DEVELOPMENT AND APPLICATION OF VIRTUAL REALITY IN E-LEARNING: A CASE STUDY INTERNET OF THINGS COURSE

Lakkana Kidbanjong[1]
Sununta Kotchasarn[2]
Mayuree Srikulwong[3]

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Abstract

Studying of Internet of Things (IoT) allows students to understand the concept of computer systems that automatically read input and control smart devices. Using smart farm environment could be a good case study for IoT. Nevertheless, constructing physical smart farm could be problematic since it involves high budget allocation as well as the management, control and administration of the farm and devices. Developing a virtual environment that can depict smart farms could help solving this limitation. In this paper, we describe the process of getting requirements and developing smart farm virtual reality (VR) system. The system models smart farm device monitoring and management through a dashboard as well as allow students to learn their activities in the virtual environment in order to have a deep understanding on the concept of IoT. This research is funded by Research and Development Fund from the Office of the Broadcasting Commission television business and the National Telecommunications Commission (NBTC). The study result can be a guideline for virtual reality application development in other subjects and future study is also recommended.

Keywords: Virtual Reality, E-Learning, Internet of Things, Application

[1 2 3] Faculty of Science and Technology, University of the Thai Chamber of Commerce, 126/1 Vibavadi Rangsit Road, Bangkok 10400
E-mail: [1] lakkana_kid@utcc.ac.th [2] sununta_kot@utcc.ac.th [3] Mayuree_sri@utcc.ac.th

Introduction

Electronic learning (e-Learning) is a distance learning system through the Internet. Students can study as if they were in a classroom without any restrictions on time and place. There is a concrete evaluation system. At present, educational institutions in higher education in Thailand pay attention and develop an e-learning system so that students can access the information they need conveniently, quickly and up to date at all times. Various multi-medias have been used as a medium for presenting lessons to make it interesting and learners can understand by themselves, such as pictures, sounds, animations, etc.

At the moment, media for providing electronic education using virtual reality technology (Virtual Reality: VR) is advancing, allowing for the creation of a simulated environment using computer technology. This enables learners to identify and interact with common display and input devices, such as computer screens, keyboards, and mice.

The Internet of Things Course is a course that requires learners to understand the interaction of electronic devices such as sensor technology that assists in reading and collecting data and computer systems that are responsible for processing interesting visualizations (data visualization) that aid in understanding the data in order to achieve automation and assist in decision making for more efficient management in various areas.

Virtual reality technology is being used to create media for providing electronic lessons for an Internet of Things course. It enables students to study, learn, and comprehend the system of numerous devices without having to visit to a physical location, hence minimizing the risk of mishaps and minimizing travel time. Additionally, students may evaluate their knowledge at any moment by logging into electronic classes and accessing instructional resources.

This research has applied virtual reality media in electronic learning in Internet of Things course provided by the Faculty of Engineering, Srinakharinwirot University (SWU) according to the project of “Development Knowledge Based Learning Center using Digital Technology” for the year 2019, funded by the Research and Development Fund from National Broadcasting and Telecommunications Commission (NBTC). Faculty of Engineering, SWU, selected this content to create smart dairy farm applications as a case study in teaching such subjects that can create a more learning experience for learners than the traditional media used today. Additionally, this application demonstrates how virtual reality technology may be used to create media for providing electronic courses for an Internet of Things course.

The NBTC and SWU hope that the digital technology learning center will help prepare and develop the potential of students who will step into working age to become effective national personnel ready for the country's further development.

Objectives

1. To promote the development of teaching materials, creating content for learning, and implement more innovation and creativity in digital technology to the digital economy.

2. To develop virtual reality (VR) media for smart dairy farms for using in teaching and learning the Internet of Things course.

3. To support the application of virtual reality technology into teaching and learning related to agriculture without the need to practice in the field.

4. To encourage students' self-learning, understanding both the theory and practices concretely and applying the knowledge gained from such content to further develop the country.

Literature Reviews

Virtual Reality (VR) is a term that refers to a computer-generated environment that enables users to be aware and interact as if they were in a real setting (Office of the Royal Society, 2019). The majority of perceptual features are visible through a computer screen or three-dimensional display device. The virtual world may be interacted with by users using ordinary importing devices such as a keyboard and mouse (Trakullertyot, 2016).

The benefits of virtual reality include saving time and money on travel to physical locations, avoiding the expense of purchasing expensive real-world equipment, reducing learning time in comparison to on-site practice, and remaining safe in life and property without having to confront a real-world situation (Srifa, 2019)

At the moment, virtual reality may be utilized in a variety of industries, including medical, exhibits displaying rare or large goods, entertainment and tourism, and educational institutions to aid in teaching and learning and to improve learners' learning experiences (Lertpradit, 2017; Phothong, 2018)

In the sphere of education, virtual reality applications assist students in comprehending difficult-to-understand topics. For instance, virtual reality is used in the Netherlands to take pupils on a farm visit. Additionally, students may see the farm area's condition and speak with the farm owner during class (Sakornwasee, 2019).

E-Learning

Electronic learning (e-Learning) is a learning model that uses content transmission through electronic devices and computer networks. Learners can study content from computer-based instructional materials that have been designed and developed efficiently (Laohacharasang, 2002). Students can learn through the electronic learning model by themselves without limitation. both in time distance and place (Vichean et al., 2019). There are many forms of media applications in electronic lessons, including text, images, video clips, and ready-made programs in order to help support self-learning (Kuchontara, 2016)

Virtual reality technology is now being applied in electronic lessons to encourage learners to be interested and understand the content more deeply. For example, Saekow and Prasertsueai (2015) conducted the interactive multimedia lessons on surfing the world of computer equipment for students majoring in Computer meanwhile Wituwinit and Saenraj (2016) developed virtual multimedia teaching media on the history of Ayutthaya architecture: a case study of Rama Temple.

Internet of Things: IoT

The Internet of Things (IoT) is the network of devices that exchange and share data over computer networks with little human intervention. The operating system comprises of intelligent devices, wireless networks, and dashboards that all work together to accomplish automation objectives (Digital Ventures, 2018).

The Internet of Things is capable of storing and processing data with high precision, so reducing the possibility of mistakes and increasing operational efficiency in a variety of industries, including manufacturing and production. Additionally, the Internet of Things may assist transportation and logistics management, health and medical information systems, finance, energy and utility management, and intelligent agricultural management (Thongkamwitoon, 2016).

Thailand is a place of agriculture. At the moment, there is rising interest in bringing the Internet of Things to agriculture, namely the construction of a smart farm system for lemon plantations in Phetchaburi Province utilizing the Internet of Things (Sri-Amnuai et al., 2019). Additionally, IoT was used to create a smart farm system with Gran-Monte Vineyard in Khao Yai and Chawee Chuan Foods Co., Ltd.'s eggplant farm in Wiang Pa Pao District, Chiang Rai Province (Smart farm (Thailand), 2020). Additionally, the Digital Economy Promotion Agency (DEPA) used an IoT short-term course to develop smart agricultural water systems.

Application of virtual reality media in electronic lessons for simulating the operation of the Internet of Things

Several technologies have been created in the past to incorporate virtual reality with electronic learning. However, there is a dearth of educational applications of virtual reality and the Internet of Things. Previously conducted research concentrated on the interaction of virtual reality media and items. For instance, the notion of the Virtual Environment of Things (VEoT) was established via the development of a campus navigation application that interacted with both real and virtual objects (Mohamed et al. al., 2019).

Research by Mohamed et al. (2019) applied virtual reality to the Internet of Things for electronic lessons on the measurement of ultrasonic waves in the air. The students scan the QR code of the selected gadget, and the software provides a three-dimensional view of the equipment's functionality (3Ds). Learners may engage with the app to evaluate device operation through distance learning, without requiring a physical device.

Until now, Internet of Things course in Thailand for distance learning has not made use of virtual reality media in teaching and learning (Akhad, 2020). As a result, the researchers saw the need to design a paradigm for teaching and learning that incorporates both technologies (IoT and virtual reality media) in order to use VR equipment and software to offer material via more realistic experiences. With the advantages of virtual reality technology, it will aid learners in comprehending instructional goals. Additionally, the development cost is not prohibitively expensive in comparison to the current development environment.

This research applied virtual reality media in electronic learning in Internet of Things course of the Faculty of Engineering, Srinakharinwirot University (SWU) according to the project of Development Knowledge Based Learning Center using Digital Technology for the year 2019, funded by the research and development fund, from National Broadcasting and Telecommunications Commission (NBTC) and Faculty of Engineering (SWU) selected content to create smart dairy farm applications as a case study that can create a learning experience for learners than the traditional media used today.

Research Methodology

Demand analysis

The development of virtual reality for Internet of Things teaching and learning can reduce the limitations of practical fieldworks. This research has chosen to develop teaching materials in the form of virtual reality for smart dairy farms. The content of the smart dairy farm that is used in the development of virtual reality media for teaching the Internet of Things course will be the form of environmental observation of the large-scale dairy farm system. However, there is inability to interact with the environment, and there is no sound effects and no data analysis. Also, the system has unique models: 1) the panel scene to show the values that occur in the farm in real time and 2) a large dairy farm system simulation scene with two-dimensional and three-dimensional forms, a low polygon, and a basic animation style. For the use on VR devices, the system is a stand-alone application on the Android platform only, it can be used with Oculus Rift devices or an equivalent device with the following learning objectives:

- To enable students to learn to apply digital technology and the Internet of Things into agriculture.
- To enable students to know the location sensor, pulse sensor, and temperature sensor and apply them into managing animals in the farm through the IoT system.
- To enable students to know water quality sensors and water level sensor and apply them into systematically managing farm water systems through IoT.
- To enable students to know the humidity sensor and light sensor and apply them into controlling the grass watering system in the farm through the IoT system.

For the system development cycle, there are steps as follows.

1. Planning: Meeting team members to understand the work style, data preparation, and content details according to course objectives.

2. Requirement: The Faculty of Engineering compiles and distributes information about the Smart farm's content needs to manufacturers.

3. Storyboard: The Faculty of Engineering has developed a storyboard format for the purpose of determining and planning the quantity and type of layout and materials in the content.

4. Concept: Following approval of the storyboard, the idea for content production in 3D space is established, and the user interface (UI) is constructed.

5. Motion Proto: Writing script and program based on user interface contents such as as creating assets and raycasting of assets, including dashboard animation.

6. Prototype: Bringing all parts together to create a prototype.

7. Testing: Testing prototypes by the system users.

8. Final Product: Delivering the final work and bringing it to the server.

Virtual reality media design

The virtual reality media design is organized into two major scenes: 1) the dashboard, which displays the farm's real-time statistics; and 2) the large-scale dairy farming system model.

- **Designing various relevant elements within a smart dairy farm**

1) Elements within the control panel are shown in Figure 1:

1.1) The figure shows the total number of dairy cows categorized by age: young cows are not yet ready for mating, young cows are ready for mating, cows are ready producing or lactating.

1.2) The figure shows the overall weather conditions: humidity of the air, soil moisture, and temperature inside the farm which is the average value from the sensors installed across the farm.

1.3) The picture depicts the farm's water system, the quantity of drinking water stored in tanks 1 and 2, the amount of water in the raw water well, and the quality of the raw water.

1.4) The figure shows detail of 1.1), 1.2) and 1.3) classified by farm area.

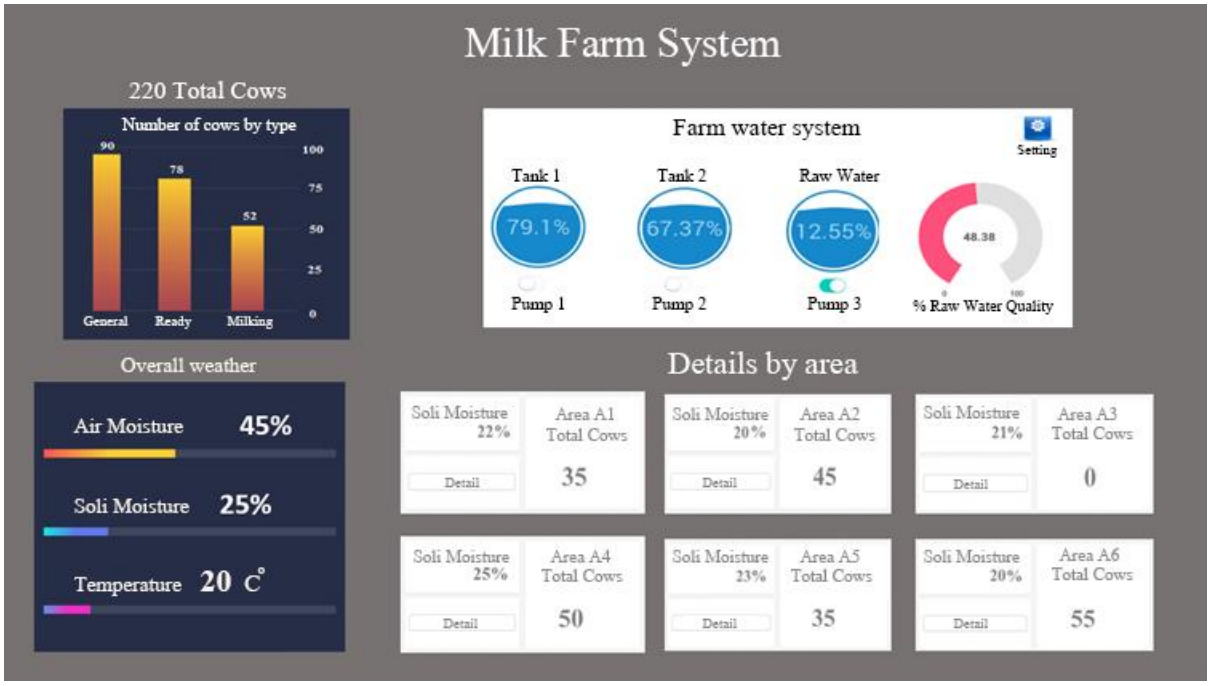

Figure 1 shows the control panel of a smart dairy farm

2) Other elements within the farm are:

2.1) Dairy cows are classified into three groups according on their age: cows who are not yet ready for mating, young cows that are ready for mating, and cows that are producing or nursing.

2.2) The sensor on the collar can monitor the heart rate and body temperature of dairy cows, as well as determine their present position in real time.

2.3) A soil moisture sensor is put in each region to determine the amount of soil moisture.

2.4) The tank's water level sensor is used to monitor the level of raw water and drinking water tanks for dairy cows.

2.5) Sprinklers are used on farms to irrigate the vegetation.

2.6) The pump is used to transfer water from raw wells to two tanks used to store drinking water and milk for dairy cows.

- **Farm scene design**

As seen in Figure 2, the scene within the dairy farm region is separated into six sections: A1 through A6. Each area is equipped with a soil moisture sensor that determines when it is appropriate to irrigate the grass. The soil moisture content was lowered by 2% per 1 hour, and the number of dairy cows in each location was determined. The following timetable applies to each area:

1) Areas A1 and A2 are designated as general greenhouses.

2) Area A3 is for dairies and dairy cows that are producing milk only. There are drinking water tanks and raw water sources.

3) Areas A4 to A6 are areas for releasing dairy cattle in the pasture.

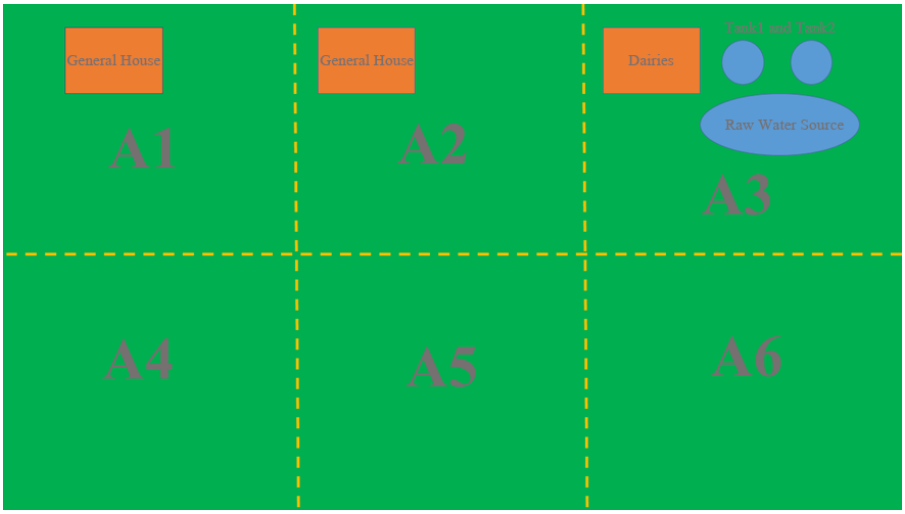

Figure 2 shows the division of the farm area

- **Management design within a dairy farm**

  Management design within a dairy farm can be detailed as follows.

1) All dairy cows are classified according to their age: young cows who are not yet ready to breed, young cows that are ready to breed, and producing or lactating cows. From the outset of the program, the life expectancy of each dairy cow is randomly assigned, and all dairy cows have sensors connected to their collars. The learners may use the dashboard to get detailed information about each dairy cow in each location. The information includes the dairy cow's code, its age, and its body temperature. If any dairy cow's body temperature exceeds 38.5 degrees Celsius, the control panel will illuminate that region with a warning light. When the student chooses to see the region, the computer determines which dairy cows had a body temperature more than 38.5 °C.

2) The collar contains cattle identification data, a central processor board, a heart rate sensor, a temperature sensor, and a location sensor. The learners may click on the collar to display facts about the software, as well as see the construction of the main processor board and sensor. Additionally, learners may observe the cow's location and zone on the control panel, as well as the cow's heart rate and temperature.

3) Water Management utilizes a water control system that is comprised of a central processor board and a water level sensor. The control panel indicates the quantity of raw water used and the volume of water in the tank. When water is pumped or sprinklers are opened to irrigate the farm grass, the amount of raw water in the well lowers. Each hour, the water level in the tank is dropped by 5%. When the water level in the tank is less than 15% of the tank's capacity and the raw water quality

is more than 40%, the program activates the pump placed in the raw water well. Water is pumped into the water tank until it is filled (100%). However, if the raw water quality falls below 40%, the control panel illuminates, and the water pump stops working. Concerning the determination of raw water quality, the learners may personalize it for testing the system by leaving out the pace at which the raw water in the well will be lowered and added.

4) The farm's land is split into six sections: Areas A1 and A2 are for general housing, whereas Area A3 is reserved for milking parlors and dairy cows that are actively producing milk; other dairy cows are not permitted to enter this area, and dairy animals in this area are not permitted to go to other areas. Additionally, sections A4 through A6 are designated for dairy cow pasture release.

5) In terms of soil management, the program shows the soil moisture value on the control panel. By reading the value from the sensor used to measure the level of soil moisture in each area, the soil moisture rate was reduced by 2% per hour When the soil moisture was less than the specified value (such values can be customized at startup), turn on automatic watering according to the sprinkler position.

Developing a virtual reality media prototype

For the smart farm virtual reality media model for teaching internet of things, there is a working procedure as shown in Figure 3.

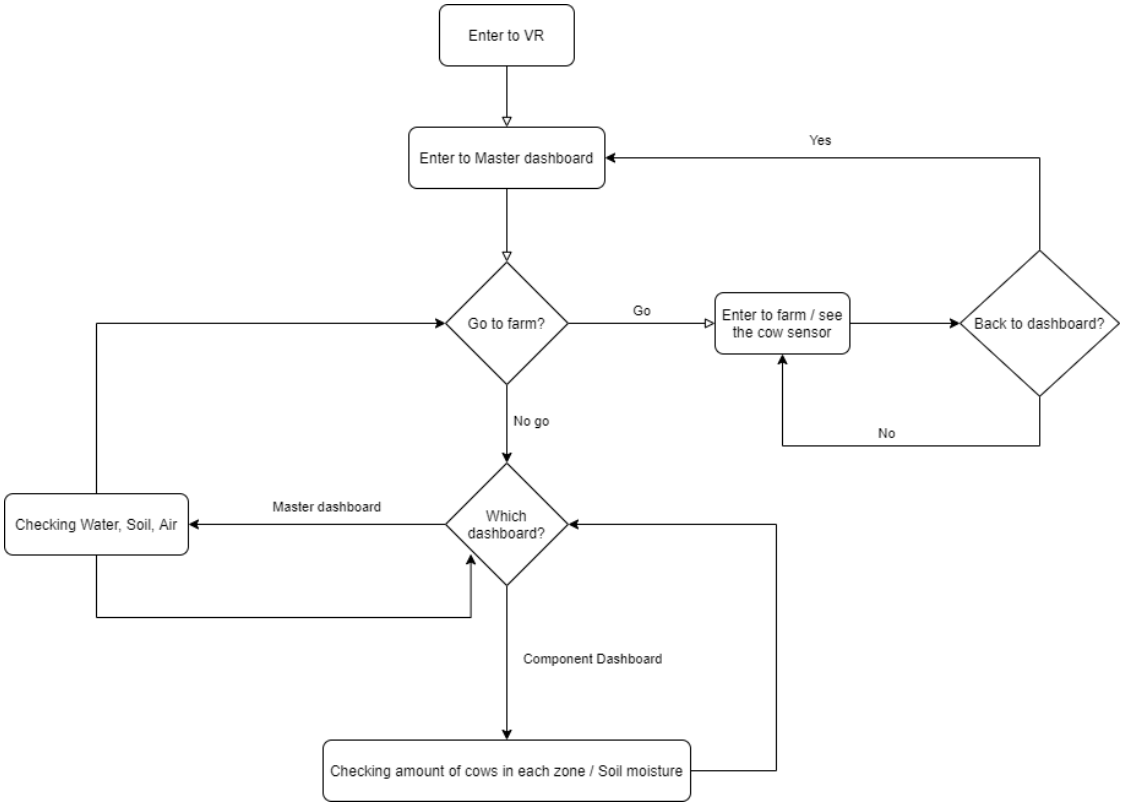

Figure 3 shows the working process of the virtual reality media prototype of the smart farm for teaching the Internet of Things

When a user signs in, the system presents the user with the primary dashboard (master dashboard), as seen in Figure 4.

Figure 4 shows the main instrument panel.

Users have the option of visiting or not visiting the farm. If users opt to visit the farm, the system will display the farm's atmosphere and dairy cows, as seen in Figures 5 and 6.

Figure 5 shows the environment and dairy cows on the farm.

Figure 6 shows the environment and dairy cows on the farm.

The sensor data attached to each dairy cow can be viewed as shown in Figure 7 and Figure 8.

Figure 7 shows a dairy cow in a sensor-equipped farm.

Figure 8 shows the sensor data.

If the users do not go to the farm page, they may return to the main dashboard to access the information. Also, the users may select between two sorts of sub-panels in this section: (1) a panel for viewing data on water, soil, and air quality; and (2) a panel for viewing data on dairy cows and soil moisture in each region, as seen in Figure 9.

Figure 9 shows a sub-panel for viewing dairy cows and soil moisture data for each section.

Conclusion

The construction of virtual reality media for the smart farm's Internet of Things course allows students to learn about digital technology's uses. Agriculture may benefit from the Internet of Things by providing a picture of the system without having to labor in the field. The user can learn about and apply positioning sensors, pulse sensors, temperature sensors, water quality sensors, water level sensors, humidity sensors, and light sensors to benefit various aspects of farm management, including farm animal management, water system management, and grass watering control, via an Internet of Things system. In conclusion, it was determined from the outcomes of system development and implementation in learning management that:

1. The virtual reality media system may be exhibited in any way that the user wishes. It is composed by two- and three-dimensional pictures. By adding more details to the farm's objects, it enables learners to have a more immersive learning experience from 360-degree view, which is controlled by rotating the head in the appropriate direction.

2. The utilization of virtual reality media technology for Internet of Things education provides learners with a novel experience. Additionally, it enables students to overcome physical barriers to accessing the actual environment of a smart farm without the institution investing in farm

construction and operation. This material assists learners in learning via the use of controls and body movement, which allows learners to comprehend the environment and develop knowledge of the course content as intended.

3. Learners may use the information obtained from using this technology to better successfully comprehend other Internet of Things-related topics

4. Virtual reality media technology provides learners with a new learning experience that is different from other types of technology media. The satisfaction survey of 30 learners revealed that were interested and impressed with the format of the media presented, with the students' satisfaction at a high level. In addition, learners provide additional comments for improving the existing environment in a system that requires further improvements such as audio and interactivity.

5. The study discovered issues with employing virtual reality technology with certain students who had motion sickness due to their unfamiliarity with the technology, including issues with the device's weight, which causes discomfort in the region where the device is worn. This is consistent with the study done by Ratanawijarn and Pongsanit (2016), who explain that continuous usage of the device may result in weariness and dizziness. Due to the nature of the graphic media and the device, the distance between the eyes and the screen on the glasses is only 5-10 centimeters. As a result, some users may find the system unsuitable for long-term usage.

Suggestions from study and for future work

The benefit obtained from this research is that the project of Development Knowledge Based Learning Center using Digital Technology, Srinakharinwirot University, can have assistants in teaching in engineering program focused on the Internet of Things course which the content is limited to only IoT. In addition, there are other limitations in terms of system requirements from the research fund which has determined the nature of the device and the nature of the intended content including the specifics that must be preliminary in order to construct the system within the stipulated time period.

However, smart agriculture is a modern farming method that makes use of numerous information technology to aid in enhancing agricultural efficiency and production, whether via increased productivity, resource conservation, or improved product quality. This also enables farmers to give nutrients in the optimal quantity and at the optimal time, as well as to guard and treat insect pests and disease outbreaks in animals in a timely way. Precision agriculture is the practice of this form of agriculture. The Internet of Things (IoT), big data, artificial intelligence (AI), and data science technologies are critical components of smart agriculture. To effectively profit from the development of virtual reality media for teaching and learning in the future, all relevant material should be included.

Additionally, future work should include case studies in additional subject areas, such as industry and business, as well as the use of technology to simulate situations such as fire detection and alarm, in order to provide a diverse range of learning content and adequately meet the needs of learners.

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