sensors etc. No system contains all the technologies together.This paper proposes a greenhouse using digital twin technology that monitors plant growth and measures environmental factors like pH, smoke, light intensity, moisture, temperature, humidity...etc. It analyzes past data for faster future prediction. Here we first identify the suitable condition for growth of the plant in a greenhouse and collect data.Then hardware assembling in the greenhouse with microprogram. Next, create an android application for representing the physical system . This system helps in analyzing the data. It bridge the gap between technology andagriculture.

II. RELATED WORK

[1].An approach to find the challenges and difficulties in digital twin technology.Also it enable technology like IoT,AI,ML, deeplearning.It is used in manufacturing,health care and smart cities.This paper contributes to a categorical review that includes not only manufacturing but healthcare and smart cities. And discusses each area,highlighting how researchers are developing Digital Twins,while also identifying challenges and key enabling technologies, thus aiding future work.

[2].By using the digital twin model and the internet of things technology in smart farming;farmers can connect different assets and systems to have a bigger picture of the different aspects and parameters that impact the farm's behavior and the final yield production and resource consumption. This is a key feature that enables farmers to make better decisions and to decrease the

environmental impact in water, land and soil resources. This paper indicates the initial stages to develop a digital smart farm. However, the final implementation of a digital smart farm is only possible when multiple systems act together in order to represent all the processes involved in the farm. This research indicates that the system design and cloud implementation are working and can be used in the deploy- ment of the next steps which are the development of IA algorithms and the other digital contexts. By having the final system working it will be possible to understand the resource consumption in farms and the impact in crop yield. This enables a sustainable development and increases food security for the global population.

[3].Another approach in which analysed how Digital Twins can advance smart farming. More specifically, it addressed the three objectives as mentioned in the introduction as follows. Firstly, the paper has defined a Digital Twin as “a dynamic representation of a real-life object that mirrors its states and behaviour across its lifecycle and that can be used to monitor, analyze and simulate current and future states of and interventions on these objects, using data integration, artificial intelligence and machine learning.” Taking into account the role in the life cycle, six distinct Digital Twins are identified: Imaginary Digital Twins, Monitoring Digital Twins ,Predictive Digital Twins,Prescriptive Digital Twins,Autonomous Digital Twins,Recollection Digital Twins. Secondly, the paper has proposed a conceptual framework for designing and implementing Digital Twins in farm management. The framework comprises a control model based on a general systems approach and an implementation model for Digital Twin systems based on the Internet of Things—Architecture (IoT-A), a reference architecture for IoT systems. The control model defines the control functions and information flows among these functions for control systems based on Digital Twins. The implementation model classifies technical functionalities, from device layer until to application layer, needed to implement Digital Twin based systems. Finally, the framework is applied to and validated in five smart farming use cases of the European IoF2020 project, focusing on arable farming, dairy farming, greenhouse horticulture, organic vegetable farming and livestock farming. The case-specific control models have provided concrete insights in how Digital Twins could enhanced the smart farming systems of the use cases. Similarly, the casespecific implementation models have been useful to identity improvements of the technical architecture.

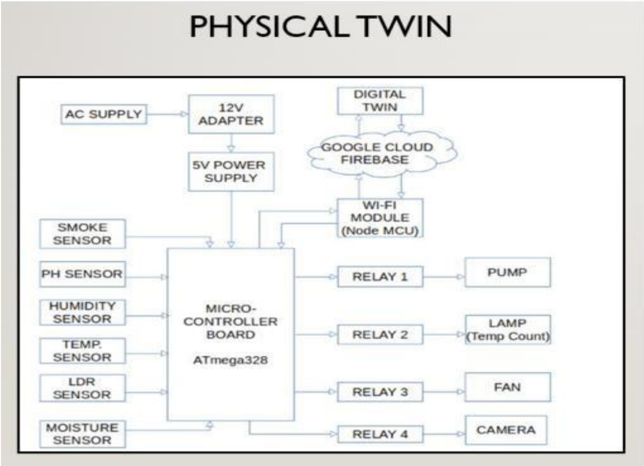
[4].An article" Digital Twin Architecture to Optimize Productivity within Controlled Environment Agriculture"were discussed to ensure food security, agricultural production systems should innovate in the direction of increasing production while reducing the utilized resources. Controlled environment agriculture and digital twins may represent fundamental tools to reach the optimization of productivity, thus contributing to the planet’s food security.The main objective of this research work was the development of a DT architecture potentially able to optimize productivity in the context of CEA applications.The objective was reached by designing an architecture that utilizes (as DTs) simulation software that enables the optimization of: (i) Climate control strategies related to the control of the crop microclimate; (ii) treatments related to the crop management. The architecture was applied to a prototype greenhouse for its validation.Lastly, Communication latency was assessed as a means to test the achievement of the communications defined within the DT architecture.

III. METHODOLOGY

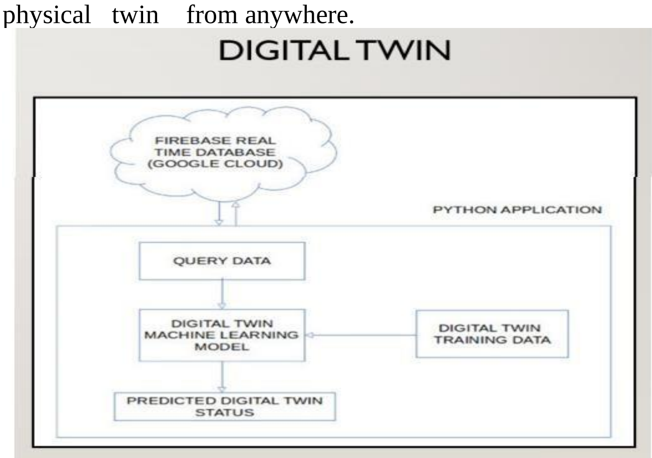
Embedded system is the basic concept of digital twin technology.Embedded system is the combination of software and hardware.An embedded system can be independent system or it can be part of a large system.An embedded system is a microprocessor based system which is designed to perform a specific task.In our project we have hardware and software part.In hardware part, ATMega328 microcontroller is programmed using embedded C programming. Then this microcontroller and various sensors for measuring,humidity,smoke,moisture,temperature,light intensity are assembled in a PCB. With the help of this programming values collected from the different sensors are passed to the cloud through wifi module. Then software part define the digital twin.The data stored in cloud is displayed using this software.We can control the various actions like pumping,faning..etc with the help of this software by automatically.Manual control is also possible.If any of the sensor values reduce or exceeds compares to the threshold value an alert will be produced by the alarm attached in the greenhouse.So the user get updated. In brief words,Sensors are installed to the the physical model.Data collected are saved to cloud storage.Based on the data current status of the physical system can be viewed.The system is trained with previous data set to predict future status. The external requirements are user,hardware and software interfaces.In user interfaces,Front end software: Python Open CV and Back end software: SQL, Python are used.In software interface are Operating system: Windows 10,Anaconda Navigator, Tensorflow.In hardware interface consists of 4GB RAM, Intel Core i5 Processor,500MB and above Hard Disk,High performance laptop,Sensors,Node MCU, Node MCU Sheild,Atmega328 Microcontroller, Microcontroller board,Relay Module,Fan,Pump, Bulb,Camera.

IV. SYSTEM ARCHITECTURE

The physical twin actually a hardware part,in which a programmed microcontroller unit called ATMega328 is connected with various sensors which measures values of various climatic conditions like smoke, pH, humidity, temperature, light intensity,moisture. All these values are collected through wifi module and stores in the cloud.

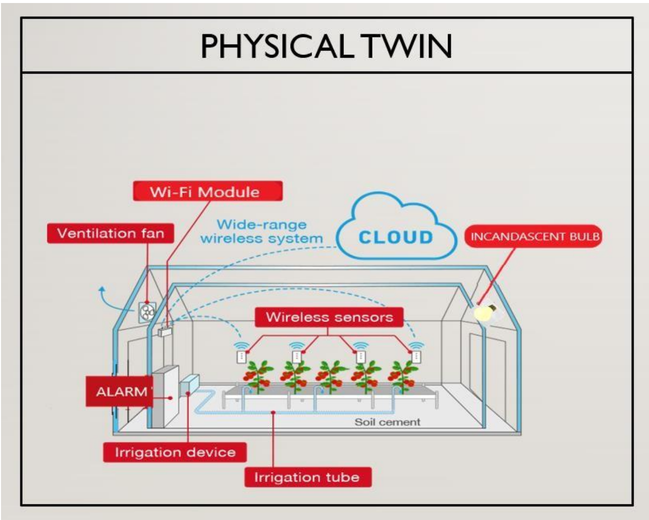


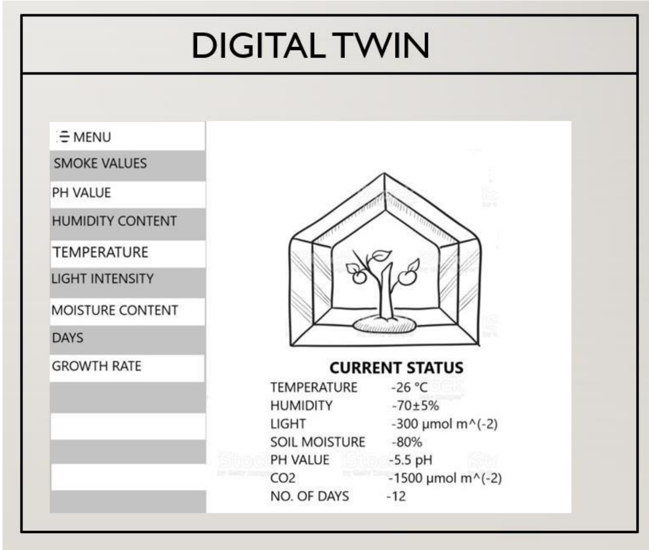
In case of the digital twin the data which is stored in the cloud are displayed with the help of the software.Also we can control the various actions like pumping,faning..etc with the help of this software.Using this android application any person can monitor this physical twin from anywhere.



V. RESULT

The below figures represent the resultant output of this paper.





VI. CONCLUSION

Visualization of the digital twin of greenhouse makes it easy to operate and control the system.It helps to Strengthen the agriculture system.Less labour work.And timely and accurate prediction results in minimal economical loss.The relevance of the project is reduce farmers difficulty in managing greenhouse without frequent visits.The major relevance of this project is that we can enlarge it from a small scale to large scale.That means with the help of the software we can monitors a single unit of a greenhouse to large no of greenhouse.That is from a home to an industrial level.It bridgethe gap between technology and agriculture.It is easy-to-use interface and it contribute towards the field of Machine learning. In conclusion we can say it drives innovation and performance.Improve the customer and farmer's experience.It provide intelligent, adaptive, and dynamic facility management and farming decision makingsuggestion.

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