TECHNOLOGY ACCEPTANCE MODEL TO EVALUATE THE ADOPTION OF THE INTERNET OF THINGS FOR PLANTING MAIZE

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Abstract

In recent days, Artificial Intelligence, or AI, has been utilized for various businesses especially in the field of agriculture. By applying the AI technology into the system, computers can understand and operate in a way that is similar to humans or sometimes even better. The use of AI can turn the very complex work of data management into an automated system which significantly helps people to work easier, quicker, and more convenient. The combination of using existing equipment with AI Technology is called Internet of Things (IOT) where all sorts of equipment used are turned into smart devices through internet connection. These smart devices can then receive various data and information through sensors on the devices. Thus, IOT is considered an important tool in collecting huge amount of data into the database which then generates big data. Big Data will be entered into AI to further improve and create constant machine learning. This research focuses on testing with maize, economical crop grown in Phetchabun province, Thailand. The objectives of this research were 1) to design and improve the IOT system through the use of soil moisture sensor, temperature, and humidity sensor (DHT11) with real time monitoring by connecting the data received to Google Sheet, and 2) to understand the factors that

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Received: 9 August 2021; Revised: 21 August 2021; Accepted: 21 September 2021
DOI: https://doi.org/10.14456/lsej.2021.13

affect the acceptance of IOT system technology. The results from this research showed that: 1) the IOT system for planting maize which is an economic crop in Phetchabun province was obtained, 2) the acceptance of this technology in terms of letting the farmers aware of the benefits and the convenience in using the IOT system. Perceived usefulness influences the adoption of technology was at a very high level, perceived ease of use influences the adoption of technology was at a high level and intention to use was at a high level. The results from research showed that the awareness for the benefits and the convenience of using this technology which leads to acceptance of the technology and increases productivity in the future using IOT system.

Keywords: Internet of things, Technology acceptance model, IoT acceptance model (IoTAM), Maize

Introduction

Maize (*Zea mays* L.), highland farming areas are found in 5 provinces, namely, Nan, Chiangmai, Loei, Kanchanaburi and Phetchabun. Maize has tall stems which can range from 60 cms up to 6 meters tall depending on the species. The diameter of the stem ranges from 0.5 – 2.0 inches. It takes approximately 100-120 days to be fully grown (Office of Agricultural Economics, 2020). The optimum conditions for the maize to grow is at temperature between 24–30 degrees Celsius, with the high presence of Nitrogen, Phosphorus, and Potassium in the soil. The soil should also have pH between 5.5–8. It is considered one of the economic crops in Thailand. Maize is an economic crop vitally important to animal feed industry in Thailand. It was estimated that the annual domestic demand for maize is 7.41 million tons, while the annual supply is only 4.62 million tons (Mimistry for the Environment, 2018).

Internet of Things: IoT.

Artificial Intelligence, or AI an alternative tool to enhance the use of existing data for further analysis, presents results quickly, correctly, and accurately (Stuart & Norvig, 2020). The data can be used to solve existing problems and support some decision-making process effectively (Rana et al., 2018; Ali et al., 2019). AI is one of the most important digital technologies in this modern age. Nowadays, AI uses operating system which imitates real human beings similar to how brains work (Tangwannawit, 2018). Huge amount of information that is put into the computer creates Big Data

(Wolfert et al., 2017) which generate Machine Learning where AI learns more from more data, hence getting smarter and smarter (Wu et al., 2016).

Internet of Things or IOT's role is to link everything together (Chen et al.,2019) with great amount of data to be stored, (Wang et al., 2018) filtered, and arrange them in order, (Digitales, 2016; Dawood, 2020) and store these data into the database (Chatterjee et al., 2018; Ardiansyah & Sarno, 2020) before transferring to AI for learning (Jin et al., 2020; Shaikh et al., 2017; Tangwannawit & Saengkrajang, 2019). While AI is a technology which enables learning and analyzing various data on its own through inputting vast amount of data again and again for the computer to remember what is needed and stored as database (Ali & Ali, 2019; Tanwannawit & Saengkrajang, 2019). After that, AI system uses these stored data to analyze (Sepasgozar et al., 2020; Sundaravadive et al., 2018) to improve itself, making it smarter, as smart as a human brain. There are currently two systems, AI and IOT, which are used together in order to provide most effective benefits.

Technology Acceptance Model: TAM

Davis et al., (1989) had presented the Technology Acceptance Model, or TAM, which was a theory to expand the knowledge further from the Theory of Reasoned Action (TRA) of Ajzen (1991). TRA is used to explain and predict behavior based on attitudes, norms, and intentions. The constructs of TRA are: Behavioral beliefs, evaluations of behavioral outcomes which lead to attitudes, intentions, motivation to comply which lead to certain actions. Davis had adapted this theory to explain the acceptance of information system that models how users come to accept and use the technology through Technology Acceptance Model (TAM).

The model consisted of a number of factors that influence their decisions about how and when they will use it such as Perceived Usefulness (PU), Perceived ease-of-use (PEOU), Behavioral intention (I), Attitude Towards Use (AT), and Actual Use (U).

Venkatesh & Davis (2003) define the Unified Theory of Acceptance and Use of Technology (UTAUT) through several key constructs: Performance Expectancy is a direct determination of a level of personal belief that the system can help improve the efficiency of their work. Rogers (2003) explains the definition of Relative Advantage in Innovation Diffusion Theory (IDT) as a level of acknowledging the innovation. Rogers

(2011) explains the process of accepting the innovation by dividing it into 5 steps: Awareness stage, Interest stage, Evaluation stage, Trial stage, and Adoption stage.

Based on the mentioned definition, it can be concluded that acceptance of technology means applying the technology that has been accepted to use which can benefit the users or promote several changes which are related to behavior, attitudes, and ease of using the technology. Moreover, by applying the technology into the users' work creates experiences, knowledge, and additional usage skills. From the TAM model in this research, it was divided into three aspects which influence the acceptance of technology:

1) Perceived Usefulness (PU)–the degree to which a person believes that using the IOT system would enhance their job performance. In this case, IOT can enhance the job performance of the young smart farmers who presented direct connection to the attitude towards usage and behavior of the user (Davic et al., 1989; Esmat & Mohamad, 2019).

2) Perceived Ease of Use (PEOU)–the degree to which a person believes that using the IOT system would be free from effort. This as well has a direct connection to the acceptance of the benefits and attitude towards using the system (Hong, 2016; Venkatesh & Davis, 2000).

3) Intention to Use-the degree to which a person likes or dislikes using the IOT system through attitude evaluation. So, Intention is an indicator to denote factors that influence a desired behavior. The intention to use consists of perceived ease of use and perceived usefulness. In addition, perceived ease of use also influences perceived usefulness (Venkatesh & Davis, 2000; Noor et al., 2020).

Materials and Methods

In this research, once the issues regarding the current agricultural system is identified, IOT technology is used to collect data from agriculture sector to analyze and present the results through dashboard. Big amount of data is used to improve the platform and link to application to monitor crop growing for farmers to generate the highest potential, with increasing crop production yield, reducing the cost, and in the end increasing the profit for farmers. The data collected on site consisted of temperature, sunlight, wind intensity, rain volume, and air humidity. These data were

analyzed and synthesized from several IOT sensor devices in order to regulate and control crop growing lands. These data collected were classified into sections and analyzed based on Big Data Center on Cloud. The steps to find algorithm are as follows:

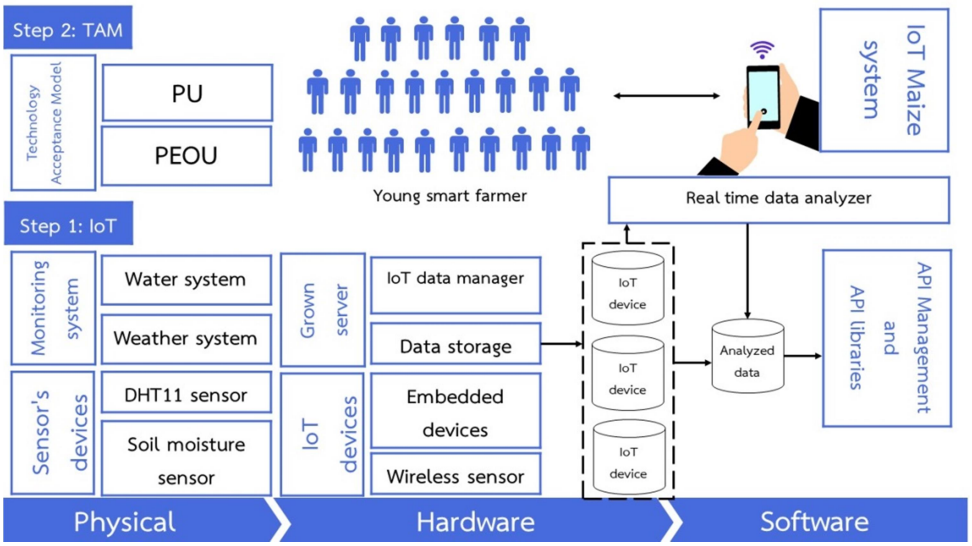

Figure 1 IOT system for planting maize architecture.

Step 1: IOT was implemented, designed, and improved 2 main parts which were Hardware and software as follows:

Step 1.1: the design and improvement of hardware in this research was developed by setting up 1 set of sensor equipment and tested at Tambon Na Ngua, Muang District, Phetchabun province. The sensor set up consisted of Arduino Uno R3, soil moisture sensor, temperature and humidity sensor (DHT11), NODEMCU ESP8266 module. All the sensors mentioned were connected together by receiving the values and data both through analog and digital. Data collection from all the sensors was done through Arduino board. The data were read and sent to a cloud system, API web service. Once cloud system received the data and recorded into the database. Firebase was connected to Wi-Fi in order to receive or send data between sensors.

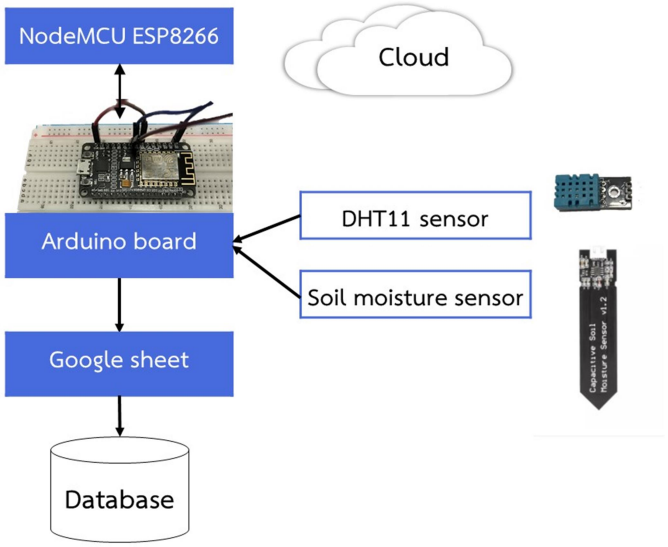

Figure 2 Process flow of IOT system for planting maize.

From figure 2, NODEMCU ESP8266 module design is to communicate on standard Wi-Fi by connecting with Arduino Uno R3. Arduino R3 is a micro-controller board with the use of small AVR as processor and command which can work independently or connect to other sensor equipment's such as soil moisture sensor, temperature and humidity sensor (DHT11). The data collected from all the sensors were stored in Google sheet.

Step 1.2: The intention to design and improve software was to manage data collection database in the form of No SQL from Google sheet. The separation of data storage of each sensory was done by data being sent from the sensor and web application part was designed to improve the maize cultivation IOT system. This was then used to write the program to control the operation of the system and write the website to present the data.

Step 2: TAM

After maize cultivation IOT system was created, the tools used in collecting the data were constructed in a form of questionnaire. All the questions in this questionnaire were divided into three parts. The first part consisted of 4 questions of perceived usefulness (PU1-PU4), the second part consisted of 4 questions of perceived ease of use (PEU5-PEU8), while the third part consisted of 3 questions of Intention to

Use (INT1-INT3). The rating scale was collected with 5-scale rating with mean and standard deviation. The data collection was done and arranged as online survey through Google Form while the illustration of maize cultivation IOT system was being conducted. The questionnaires were collected from 30 young smart farmers, as shown in Figure 3 below:

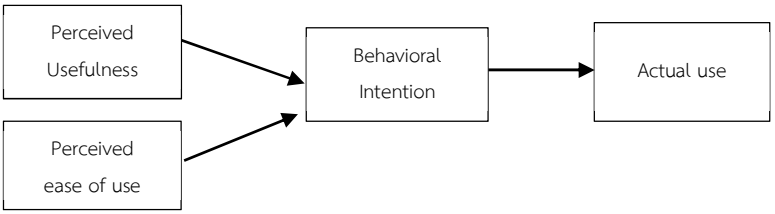

Figure 3 TAM (Davis, 1989)

Results

Results from improving the maize cultivation IOT system showed that system to examine the sensor value was done through web application. It was the system which is developed for users enabling to examine the value of different sensors and can be used in actual tasks. First, Raspberry Pi read different values from each sensor and sent all the data to cloud server for storage. The device then sent all sensor data to store in Google Sheet. Once the sensor started working, the users can access and see how the sensor was working through website simply by logging into the system. The process was presented on a dashboard, as shown in Figure 4 below.

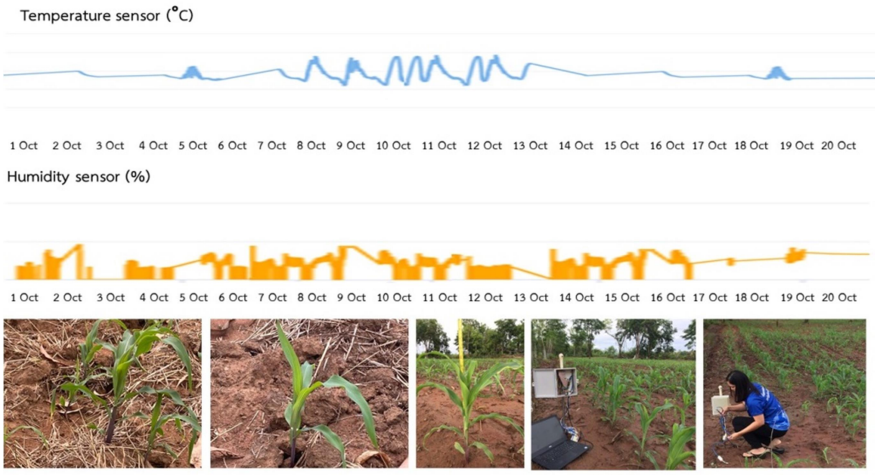

Figure 4 Results from improving the maize cultivation IOT system.

The results from testing the sensor in data storage was conducted through IOT system and data were collected from October to November 2020. The results from example data collection sensor showed that the measurements of the sensors function properly based on our objectives set, as shown in Table 1 below:

Table 1 Results of example data collection from IOT sensors of planting maize

No	Test	Day									
		1	2	3	4	5	6	7	8	9	10
1	Soil moisture sensor	495	472	462	469	466	472	465	469	466	473
2	Temperature sensor (°C)	33.50	33.29	32.39	33.39	32.19	33.00	31.90	32.69	32.20	33.20
3	Humidity sensor (%)	55.19	54.80	59.40	58.40	58.40	57.00	58.40	58.40	56.09	55.19

The results from the acceptance of technology showed that in terms of the perceived usefulness, the degree of acceptance was at the highest level. In terms of the ease of use, the degree of acceptance was at high level. And the degree of intention to use was also high as shown in Table 2, 3 and 4 below:

Table 2 Results from the acceptance of Technology in terms of the perceived usefulness

Measures of perceived usefulness	Mean	S.D.	SE	Acceptance degree
1. Use IOT system to increase performance in farming job.	4.70	0.46	0.85	Highest
2. Use IOT system to help increase job efficiency in cultivation maize since it can show temperature and humidity results, making it fast to store and process data immediately.	4.46	0.57	0.10	High
3. Use IOT system to increase efficiency in examining the temperature and humidity accurately, and faster.	4.60	0.50	0.91	Highest
4. Use IOT system through Internet to promotes(deleted) more convenience for new generation farmers, enable quick access to data without any constraints in location to access to the data no matter where they are.	4.56	0.50	0.92	Highest
Total	**4.58**	**0.51**	**0.05**	**Highest**

Table 3 Results from acceptance of technology in terms of the ease of use

Measures of ease of use	Mean	S.D.	SE	Acceptance degree
1. IOT has an easy to use-format, not a hassle to learn is one of the main factors to choose to use the system.	4.43	0.63	0.11	High
2. IOT is an alternative system in agriculture design to make the system easy to use.	4.23	0.73	0.13	High
3. IOT format is easy to use and convenient to be used instead of conventional labor routine work.	4.70	0.60	0.11	Highest
4. IOT format has the process that is not complicated, only internet is required to work and sensor can store the data instantly.	4.33	0.48	0.88	High
Total	**4.43**	**0.63**	**0.06**	**High**

Table 4 Results from acceptance of technology in terms of the intention to use

Measures of Intention to use	Mean	S.D.	SE	Acceptance degree
1. I intend to use the IOT system for planting maize.	4.50	0.51	0.93	Highest
2. I anticipate to using(deleted) the IOT system in the near future.	4.33	0.48	0.88	High
3. I will continue using the IOT system to increase productivity for planting maize.	4.53	0.51	0.93	Highest
Total	**4.46**	**0.50**	**0.05**	**High**

Discussions

Thus, in can be applied to large-scale agriculture sectors which enable control of production, the risk of drought, and predict the water volume which was consistent with the results from the studies of Ali & Ali (2019); Tangwannawit & Saengkrajang (2021) who had studied the smart farming model with the use of IOT. Based on the smart agriculture in combination with various hardware, it was found that IOT focuses on utilizing smart agriculture. And function that can assist data collection using remote control such as weeding, watering, and detecting humidity can improve agricultural productivity. Results of adopting to the technology in terms of perceived benefits in

actual and perception of ease of use were aligned with the correlation theory TAM based on the results from the study done by the researchers (Hong, 2016; Esmat & Mohamad, 2019) who had explained that perception of ease of use influences the perception of having benefit and influences the attitude towards use.

For future work, the research will create an IOT system for maize cultivation on a larger experimental plot and collect data into the database from a large set of nodes to store in big data and use them to analyze to find the suitable algorithm. To find the lost values, the K-mean technique will be used based on various sensor data and optimizing them to obtain a suitable classification group to use in forecasting and controlling the watering of plants. It will also be used to analyze the volume of water based on groups to predict whether the amount of water currently using can be saved or not. After that, AI will be used to learn and be able to automate several tasks.

Conclusions

Based on the analysis, factors that showed impact towards acceptance of maize cultivation IOT system of the young smart farmers can answer the results as follows:

Perceived usefulness influences the adoption of technology. From the research results, it was found that the mean was at the highest level. The first construct was accepted with a positive value. Thus, it can be interpreted that the perceived usefulness influences the adoption of IOT system for maize cultivation.

Perceived ease of use influences the adoption of the technology. Based on the results of this research, the statistical value of the mean was at a high level. Therefore, the second construct was accepted, and value was positive. Thus, in can be interpreted that the perception of simplicity and ease of use influence the adoption of IOT system in maize cultivation.

Intention to use influences the adoption of the technology. From the results of this research, the statistical value of the mean was at a high level. The young smart farmers have intention to use IOT system in maize cultivation.

Acknowledgements

This project was financially supported by the Thailand Research Fund and Phetchabun Rajabhat University, Contract No. PCRU-2564-RA05.

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