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A Comprehensive review on automation in hydroponic agriculture using machine learning and IoT

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Abstract

When food consumption is a very important condition, it is the sector that plays an important role. Must support current conditions where there is less land for agriculture and food security. The traditional methods used by farmers today are not sufficient to serve the increasing demand, so that limited land is an important factor in developing hydroponic agriculture. The hydroponic farming proposed in this study, there are two agriculture and fisheries. Only agriculture is discussed in this study. With the development of the hydroponic farming system, this system is very suitable for the conditions that need to be developed. The most pressing need is to clarify issues such as pest control and environmental impacts in fishing practices. The methodology used in this research is image preprocessing to collect structured and unstructured data to obtain information with the help of machine learning and IoT. The proposed machine learning method is Naive Bayes. Because the Naive Bayes method in some literature is more suitable for agriculture, but still overrides accuracy. The ultimate goal is to help farmers in producing food with alternative media.

Keywords: *hydroponic, IoT, Machine learning, embedded system*

INTRODUCTION

Agriculture plays an important role in the global economy. Changes towards increasing food yields increase as the human population increases. Food is a primary need for every human being. Changes in planting media are an important requirement. Where agricultural land is reduced, Hydroponics is an effective planting system in overcoming land problems. In the Hydroponic System there is also machine learning to help analyze a data set variable to form a pattern that will later be used as information for humans. Figure 1, below.

Figure 1 shows a schematic of the machine learning process in hydroponic agriculture, there are several machine learning methodologies that can be used. Here we used the Naive Bayes method, which is considered very suitable for the complexity of the calculation algorithm and various kinds of predictions and classifications. In addition, there are also several researcher using the majority voting techniques as a random tree to build a recommendations for suitable plant proposals that are efficient and effective (Reddy et al., 2019). Development prediction, detection results, quality and many more machine learning techniques (Liakos et al., 2018)

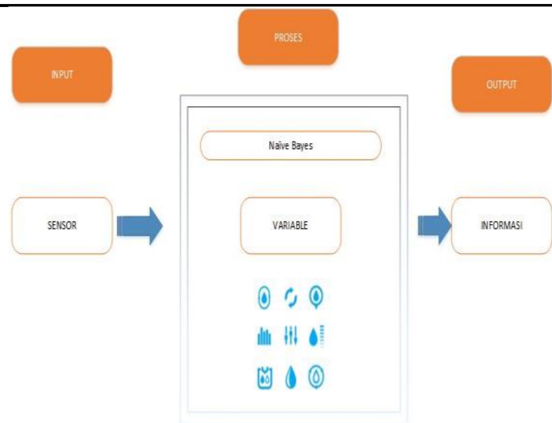

Figure 1. Machine Learning Hydroponic

With the help of Machine Learning IoT, it is hoped that it will become an added value for farmers to increase agricultural yields and also alternative media other than land. It is also referred to as Digital Farming which means the use of a structured computer system to calculate different parameters like pest detection. Machine learning used is Nave Bayes. Nave Bayes is used as the initial method using the Artificial Intelligent method. In the input data from Figure 1. Data is obtained from several sensors installed in the form of primary data and structured data and unstructured data.

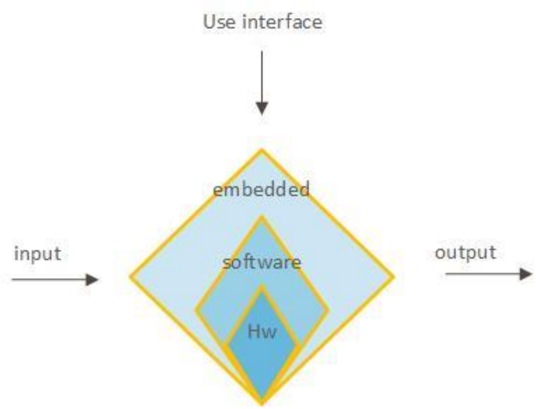

Figure 2, embedded system

In Figure 2 is a schematic of the embedded system algorithm used in the IoT system. Embedded system is a system built from hardware and software. The input in this system is generated from a variety of sensors installed on the IoT hydroponic system. Through the hardware software process, output is generated in the form of data which will be needed by Machine Learning. In addition to structured data sensors, the aim of this research is the images of leaves affected by pests can be detected by thermal sensors (unstructured data) and the images can be preprocessed.

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LITERATURE REVIEW

The position of the research being carried out lies in the acquisition of unstructured datasets and the process of obtaining hydroponic growing media datasets using IoT Machine learning.. The hydroponic system on the surface also clogs soil pores and kills beneficial microorganisms. Or, limited places of water supply cannot do irrigation during planting season because water requirements are often exceed the supply due to conventional types of irrigation such as sprinklers or in that it allows water to directly irrigate the rice fields (Kodali et al., 2017).This system does not require large enough agricultural land and hydroponics. All of these can be replaced with hydroponic systems, vegetable farming and hydroponics for the resulting catfish. An automatic calibrated pH sensor is able to detect and regulate the imbalance in the pH level of the nutrient solution used in agriculture (Cambra et al., 2018). Green House is an important part of the agricultural and gardening sector in our country because it can be used to grow crops in a managed climatic conditions for optimal yields (Bhagwat et al., 2018). The relationship with computerization in a Smart green house, is that the development of vegetable and hydroponics growth requires a relationship with conditions that are in accordance with the conditions of the surrounding environment, to avoid outside interference. With these conditions, sensors are needed to see the state of the environment in the Smart Green House. For all sensors to be controlled and viewed in real time, a technology called IoT is needed. Internet of Things (IoT) is the backbone of the change in today's developing technology era. Basically, in the real world things that have sensor capabilities, sufficient power supply and connectivity to the internet that make sensor analysis in the environment can be recognized by IOT (Vyas et al., 2018). The level of reliability of the sensor can be determined from the scheduling and environmental parameters(Singh & Chandra, 2018).

The power supply at the Smart Green House is not yet an important thing to pay attention to, the power supply or source of electrical energy should also be very important, because it holds the Green concept. Renewable energy is energy that is sourced from resources that are continuously replenished, such as sunlight, wind, rain, tides, waves and geothermal energy. Now there are various technologies that have this ability (Chehri & Mouftah, 2013). Likewise for the sensors that play a very important role, these sensors must be reliable and calibrated so that the output is suitable and precise. The development of IoT which includes smart sensors, devices, network topologies and several other technologies, is a solution to the main challenges facing agricultural progress (Rayhana et al., 2020). Artificial Intelligence and Machine Learning have penetrated in medicine, and many other sectors (Jha et al., 2019).

RESEARCH METHOD

In hydroponic farming, water is used as a growing medium. The use of data collection methods from several sensors, namely structured data and unstructured data. Then the data is collected, after that the data is validated, each sensor is calibrated, then preprocessed so that the data can be generated by machine learning. the information is useful for farmers to improve agricultural yields. Big data that can find out the pattern with the help of Machine Learning with naive bayes classification method, obtained the desired structural pattern in the process of plant growth and development.

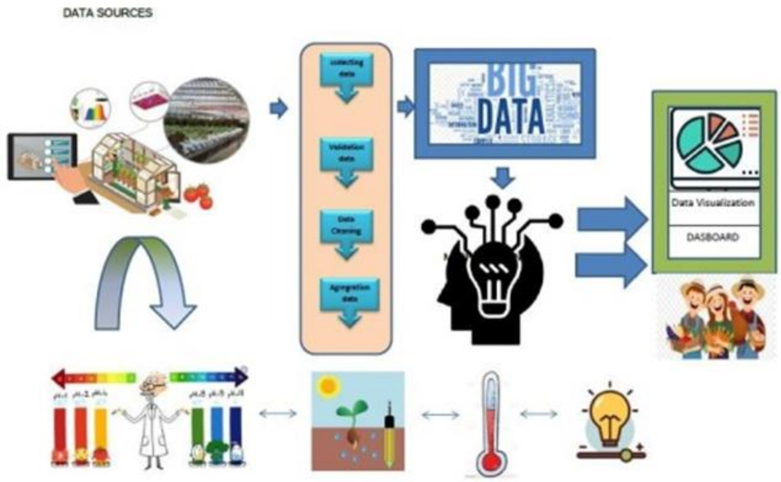

Figure 3. Methodology of research

FINDINGS AND DISCUSSION

Machine Learning (Naïve Bayes) in Hydroponic Farming.

In this hydroponic farming system, determining the data generated by the various sensors installed, including water humidity sensors, water pH, water clarity level is very important to provide input to the machine learning process. The machine learning process that will later be used is naïve Bayes. The use of naïve Bayes is to classify the data generated on the sensor, the information to produce healthy plants, fertile plants from environmental factors.

In Figure 4, a schematic flowchart of Naive Bayes is shown. Which there is an input and training data and also a testing data. Then from it, data is calculated and expected to get the resulting predictions so that the results are in accordance with what is expected. The calculations can be seen in the schematic formula below clearly.

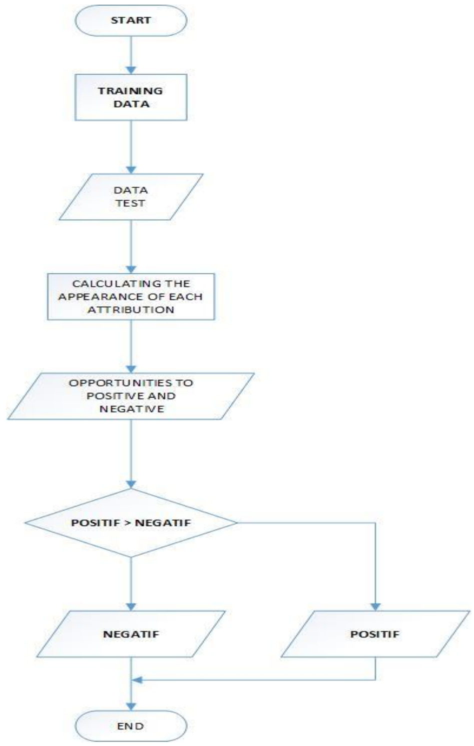

Figure 4. Machine learning flow chart naïve bayes

Naïve Bayes is the easiest classification to calculate probability and statistics based on the Bayorama Theorama . (Zhang et al., 2016)

$$P(H|E) = \frac{P(E|H) x P(H)}{P(E)} \quad (1)$$

P(H|E) : The conditional probability of a hypothesis H occurs if the evidence is provided.

P(E|H) : The probability that a proof E occurs will affect the hypothesis H.

P(H) : The initial (prior) hypothesis of H hypothesis occurs regardless of any evidence.

P(E) : The initial probability (prior) of evidence E occurs regardless of the hypothesis / other evidence.

In essence, simple Bayes counts for categorical types features as in the case of plant classification with features "bark cover with value {twig, leaf, limb} or casing for" plant type "features with a value of {male, female}.

For each class yj, the conditional probability of class yj for feature Xi is :

$$P(Xi = xi|Y = yi) = \frac{1}{\sqrt{2\pi\sigma ij}} exp - \frac{(xi - \mu ij)^2}{2\sigma^2 ij} \quad (2)$$

P : Opportunity

Xi : I-th attribute

xi : I-th attribute value

Y : Class sought

yi : Sub-class sought

μ : mean, average of all attributes

σ : standard deviation, variants of all attributes

Naïve Bayes (NB) is one of the most well-known algorithm data mining algorithms for classification (Wu et al., 2008). in many of these studies using the Waikato Environment for Knowledge Analysis (WEKA) in determining Naïve's performance Bayes classifies weather, agricultural, and sales price data to recommend types of food crops (Setiadi et al., 2020). Felt very suitable for hydroponic farming

Hydroponic

The hydroponic system is an important tool for the production of crops in indoor agriculture such as plants with artificial lighting (Son et al., 2015). This hydroponic system can also be placed outside the area with protection such as being covered in material. The goal is to avoid external disturbances.

In Figure 5, an image of the hydroponic system is shown that the water with pipes as the irrigation medium. The system below is a system of agricultural and fishery crops. This study shows that if hydroponic systems are designed and conditioned for their proper use, they can provide benefits for agriculture and fisheries (Magwaza et al., 2020). Therefore the use of hydroponic systems in urban agriculture can form a solution to the problem of urban food security.

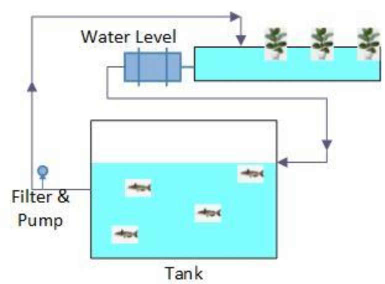

figure5. schame of hydroponik

Still in figure 5. is a picture of a water reservoir and plants. There is a tap or filter pump that is used for water control and also for water level marking. There are two habitats, the first is fish ponds and the second is plants. Therefore, if this situation goes well, vegetable and animal products can be produced.

Wireless Automation System in Hydroponic Farming

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The agricultural sector, especially in hydroponics, must adapt to the breakthroughs and discoveries that arise in the field of automation (Yong et al., 2018). Development of embedded systems applied to agriculture, irrigation systems, planting systems and others. The system used is a variety of sensors such as temperature sensors, humidity sensors, and light intensity sensors in agriculture. This sensor sends the perceived data to the database on the ZigBee / thinkspeak server via the embedded system and the use of wsn (wireless system network), makes it easy to monitor agricultural lands.

Wherever we are, this is required by several conditions that must be met, including the Zigbee. It can be seen in the figure below, is a schematic of an embedded system process connected to a WSN, connection with sensors until finally getting a dataset.

It can be seen in the figure below, is a schematic of an embedded system process connected to a WSN, connection with sensors until finally getting a dataset. The resulting dataset through machine learning will get patterns that can help humans in making decisions and further research in agriculture. In the wireless connection scheme in this application, it will read sensor data from Arduino via Ethernet shield and send data to the Thingspeak Webserver and store measurement data and display it in graphical form and can also be displayed in graphical form on mobile-based applications (Vatari et al., 2017)

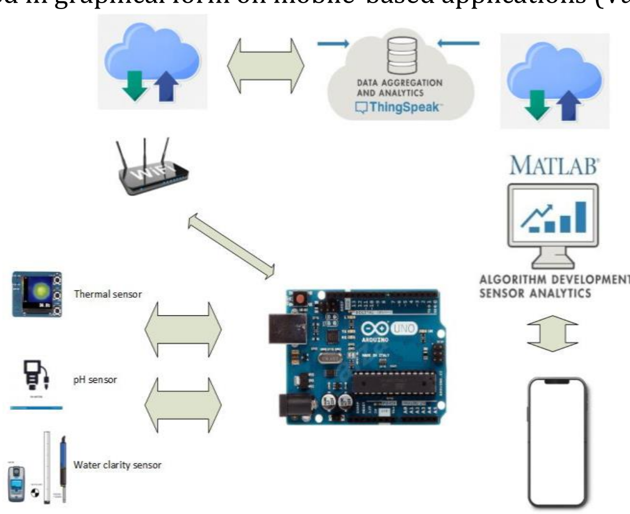

Figure 6. IoT agriculture scheme

The sensors used in this embedded system include the water clarity sensor, pH sensor, and thermal sensor. Water clarity sensors are used to obtain data on water clarity, pH sensors are used to obtain data on water pH and humidity, thermal sensors are used as an unstructured data with images to control plant leaf pest data. The end result of the combine structured and unstructured data is expected to produce data patterns resulting from plant classification.

The collection of datasets that are grouped into 2 types of dataset, namely by using several types of sensors installed in the smart green house as a monitoring tool. Dataset in the form of numerical numbers from pH sensor, clarity sensor and thermal sensor can be generated. Below is an example of a structured sensor dataset. The result is a structured dataset and an unstructured dataset, which is generated from sensors installed on the IoT system. The data sets generated earlier are then searching for the learning patterns through the supervised learning method, the Naive Bayes method. this method has been carried out effectively on a simple and not so large data of agriculture(Liakos et al., 2018).

In table 1 below is an example of a public dataset, which is obtained from github, which is a dataset of leaves from plants whose growth is recorded from their size. Data collection is carried out daily, weekly and monthly. Below is just an example

Table 1. example of a plant leaf sensor dataset

Location	Date	VW_30cm	VW_60cm	VW_90cm	VW_120cm	VW_150cm	T_30cm	T_60cm	T_90cm	T_120cm	T_150cm
CAF003	11/10/2010	NA	0.231	0.251	0.271	0.341	NA	9.61	10.75	11.55	12.32
CAF003	11/11/2010	NA	0.23	0.25	0.27	0.34	NA	9.24	10.46	11.4	12.25
CAF003	11/12/2010	NA	0.23	0.25	0.269	0.34	NA	9.01	10.22	11.24	12.14
CAF003	11/13/2010	NA	0.229	0.249	0.269	0.339	NA	8.75	10.01	10.99	12.03
CAF003	11/14/2010	NA	0.229	0.249	0.268	0.339	NA	8.38	9.76	10.9	11.88
CAF003	11/15/2010	NA	0.228	0.248	0.268	0.339	NA	8.22	9.53	10.73	11.76
CAF003	11/16/2010	0.312	0.229	0.249	0.269	0.34	7.26	8.35	9.42	10.53	11.63
CAF003	11/17/2010	0.308	0.231	0.25	0.27	0.342	6.78	8.4	9.4	10.45	11.51
CAF003	11/18/2010	0.321	0.231	0.25	0.27	0.342	6.28	8.3	9.37	10.37	11.4
CAF003	11/19/2010	0.314	0.23	0.25	0.27	0.341	5.33	8.05	9.24	10.28	11.3

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Then an unstructured dataset, which are the images generated from a paired thermal sensor. Below is the example. what the author wants to suggest is a continuation of the classification of images generated from the thermal slide installed from the IoT system (plant pests), so that this information can be useful for farmers.

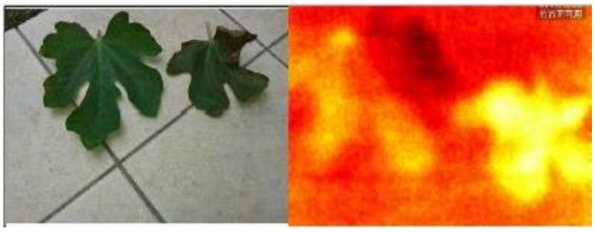

Figure 7. image sensor thermal (Chien et al., 2018)

Seen in fig 7, from the combination of these datasets as an examples which later will be applied to the hydroponic systems with smart green houses. Agricultural system monitoring tools are indispensable to reduce human interference in reality. The demand for food is getting higher day by day.

CONCLUSION

Supervision is a major concern because it helps reduce labor or reduce human intervention and increase production. Artificial Intelligence has been used and applied in crop selection and assisting farmers in the selection of fertilizers, crop pests and irrigation. With the help of the database that the user has collected and the system set up, suitable for communicating between them, the goal is to decide which crops to harvest and also to encourage the maximum growth of fertilizers. Many important machine learning methods can ensure farmers with better crop management and growing media. On this support, it will help the farmers in farming and farming. IoT technology is also very helpful in monitoring data in real time. IoT technology can help obtain data in the form of crop systems, irrigation systems, and plant pest control systems. This paper contributes an idea to create a system using an IoT sensor enclosure. Thermal sensor which is the focus of research and preprosesing data image are the further research. Tresholding , gray scale and cropping image are some technique for preposesing. Generates Image data to be part of the input for machine learning generating information for agriculture. Bright image is affected by pests and not bright image is not affected by pests.

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