Journal of Advanced Research in Embedded System
Volume 6, Issue 3&4 - 2019, Pg. No. 29-33
Peer Reviewed Journal

Review Article

A Review of IoT Implementations in Environment and Agriculture

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How to cite this article:
Joseph FJJ. A Review of IoT Implementations in Environment and Agriculture. *J Adv Res Embed Sys* 2019; 6(3&4): 29-33.

Date of Submission: 2019-12-16
Date of Acceptance: 2019-12-26

A B S T R A C T

This paper reviews a span of literatures in the implementation of IoT systems in Environment and agriculture. The motivation for this literature study is to provide insights on various sub domains in the above mentioned fields and the research challenges listed in the system designs. The literatures studied are from various sources of internet and constrained to those available in English. These methodologies are explained in brief about the theoretical architecture, middleware APIs, sensors used, actuator modules connected, data collected and the processing of data. This information is compiled to study the challenges and problems available. The discussion of literature studied lists the potential opportunities and challenges with the research in IoT system implementation in Environment protection and agriculture.

Keywords: IoT, Smart Farming, Smart Aquaponics, Smart Aquarium, Environment Monitoring

Introduction

IoT is one of the most promising technologies which is easing the lives of millions through automation. In the recent years, IoT is seen beyond the scope of automation. The advent of Big Data and the processing of data collected from the IoT devices has been done in the recent past with the help of machine learning.

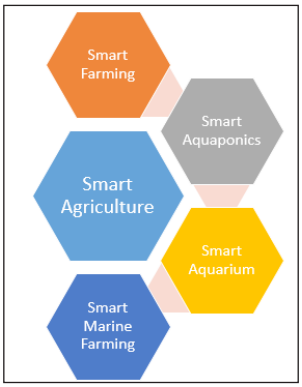

Figure 1.Smart Agriculture and its Verticals

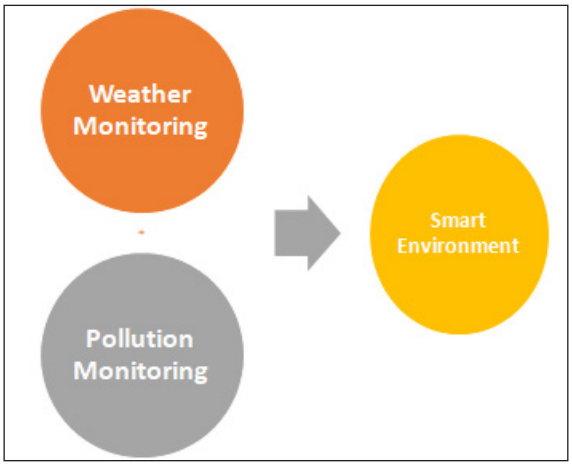

Figure 2.Smart Environment and its Verticals

The Figure 1, above shows the verticals available for smart agriculture. Smart farming deals with IoT based farming of crops in fields, green houses and other controlled environments by using sensors and actuators. Smart Aquaponics is a combination of smart farming and smart aquarium. Smart Aquarium is the analysis of data with

aquarium hobbyists.[1,2] This system is used by hobbyists, aquarium breeders and retailers. The aquarium systems with IoT are used for controlling the parasitic attacks and maintaining water quality in aquarium. Smart marine farming deals with IoT in farming of marine animals like shrimp, salmon, sturgeons etc. Smart aquarium and marine farming are beneficial to breeders and retailers to a greater extent in reducing the mortality of the fishes.

Related Work

Smart Agriculture includes the implementations in farming, aquaponics and marine farming. Environment monitoring includes IoT based weather monitoring and pollution monitoring. The sections below have an extensive study of various implementations in the above mentioned verticals. It has so many verticals to transform and provide AI based environment. There are plenty of resources online to develop an IoT based system.[3] Total number of papers taken in every domain listed in Fig 1 and 2 are listed below.

Smart Farming

A Rest API based design and implementation is proposed in.[4] A connected farm based architecture is introduced to provide an IoT based system for better maintenance of crops and the farms. End Users are provided with Mobius connected through Rest API. This API connects from the IoT systems installed in many farms connected through the same network. Mobius supports Machine to Machine (M2M) communication. The IoT systems and the Mobius interface are connected using & Cube middleware. This system monitors various parameters like CO_2, humidity, soil moisture, temperature and light intensity using sensors. Based on this input from the IoT devices, actuators like water sprinkler, LED lights, ventilation units are operated as actuators. This is done as an implementation and proposed to use IBM Watson as a future addition. This addition is expected to provide a knowledge base for the farming community.

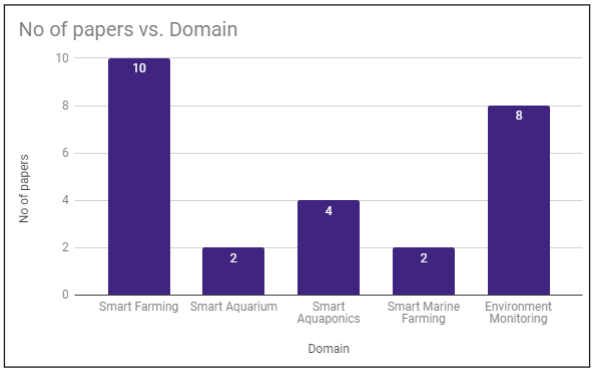

Figure 3.Number of Papers Listed in Review

A wireless IoT based smart farm architecture and implementation is reported by.[5] This includes hardware and software design. The hardware design enables MQ Telemetry Transport (MQTT) for communication and uses Arduino micro controllers to collect data from sensors. The wireless system uses low power Bluetooth and Low Power Wide Area Networks (LPWAN). The IoT Nodes, users and databases are bridged using MQTT broker. The wireless communication between MQTT and IoT device node is claimed to be a maximum of 500 meters. This implementation is aimed at the monitoring of greenhouse data and communication between the nodes. LPWAN which is used in many other methodologies prove to have a greater scope of less power consumption and easier data transmission.

Modelling of smart farm is reviewed for the design and development by.[6] The exemplar models of transcontinental enterprise farming techniques from Australia, Europe and North America were taken for the study. Apart from modelling, reduction of methane emissions and food intake design was also objective to this survey. The implementation of IoT based system in this design is to enable user centricity and sustainable decision making.

Cloud Computing and IoT based model is proposed by.[7] This model is a proposed theory on how IoT can be implemented using cloud in smart agriculture. Apart from generic agriculture, many crop specific sectors also implementing IoT based smart farming. Such an architecture is implemented by Chieochan[8] for Lingzhi mushroom farming. This uses MQTT with LINE API and NETPIE REST API as middleware. This is used to automatically control the water sprinklers and fog pumps in the farm. This uses Node MCU for data collection from sensors and Node JS in the front end provided to the user. The experimental results in this model reveals the practical implementation of the system in real time and the infographics generated by the APIs.

IoT based data analysis based smart farming was proposed by[9] using LINE API for the user interface of mobile application. This framework was developed to induce and increase the crop yield. This is a combination of mobile and web based application connected to the IoT nodes installed in villages taken in the study scope of research. Agri IoT based architecture for smart farming is proposed with a query based approach.[10] This system presents an architecture for IoT in agriculture in a layered approach. It has 11 main components including data wrapper, device manager, discovery module, data aggregation etc and semantic annotation. Security in IoT based smart farming is presented in.[11] It has sensors and electronic devices controlled using Python scripts and claimed a success of over 80% in test cases. The security includes control of rodents, diseases and attacks on crops. An AI based Edge architecture using deep learning in smart farming IoT is proposed[12] using Convolutional Neural Networks. It uses

a five layered architecture including Edge, Fog and Cloud. Smart irrigation based technique for precision agriculture is presented in.[13] An IoT driven wireless sensor network and soil quality control is presented in this architecture using ZIGBEE. This methodology proved better due to the rigorous deep learning implemented using Convolutional Neural networks.

Smart Aquaponics

IoT for smart aquaponics has to concentrate on both water and substrate quality. Beyond the traditional agriculture, the vegetation in this farming grows from the nutrients obtained due to the Carbon and Nitrogen cycles in the fish tank. There is not much soil in the substrates of vegetation. A smart aquaponic farming ecosystem was proposed by.[14] The hardware of this system uses Arduino Uno, Arduino WiFi shield and relay modules. The sensors and actuators are added to both water in the sump, fishtank and the hydroponic plant modules. The frontend of this system is developed using Blynk Application. IoT based smart aquaponics was developed as an application[15] and developed predictive analytics. An automation pyramid which consists of Enterprise Resource Planning, Supervisory Control and Data Acquisition and Manufacturing Execution Systems is applied. Five locations in Germany, Belgium, Spain and China were chosen and performance was studied. The stocking density was made optimum and the fish weight was increased. Dissolved solids like Ammonia, Nitrates, Phosphates and other suspended solids were controlled using this system. An API with Mongo DB is done track various sensors which record pH, temperature, water flow rate etc. An Arduino based pH monitoring system was proposed by[16] for maintaining water quality of aquaponics fish. This implementation was aimed to maintain pH to maintain water quality. Pumps and filters were controlled by Arduino and pH sensors. The increase and decrease of water flow rate controlled the pH of water when the dissolved solids were too high for the plants to absorb. This is an artificial means of managing the Nitrate cycle. Antares IoT platform is used as a front end to analyze the data.

Smart Aquarium

Fish Talk was proposed in[1] as a mini aquarium based IoT systems. This has sensors attached to the aquarium and uses AI to monitor and manage the water quality of the aquarium system. This model was specifically proposed for aquarium hobbyists. Aquarium monitoring system developed in[2] shows the communication systems to be developed for smart aquarium. This applies to fresh water tropical aquarium.

Smart Marine Farming

Ocean environment monitoring includes ocean sensing and monitoring, water quality monitoring, deep sea fish monitoring, wave and current monitoring using IoT.[17] This review is done on marine environment alone. However, there is less significance on fishes farmed in marine environment. Smart marine farming is also increasing as exponentially as the smart farming. There are many proposed methodologies available like the one in.[18] This presents a framework to manage the marine water quality using underwater nodes, surface buoys and surface nodes communicating over satellite. Data collection from sensors re done using MSP 430 with WiFi module.

Environment Monitoring

Environment monitoring includes weather and pollution monitoring. An IoT based architecture was proposed and implemented by.[19] The data collected in this process was subjected to the study of features in empirical analysis[20] are processed using HoVer representation[21] and the unified approach with the implementation of Support Vector Regression is proposed[22] and the results reported with correlation coefficient was found to be good enough to predict the regression of PM2.5 concentrations over the next few months. This framework has the monitoring of both weather and pollution monitoring. Similar implementations are provided by many others in.[3,23-27]

A handmade seismograph using Arduino was developed by Yoshio Okamoto.[28] This system is implemented in some locations in Japan and Thailand. This system uses an Arduino based analog sensor which records vibrations in three different perspectives and the data is transmitted through the serial port and received using Processing tool. This acquired data is stored digitally and safer than the traditional storage. The terminals installed in Thailand has detected the vibrations emitted by the nuclear tests done by North Korea and earthquake in the pacific countries and islands. This is a lesser known innovation in the field of seismology.

Discussion

The review of papers taken for this study is from journals and conference proceedings available in most of the eminent research databases. The inference from the study lists some advantages and potential area of improvement in the future. Most of the methodologies discussed in smart farming and environment monitoring has implementations and predictive analytics to observe. When it comes to smart aquarium, aquaponics and marine farming, there are relatively less number of literatures available to study the feasibility. This system which monitors and predicts the parameters are much needed in the future enhancement. The future work could be enhanced in smart aquarium, aquaponics and marine farming using machine learning techniques as discussed in smart farming. This approach could bring more technologies available to the above

mentioned domains. Most of the smart farming and smart environment techniques reviewed are developed from the Kingdom of Thailand. This is revealed after an extensive search of literatures.[8,9,14,19,22]

Conclusion

An extensive study of research articles on IoT based implementation in agriculture and environment monitoring systems are studied from various sources and libraries available online. The study and discussions show that there are a lot of research issues to be solved in the future work and the available technologies and solutions to the problems in the current scenario. The total number of papers reviewed in this paper for each domain shows a clear indicator of the advancements done in those domains using IoT. Lesser reviewed domains have more scope with the research in IoT and machine learning.

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