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Agro Sense: Intelligent Crop Suggestion and Health Montoring System

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***Abstract*—This paper presents a smart husbandry system that uses IoT and web technologies to help farmers make accurate and timely opinions regarding crop civilization. The system employs an ESP32 microcontroller connected to soil moisture, rain, and LDR detectors to collect real-time environmental data. A Flask web operation allows growers to input a crop name, and the system analyzes whether the current soil and climate conditions are suitable for growing that crop. It also recommends applicable diseases and notifies the stoner via dispatch if any issues are detected, similar to the need for irrigation or fertilization. The integration of detector data, intelligent analysis, and automated cautions provides a dependable and effective result for precision husbandry, helping growers to optimize resource operation and ameliorate crop yield. Additionally, the system incorporates secure data transmission protocols to safeguard the confidentiality and integrity of stoner data. It also features a scalable armature, allowing easy integration of fresh detectors and modules to support larger ranges and different crop conditions. The system maintains a historical database of environmental parameters and crop performance enabling farmers to make data driven decision over time. The user-friendly interface supports real-time monitoring on both desktop and mobile devices ensuring accessibility and convenience.**

***Index Terms*—Smart agriculture, precision farming, IoT in agriculture, ESP32 microcontroller, soil moisture sensor, rain sensor, LDR sensor, Flask web application, crop recommendation system, real-time environmental monitoring**

1. INTRODUCTION

Agriculture is the backbone of numerous husbandries, especially in developing countries where a significant portion of the population relies on tilling for their livelihood [1]. Still, with adding climate unpredictability, soil declination, and limited access to expert advice, growers face multitudinous challenges in achieving optimal crop yields [2]. Traditional husbandry styles frequently fall suddenly in addressing real- time environmental changes, leading to the hamstrung use of water, diseases, and other essential coffers [3]. To overcome these limitations, there's a pressing need to integrate ultramodern technologies similar as the Internet of effects (IoT), Artificial Intelligence (AI), and pall computing into agrarian practices [4]. These technologies enable data-driven decision-timber, which are critical for enhancing productivity and sustainability in husbandry.

The Intelligent Crop Suggestion and Health Monitoring System introduces a new approach to smart husbandry by combining real-time environmental data collection, intelligent analysis, and automated cautions. The main part of the system is the ESP32 microcontroller, which connects to sensors like soil moisture sensors, rain sensors, and light sensors to monitor important farming factors.
The system leverages a Flask web operation, where growers can input the name of a crop. The operation analyzes the current soil and climate conditions to determine whether the crop is suitable for civilization [4]. In addition to recommending the most applicable crops, the system also provides specific toxin suggestions grounded on detected scarcities [5],[6].

Additionally, the system continuously monitors crop health, sending dispatch announcements to inform druggies when irrigation or fresh nutrients are required [3],[5]. This technology reduces homemade trouble while maximizing effectiveness and delicacy. Designed with a stoner-friendly interface, low perpetration cost, and smart announcement system, the result is especially salutary for small-and medium-scale growers. It empowers them with accessible, wisdom-grounded perceptions acclimatized to their field conditions. Likewise, its scalable and adaptable armature holds great pledge for revolutionizing husbandry - making it more flexible, sustainable, and data-driven [2],[6].

2. RELATED WORK

The Internet of Things (IoT) is a network of interconnected physical devices that collect, share, and act on data. These devices, embedded with sensors and communication capabilities, can monitor various conditions like temperature and motion. By connecting to the internet, IoT devices can transmit real-time data to other systems for analysis or action. This technology enables automation and smarter decision-making in areas such as home automation, healthcare, and industrial safety [7],[8]. In mining, for example, IoT can help monitor hazardous conditions and improve worker safety. The ability to connect devices wirelessly makes IoT versatile and widely applicable.

Recently, several smart agriculture solutions have emerged to tackle the limitations of traditional farming. IoT-based systems for precision farming have shown promising results in real-time monitoring of soil moisture, temperature, and humidity, enabling more efficient resource utilization. For example, systems like Smart Irrigation Systems use moisture sensors and weather data to automate watering, significantly reducing water wastage [2],[3]. Research has also explored machine learning-based crop recommendation systems, which analyze soil and climate parameters to suggest the most suitable crops for cultivation. [5],[6]. Projects like AgriBot have demonstrated the integration of robotic systems with sensors to monitor field conditions and assist in crop selection and maintenance.

Furthermore, platforms such as Digital Green have contributed to personalized advisory services, offering farmers guidance based on localized data through ICT and video-based learning. Other systems have combined Arduino or Raspberry Pi with GSM modules to provide SMS alerts for environmental changes. [4], [10]. These innovations form the foundation for the development of comprehensive smart farming solutions and highlight the increasing role of IoT, AI, and cloud computing in transforming agriculture.

The Intelligent Crop Suggestion and Health Monitoring System builds on these efforts by integrating real-time sensing, intelligent decision-making, and automated communication in a cost-effective and scalable framework designed specifically for small and medium-scale farmers. In the current agricultural landscape, many farmers still rely on traditional methods and manual observation to determine soil conditions, weather patterns, and crop suitability. These methods are often inaccurate and time-consuming, leading to poor decision-making, overuse or underuse of fertilizers, and unnecessary irrigation. Some farmers use basic sensor-based systems, but these typically do not include intelligent analysis or automated crop recommendations. They mainly display raw sensor data, which requires the farmer to interpret and act upon it manually.

Moreover, existing systems rarely integrate real-time data with crop-specific knowledge. While some platforms provide general agricultural advice, they do not offer personalized suggestions based on actual environmental conditions at the user's location. Also, most of these systems lack automatic alert mechanisms such as email notifications for critical issues like low moisture or the need for fertilizers, resulting in delayed actions that can negatively affect crop health and yield.

Overall, the existing systems are either too basic or not integrated, lacking intelligent decision-making, automation, and user-friendly interfaces. This creates a gap in providing farmers with accurate, real-time, and actionable insights, which the proposed system aims to fill by combining IoT sensors, a Flask-based web application, crop suitability logic, and automated notifications.

3. PROPOSED SYSTEM

The proposed system is a smart agriculture solution that integrates IoT and web technologies to help users make informed decisions about crop cultivation. It consists of an ESP32 microcontroller connected to sensors like soil moisture, rain, and LDR (light intensity), which monitor real-time environmental conditions. These sensors continuously gather data about the soil's moisture level, rainfall, and sunlight availability—key factors that influence crop growth. The ESP32 sends this data to a central Flask web server through Wi-Fi. The Flask web application serves as the user interface where farmers or users can enter the name of a crop they want to grow. The server receives the sensor data and analyzes it against the ideal growing conditions required for the specified crop. Based on this analysis, the system determines whether the selected crop is suitable for the current conditions and displays the result. Additionally, it recommends the most appropriate fertilizers to improve soil quality and support healthy crop growth. To enhance crop monitoring and management, the system also includes an automated notification feature. If the sensor data indicates any problem—such as low soil moisture, insufficient rainfall, or poor light conditions—the system generates an email alert to inform the user about necessary actions like irrigation or fertilization. This intelligent and responsive system supports precision farming by minimizing human error, optimizing resources, and increasing crop yield through timely decision-making.

ESP32: The ESP32 is a low- cost microcontroller with erected- in Wi-Fi and Bluetooth capabilities, making it ideal for IoT operations. In this design, the ESP32 acts as the central regulator that collects data from detectors and transmits it to Flask. Its high processing speed, multiple GPIO legs, and energy effectiveness make it suitable for nonstop real- time environmental monitoring in agrarian systems.

Humidity Detector: The soil humidity detector is used to measure the water content in the soil. It plays a pivotal part in determining whether the soil is dry, or overwatered. This data helps in assessing the irrigation requirements of the crops, water is supplied only when necessary, thereby conserving coffers and supporting healthy factory growth.

Rain Detector: The rain detector detects the presence and intensity of downfall. By covering downfall in real- time, the system can decide whether or not to initiate irrigation, precluding water destruction during stormy ages. This detector helps in optimizing irrigation schedules and perfecting the overall effectiveness of water operation in husbandry.

LDR(Light Dependent Resistor) : The LDR detector measures the intensity of ambient light or sun. It provides vital information about the vacuity of natural light for crops, which is important for photosynthesis and factory health. Grounded on light situations, the system can recommend shade- loving or sun-dependent crops, enhancing crop selection delicacy.

Flask: Flask is a feather light Python web frame used to produce the backend for the system. It receives detectors data from the ESP32, processes it using intelligent algorithms, and displays the results on a web interface. Flask is also responsible for generating crop recommendations, toxin suggestions, and environmental cautions, making it the brain of the decision- making process.

Temperature Detector: The temperature detector measures the girding air temperature, which is a critical parameter for determining suitable crops and detecting extreme rainfall conditions. This data helps in conforming husbandry strategies to suit the climate and provides early warnings for temperature-sensitive crops, better yield and crop health.

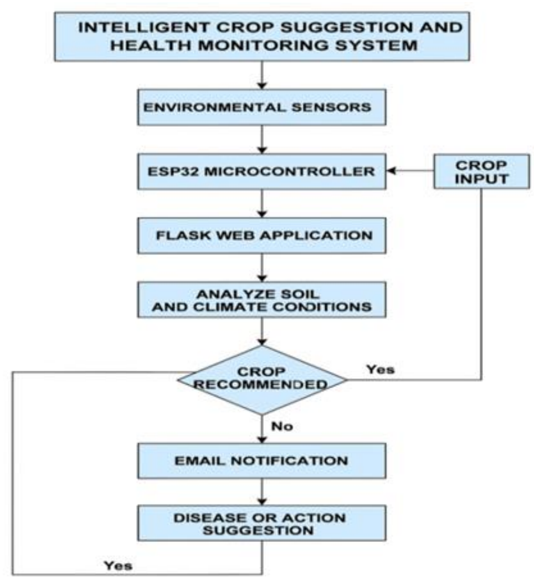

Figure1: FLOW CHART OF THE PROPOSED SYSTEM

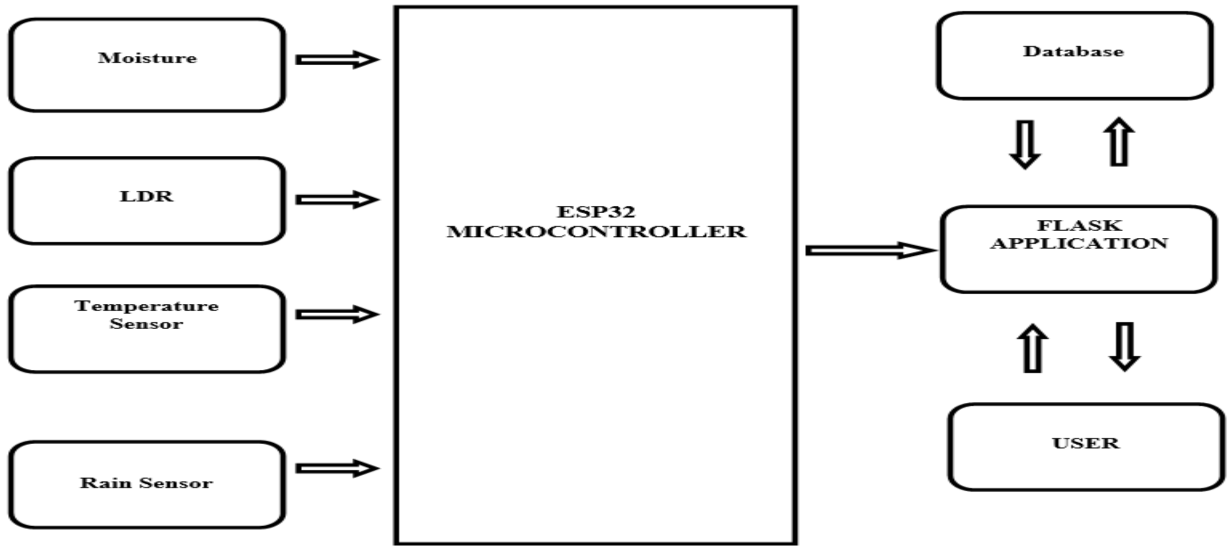

Figure 2: BLOCK DIAGRAM OF THE PROPOSED SYSTEM

4. WORKING

The system begins with the ESP32 microcontroller collecting real-time data from connected sensors, including a soil moisture sensor, a rain sensor, and an LDR (light-dependent resistor) sensor. These sensors measure the moisture level in the soil, detect the presence of rainfall, and monitor sunlight intensity, respectively. The collected data is then sent to the Flask web server via Wi-Fi, allowing remote monitoring of environmental conditions.

On the Flask web interface, users can input the name of a crop they wish to grow. The application retrieves the latest sensor data and checks whether the current environmental conditions match the optimal requirements for the entered crop. Based on this analysis, the system informs the user whether the crop is suitable for cultivation in the current climate and soil conditions. If needed, it also suggests the appropriate type of fertilizer to improve the soil for better growth.

If the system detects any problems—such as low moisture indicating a need for irrigation, lack of rainfall, or insufficient sunlight—it automatically sends an email notification to the user. This alert helps the user take immediate action, ensuring that the crops remain healthy. The entire process provides a smart, automated, and user-friendly way to support efficient and informed agricultural decisions.

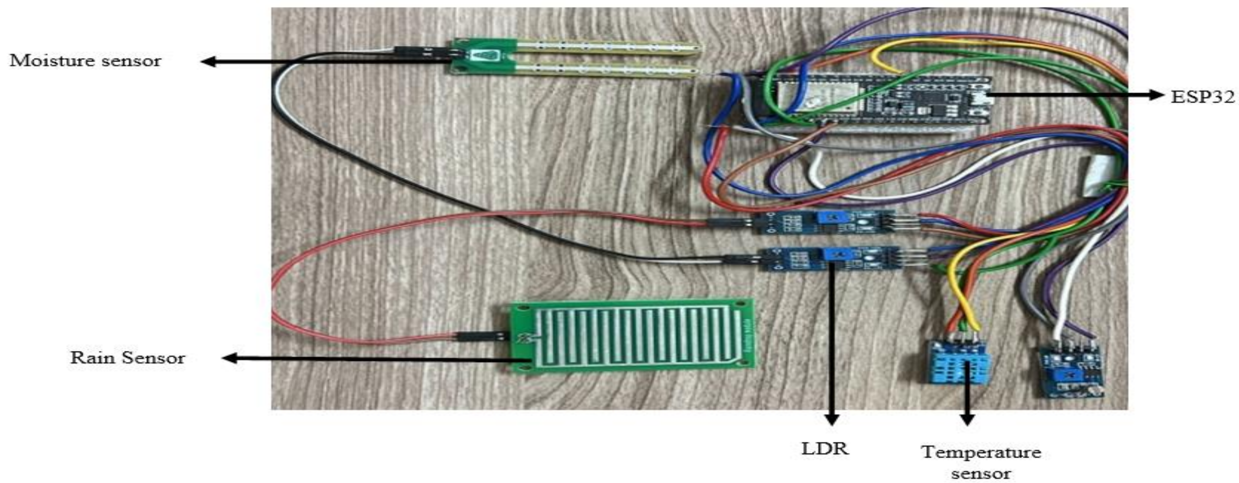

Figure 3: HARDWARE MODEL

5. RESULT AND DISCUSSION

The advanced system successfully integrates IoT-grounded environmental monitoring with an intelligent web operation for crop recommendation. When tested, the ESP32 microcontroller directly collected real- time data from the soil humidity, rain, and LDR detectors. This data was reliably transmitted to the Flask web where it was reused to estimate crop felicity. The system effectively anatomized whether the given crop matched the current soil and climate conditions and handed applicable toxin suggestions.

One of the significant issues of the system was the automated dispatch announcement point, which worked as intended. Whenever the detector values crossed a threshold (similar as low humidity or lack of sun), the system instantly transferred an dispatch alert to the stoner, icing timely intervention. This helped pretend real- world situations where growers could take immediate corrective conduct, similar as irrigation operation. The discussion reveals that the system provides a low- cost, effective, and scalable result for perfection husbandry. It reduces reliance on traditional husbandry styles and homemade decision-making by automating the crop selection and monitoring process. Still, advancements can be made in unborn performances by adding further detectors (e.g. pH, temperature), using machine literacy for smarter recommendations, and enabling multilingual support to feed to original growers across different regions.

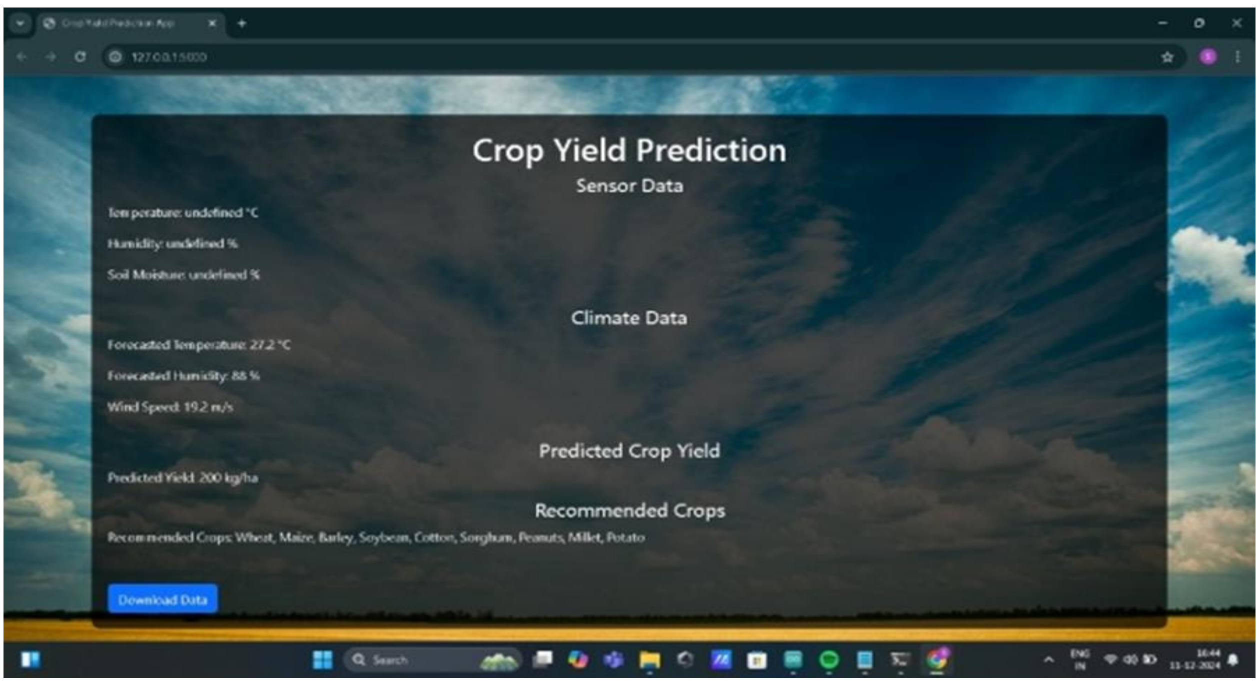

Figure 4: OUTPUT

Parameter	Value	Threshold	Status	Recommendation
Soil Moisture	32	30-60	Suitable	No action needed
Rainfall detected	Yes	-	Detected	Sufficient
LDR	720 Lux	600-1000 Lux	Optimal	Sunlight sufficient
Crop	Tomato	-	Analyzing	Suitable
Disease Alert	None	-	Safe	No disease
Fertilizer	Yes	NPK below 230	Needed	Apply NPK

Table 1: Output table of the proposed system

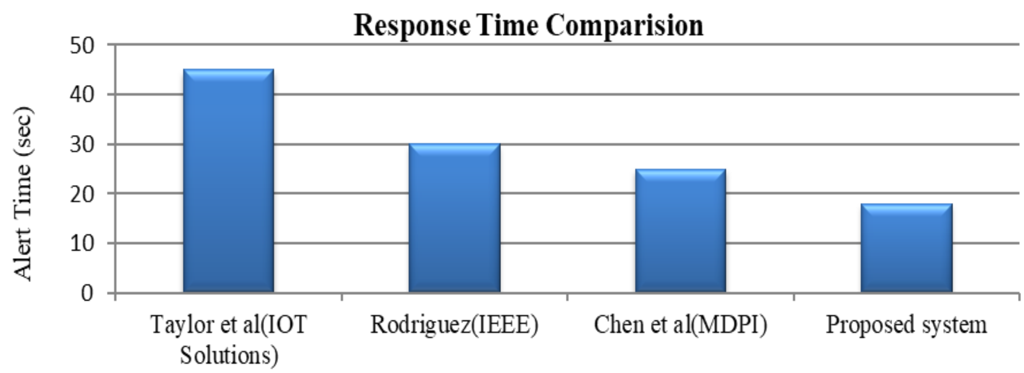

Fig 6: Response Time comparison graph

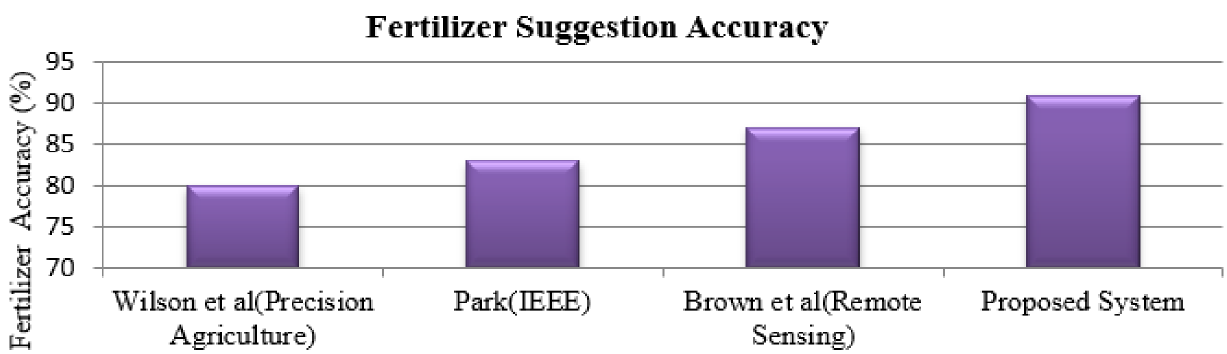

Fig 7: Fertilizer Suggestion Accuracy graph

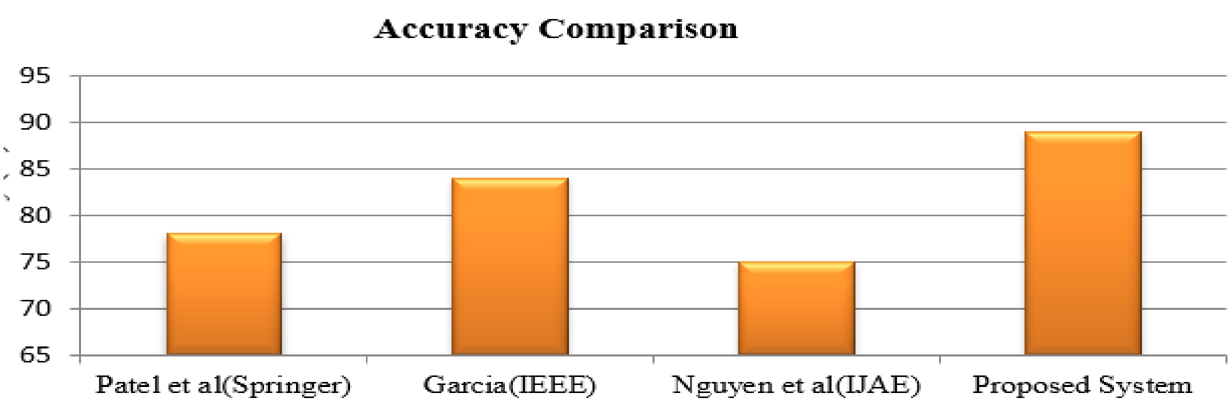

Fig 8: Accuracy comparison Graph

6. CONCLUSION

The proposed smart husbandry system leverages IoT and web technologies to revise husbandry practices by furnishing real- time, data- driven perceptivity to growers. By integrating environmental detectors similar as soil humidity, rain, and LDR sensors with an ESP32 microcontroller, the system ensures accurate monitoring of essential factors affecting crop growth. Through a Beaker- grounded web operation, growers can input crop details and admit individualized recommendations grounded on current climate and soil conditions, optimizing resource use and enhancing crop yield. The system not only improves effectiveness through automated irrigation and fertilization cautions but also supports complaint discovery and visionary measures to alleviate crop damage. Its secure data transmission protocols insure the confidentiality and integrity of planter data. Likewise, the scalable armature allows easy integration of new detectors and modules, making it adaptable to granges of all sizes and different crop requirements.

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