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A Framework for IoT Based Irrigation Monitoring and Prediction Algorithm

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ABSTRACT
Robust measurement and prediction of soil moisture content and other weather variables are vital for the effective use of increasingly scarce water resources for precision irrigation. Internet of things (IoT) and machine learning algorithms are trending technology that can help achieve precision irrigation which can also enhance food security. In this paper, the implementation of this IoT framework was done using ESPressoliteV2.0 module interfaced with different soil moisture sensors to sense the volumetric water content of the soil, flow meter to measure flow rate and a weather station to compute the evapotranspiration ratio (ETo), which was called by the Raspberry Pi. The combination of both soil moisture content and ETo value variation are used in monitoring and controlling of the irrigation. The proposed framework that will enable the integration of machine learning algorithm into the developed IoT system for prediction help achieve water saving. This system also enables remote monitoring of the greenhouse by the farmer, by making available the data of the above-mentioned parameters over the Internet and provides a promising solution to farmers.

Keywords: Soil Moisture Content, Internet of Things, Machine Learning, Evapotranspiration, Raspberry Pi

I. INTRODUCTION

Population growth, global warming, and increasing droughts are creating an unprecedented strain on the continued availability of water resources. Since irrigation is a major consumer of fresh water, wastage of resources in this sector could have strong consequences on food security. The challenge of ensuring irrigation across the world cannot be achieved without a major improvement in irrigation system by integrating cutting-edge technology such as the Internet of Things (IoT) for water management, machine learning strategies for prediction to account for the variabilities present in the environment and enhance precision Irrigation. Precision irrigation system plays a major role in providing significant contributions to food production and in reducing the stress passed through by farmers. Irrigation system needs to be precisely designed so as to be able to predict and deliver the appropriate amount of nutrients and water to the crops where and when it is needed based on the requested amount calculated for each crop [1],[2]. Therefore, to achieve precision irrigation, internet of things (IoT) and artificial intelligence techniques such as neural network, fuzzy logic, K nearest neighbour, decision tree, etc., should be leveraged upon to help achieve optimal water saving, maximize yield and minimizing environmental disturbance.

In the current decade, Internet of things (IoT) has been widely implemented in several fields such as Agriculture [3], healthcare [4], smart city [5], commercial [6] and industrial [7]. It has provided an efficient means of the monitoring system as the user can monitor their system anywhere and at any time [8]. In agriculture, the application of IoT has the main aim to connect physical objects (Things) such as sensors, camera, and robots to the Internet using low power network connectivity to measure variables such as soil moisture, temperature, humidity, images of plant and other weather conditions. Experts have estimated that connected IoT devices will see exponential growth in the coming years with 50 billion devices connected by 2020 and an average of 6.58 connected devices per person [9].

Therefore, it would be advantageous to implement the IoT platform to monitor and control the irrigation operation with the main aim to provide a competent platform in crop and irrigation monitoring for farmers in the future. The data generated in modern agricultural operations using IoT platform by different sensors that enable a better understanding of the operational environment (an interaction of dynamic crop, soil, and weather conditions) and the operation itself (machinery data), can be used for predictions more accurate and faster decision making in real time.

Machine learning which is a part of Artificial intelligence plays a key role which allows devices to learn without being explicitly programmed [10], [11] It also deals with scientific correlations between physical parameters making use of it various prediction algorithms that can be used to apply intelligence to the process of irrigation water predictions. They are expected to aid farmers in plant management or environment control, but they are mostly based on offline and static information, deviated from the actual situation on the farm. However, parallel management can be achieved using the internet of things, computational experiment, and parallel execution. This will provide a generic framework of solution for intelligent online decision support, where the monitored variables are stored on IoT platform and used to train a preferred machine learning model for prediction of various factors which have a direct impact on crop growth for decision and control purposes.

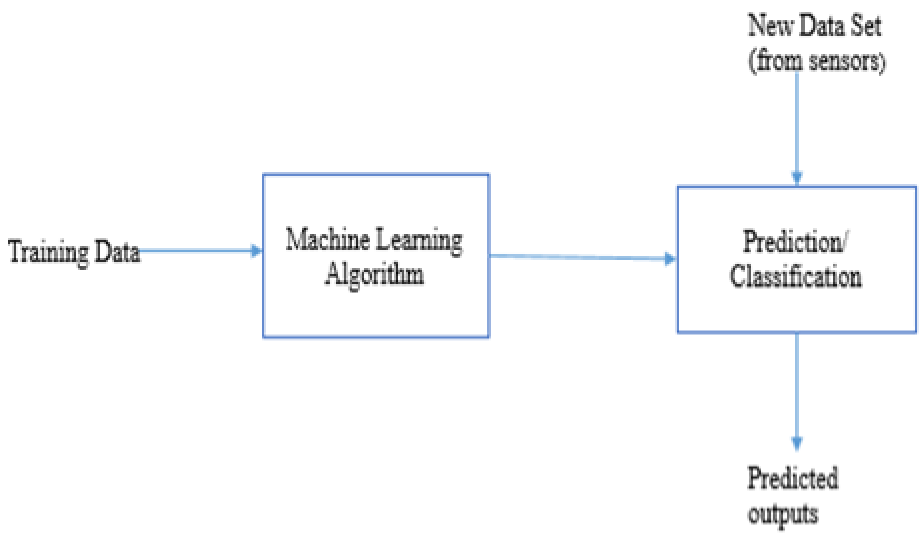

Figure 1. A typical machine learning approach.

This framework is aimed at optimizing water use efficiency, productivity, sustainability in precision farming and also ensuring the feasibility of running machine learning algorithms on an IoT edge device. Therefore we propose a framework on IoT based machine learning algorithm.

II. MATERIALS AND METHODS

A weather station was integrated with an IoT Arduino controller where the reference to evapotranspiration (ETo) inside a farm located in Lagos State, Nigeria, was computed to estimate the amount of water loss from the plant. Evapotranspiration (ETo) is a process which includes loss of water from the plant as well as soil surface into the environment [12]. The computation was done using “Equation 1” an FAO-56 Modified Penman-Montieth equation based on weather data measured by the Davis Vantage Pro 2.

$$ET_{O=}\ \frac{0.408\Delta(R_n - G) + \gamma\frac{900}{T+273}U_2\,(e_s\ - e_a)}{\Delta + \gamma(1 + 0.34u_2\,)} \qquad (1)$$

The FAO-56 equation requires weather data such as sunshine hour, wind-speed, relative humidity, solar radiation, average temperature, soil heat flux density, saturation vapour pressure, actual vapour pressure, the slope of the vapour pressure curve and psychometric constant as inputs[13].The ETo and other weather variables of the greenhouse are logged and are available on the greenhouse IoT database. The Intelligent IoT based Irrigation System as shown in figure 2 was further developed using espressiolite2 and Raspberry Pi as controller

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and processing unit. The VH400 moisture sensor senses the volumetric content of the soil, while an IoT wireless weather station deployed in the greenhouse where the Eto value is computed and further called by the Raspberry Pi to determine the crop water use. The YF-S201 water flow sensor measures volume of water used for irrigation at every irrigation time step, are interfaced to Raspberry Pi via an ESPressioliteV2.0, where sensed data is collected for decision and action.

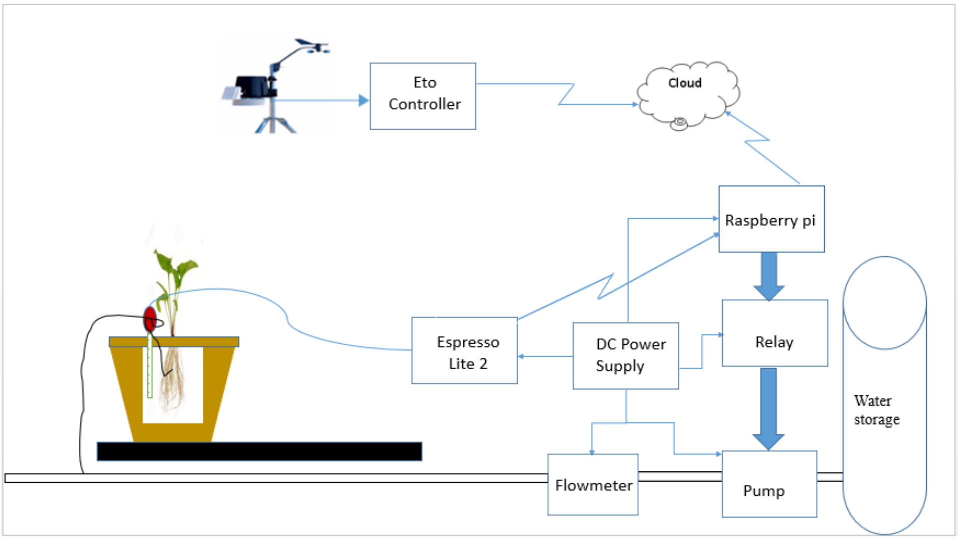

Figure 2: The IoT Irrigation System framework

In addition to these sensors, the actuator (water pump) via a solid state relay also connected to the Raspberry Pi for pumping the water, while a camera connected to the Pi to monitor the growth rate of the plant inside the greenhouse.

Lastly, the data from the greenhouse being irrigated is stored in Webpage of Cloud for farmers to access and monitor trend as well as performance. The combination of the volumetric water content (VWC) and Evapotranspiration (ETo) value are used to decide the irrigation instance of the system.

III. RESULT AND DISCUSSION

From both graphs in figure 3 above, it can be seen that there exist a relationship between data of the volumetric water content of the soil and evapotranspiration (ETo) when both are plotted against the time. As the water loss due to evapotranspiration increases, there is the corresponding decrease in the volumetric water content of the soil, showing that more water is needed to be supplied for irrigation. So both variable has a direct impact on the amount of water to be applied to the plant.

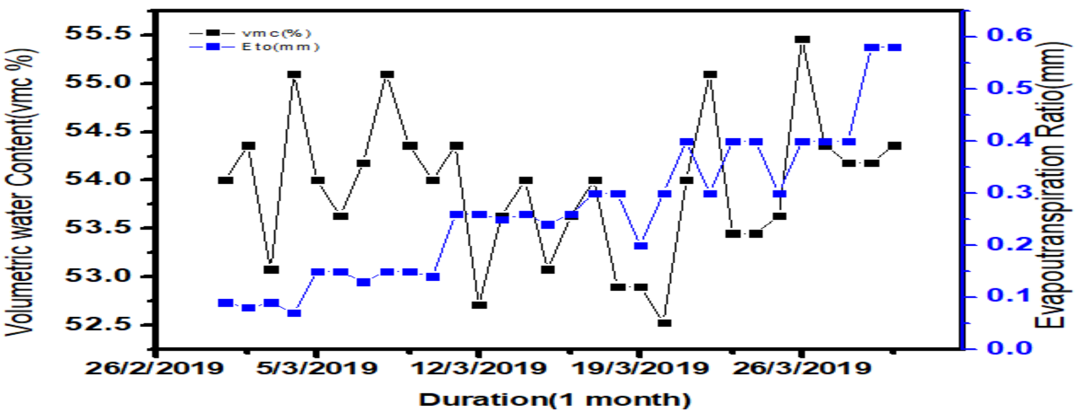

Figure 3. Graph of Soil moisture and ETo value measured

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IV. PROPOSED FRAMEWORK

The developed IoT irrigation controller has employed wireless sensors for monitoring the soil moisture content, evapotranspiration, and flow rate as a condition for irrigation decisions. The system communicates with the webserver for the storage of the data collected. In these system, an intelligence which analyses the real-time data based on past experience for irrigating the field does not exist. Therefore, the proposed framework that will leverage on the developed IoT system that captures the data from the greenhouse, analyse it using simple machine learning algorithm, make predictions and accordingly controls the relay for watering the field.

There term machine learning has been carried out towards crop yield and crop disease prediction only. There has been no much research reported which employs machine learning algorithm towards analysing the soil condition and weather variables real time, based on trained data set for irrigation of field automatically without any human intervention. We, therefore, propose a framework of intelligent IoT based irrigation system where the flow meter and moisture sensors and weather station for ETo computation and other variables are deployed in the greenhouse. The sensed moisture, flow rate, ET, and other weather variables are then wirelessly transmitted using expression lite via Wi-Fi to Edge device called Raspberry Pi. The machine learning algorithm will be embedded on the Raspberry Pi which will make use of the harvested data set for prediction and forecasting the amount of water required for irrigation.

Finally, the analysed data along with field irrigated are expected to be updated in the cloud server which lets the farmer know the condition of soil and also water being irrigated. The framework of the Machine learning IoT based System is shown in Figure 5.

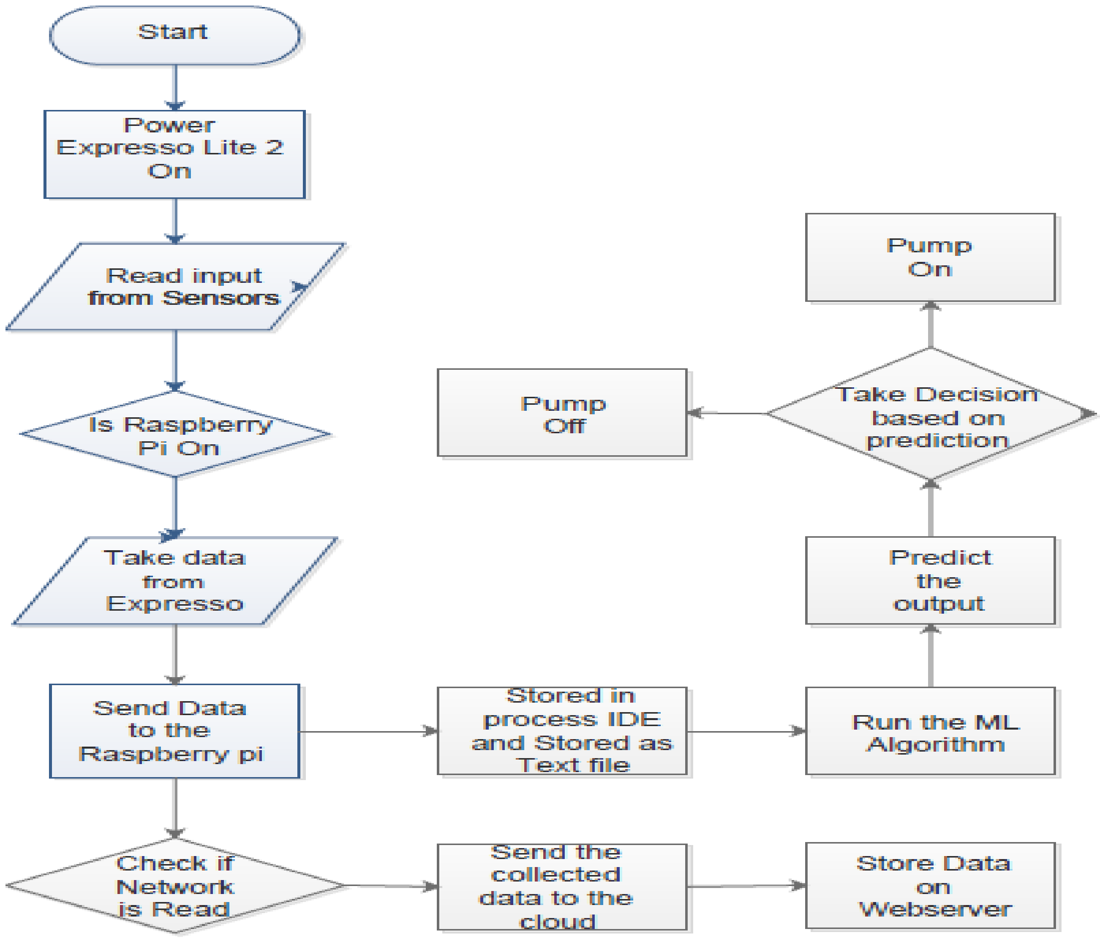

Figure5.Proposed IoT Machine learning algorithm framework

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V. CONCLUSION AND FUTURE WORK

The paper proposed an IoT based irrigation system framework that will enhance precision irrigation through the integration of machine learning algorithm leveraging on the IoT platform which will be used for performing data prediction based on data sensed by sensors. The IoT system platform will provide an automated solution for data prediction in real time. When implemented, the produced result will be helpful for a farmer to take accurate decisions, better yield, and high water saving.

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