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Research design and production of ambient atmosphere monitoring control system internet of things technology application

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ABSTRACT

In this paper, presents solutions to application internet of things (IoT) technology in the field of high-tech agriculture, livestock in Vietnam is currently a new problem. The system includes an application on a smartphone; access the parameters via the web, on the computer. The product has a monitoring function: the ambient atmosphere indicators of the pig farm (temperature, humidity, CO_2, NH_3, H_2S gas, and Biogas pressure), on the website 24/24 hour and control automatic control monitoring system. This is a problem of researching, designing and manufacturing products to automatically control the quality of the ambient atmosphere to improve productivity and quality of pig raising in practice at Bach Khoa Production, Trade and Service Joint Stock Company Bach Phuong (Address: Vinh Hao Commune, Vu Ban District, Nam Dinh Province, Vietnam).

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1. INTRODUCTION

Today, allowing the application of modern science and technology in the field high-tech agriculture and livestock is being focused on and growing strongly. In particular, remote measurement, control, monitoring and environmental data collection techniques are applied in the development of high-tech agriculture to improve production efficiency and ensure agricultural development sustainable green industry in the future. The revolution of the internet of things (IoT) has created huge changes in human life now and in the future. With the development of the internet and smartphones, computer, electronics and especially sensor measuring devices and IoT monitoring are becoming a new trend in Vietnam as well as around the world. Monitoring gas environmental parameters in the livestock sector, thereby improving the quality of the gas environment to avoid pollution to the surrounding environment. This is a very important issue in industry as well as agriculture [1]–[3]. Developed countries such as the Netherlands, the United States, France, China, Germany, Korea, have been applying new IoT technology to improve the productivity of shrimp and fish farming, bringing high economic benefits and lowering production costs. On the other hand, with the rapid development of science and technology, many businesses/households now raise pigs in rural areas; as well as livestock farms in Vietnam that have applied IoT in agriculture in general; and in pig farming in particular, [3]–[5]. This new technology has helped the livestock industry create a new breakthrough, from qualitative production to accurate production based on data collection, synthesis and statistical analysis. From depending on livestock farming and manual handling of barns; environment, biogas, the application of high technology has brought many benefits to farming households; livestock enterprise. Specifically, proactively adjust parameters (temperature, humidity, CO_2 gas, NH_3 gas, H_2S gas, and biogas gas pressure) to achieve the desired effect [6]–[8]. Sensor and measurement equipment systems will be connected to each other, integrated on the IoT technology platform to monitor and collect data, and connect to cloud infrastructure to retrieve data and analyze it. Make decisions to optimize gas volume, temperature, humidity, CO_2, NH_3, H_2S and biogas pressure, thereby automating daily animal health monitoring activities and providing monitoring solutions parameters in real time [3], [9]–[15]. In particular, with the application of IoT to livestock farming, product quality will be improved, thereby contributing to building the position and brand of products, especially quality export and agricultural products high [14]–[16].

In this article, the authors propose to focus on researching and designing and manufacturing systems for monitoring and controlling parameters of gas environments including (temperature, humidity, CO_2 gas, NH_3 gas, H_2S, and gas pressure) based on the application of IoT technology for livestock households and pig farms. This system allows monitoring and controlling the operation of equipment through applications on smartphones, computers, iPhone, and iPad, to collect and process data of livestock farms farming. Thereby making decisions to control the system (such as: cooling and lowering the temperature, increasing the heat when the humidity is too low, reducing the amount of CO_2, NH_3, H_2S, and Biogas pressure) to meet the standards and does not affect the surrounding environment [16]–[19].

2. RESEARCH CONTENT

2.1. The building models and design supervision and control systems

Consider the livestock farm system model with a large-scale farm including sensor system equipment and livestock monitoring; is described and shown in Figure 1. Research on production and business organization and development of gas environment monitoring and control equipment, analysis and management of data applying IoT technology in small and medium-sized livestock farms (pigs and poultry) in Nam Dinh province in Vietnam. The monitoring system includes parameters: through smart sensors such as; Measure temperature, humidity, CO_2, NH_3, H_2S, biogas pressure and artificial intelligent (AI) camera. From there, research, test, calculate, build models, evaluate, survey and compare between traditional and manual livestock farm models; Compare with current advanced livestock models to provide design and manufacturing solutions for control systems [14], [20]. The system includes a host computer that collects data and runs a monitoring and control interface on a control board basis. Devices are accessed remotely via Wi-Fi network or internet to access supervision interfaces such as phones and tablet computer [2], [5], [21], [22].

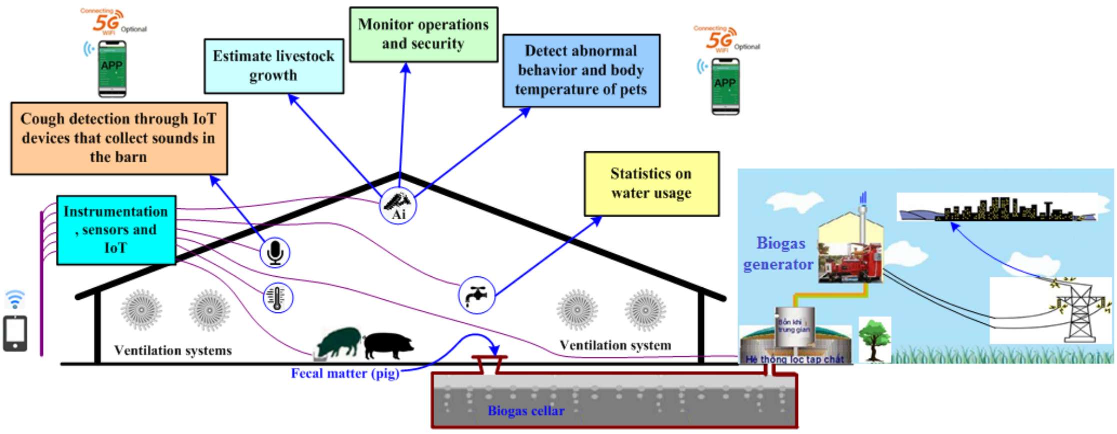

Figure 1. The smart farm management system

In Figure 2, the cages and material storage system, lighting space, drainage system, ventilation fan system, AI camera system, gas environmental sensor system (NH_3, CO_2, and gas H_2S). Calculate, design, manufacture, and control circuits in a detailed and effective manner [6]. On that basis, the research team calculated, designed, and manufactured the system control circuit as required based on IoT technology. Achievable parameters: Temperature needs to reach from (15÷35) degrees Celsius, the required humidity is from (40÷90)%, NH_3 gas: less than 25 ppm, CO_2 gas: less than 4%, H_2S gas: less than 25 ppm, module ESP32, intermediate relay set to receive system control switching commands. The system monitors gas environment indicators with the control circuit as shown in Figure 3. The system is capable of controlling 05 gas environment parameters (temperature, humidity, CO_2, NH_3, and H_2S) based on parameters. Accurate measurements from online sensors 24/7 on the Website via phone or computer. Then the controller located at the central farm sends data to the server via the web. Collecting data via the internet from computers; Through the web server system, it collects data and runs with the control system monitoring interface. Some devices access data remotely via Wi-Fi network; WiMAX or internet to access via surveillance like, phone, and tablet computer [22]–[27].

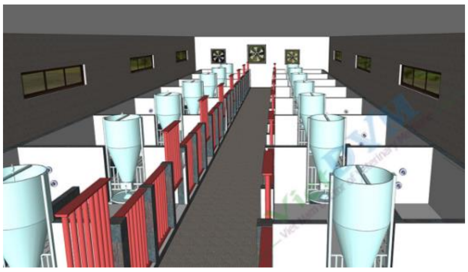

Figure 2. System model cages of 3D space

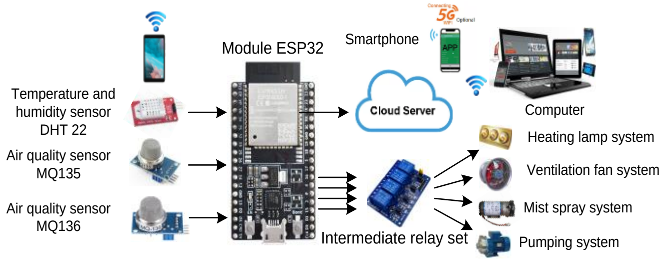

Figure 3. Principle diagram of IoT technology livestock farm control system

The image of the electrical cabinet is built as shown in Figure 4. The electrical cabinet includes: 12 V/5 A honeycomb power source, control circuit, LCD display to monitor temperature, humidity, NH_3 gas, CO_2 gas, and H_2S gas. Integrated automatic control in the farm: temperature control (through water pump, fan, heating lamp), humidity control (through mist pump system, fan), air filtration control (through pump and fan systems). Thereby saving energy (electricity, water), operating labor costs, improving animal productivity and quality, minimizing air pollution around the farm.

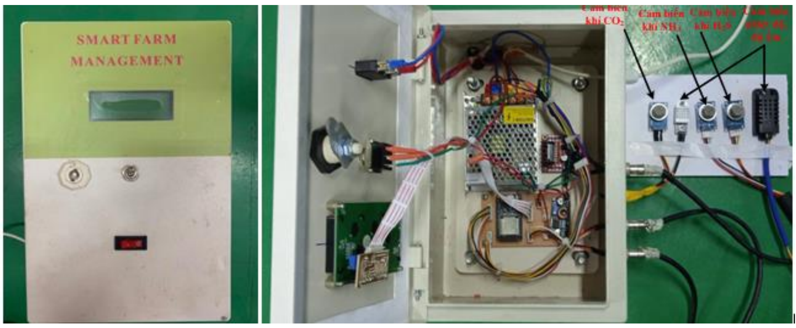

Figure 4. The system controller electrical cabinet

2.2. The control program to monitor temperature, humidity, NH_3 gas, CO_2 gas, H_2S gas

The controller controls and monitors the operation of the gas environment: temperature, humidity, NH_3 gas, CO_2 gas, and H_2S gas. Includes 2 control modes: auto and manual. Auto mode: temperature greater than 35 ºC will automatically turn on the fan, temperature less than 12 ºC will turn on the heating device, humidity <40% will turn on the mist sprayer, humidity >90% will control the air filtration system, if the air quality in the barn is poor (when the sensor reports), control the fan system to filter the air. The manual mode: can control pumps, fans, mist sprayers, heating lamps, and measure biogas pressure with the ON/OFF buttons on the control cabinet.

Instead of performing calculation expressions and mathematical equations, the research team here provides technical requirements to ensure full functionality of the pig farm, thereby building program code to load onto the on chip and assemble the circuit to meet technical requirements based on the control program algorithm flow chart illustrated in Figure 5. The gas environment monitor in the air quality monitoring and control model for pig farms is designed with a function that allows setting an upper threshold, when the allowable threshold is exceeded. Use sensors to automatically collect information from the control system via the website and chart the main parameters (temperature, humidity, NH_3 gas, CO_2 gas, and H_2S gas). Monitor temperature, humidity, NH_3 gas, CO_2 gas, and H_2S gas. In addition, there can be additional biogas gas pressure, then the electrical control and monitoring equipment has also been promptly integrated (with an expansion module) to improve air quality and the surrounding environment.

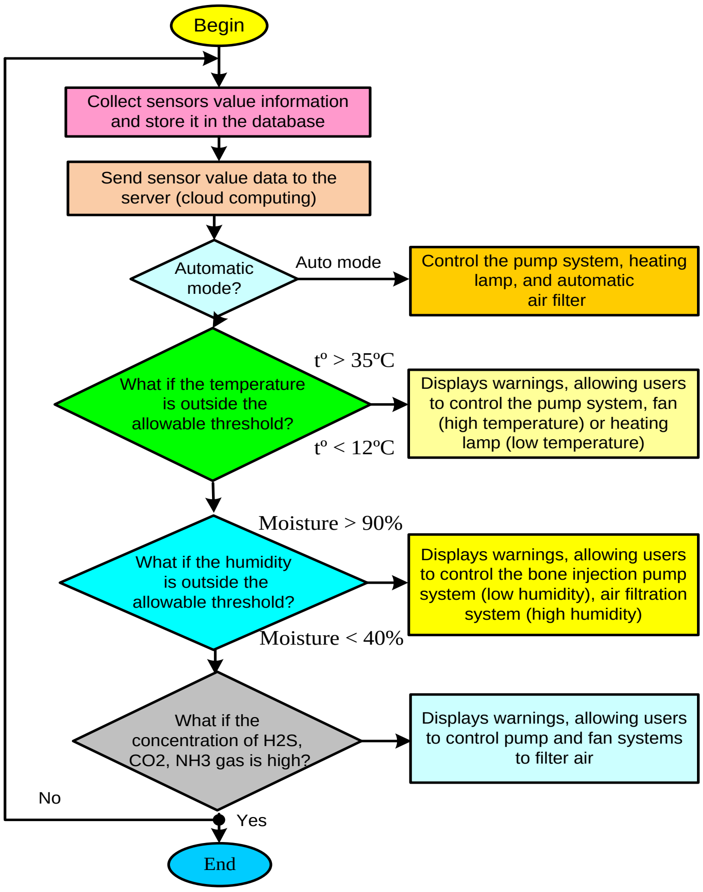

Figure 5. Control program algorithm flow chart for livestock farm system with IoT monitoring

3. RESEARCH RESULTS AND DISCUSSION

To perform the process of controlling and monitoring the system with gas environment parameters (temperature, humidity, NH_3 gas, CO_2 gas, and H_2S gas) that are considered necessary, control has been integrated here. Automation on the farm: temperature control (through water pump, fan, heating lamp), humidity control (through mist pump system, fan), air filtration control (through pump system, fan). Thereby saving energy (electricity and water), operating labor costs, and improving the value of animal productivity and quality. Experimental studies show the effectiveness of the model proposed by several studies [20], [23], [25], [27].

Monitoring results on the website through computer as shown in Figure 6 to Figure 11. Monitoring results on the website via phone is shown in Figure 12. In particular, Figure 7 describes in detail the measurement table with the results of the last 10 readings with parameters of temperature, humidity, H_2S, CO_2 and ventilation fan for the barn.

Figure 8 shows the temperature characteristics measured at different times on the monitoring interface via computer and phone. This characteristic accurately represents parameter values when changing the temperature of the environment. Figure 9 shows the humidity parameters with the 10 closest parameters, the characteristic curve shows that the humidity is always stable with the actual value of the environment.

Figure 10 is the measured results with the characteristic curve showing the measured parameters of CO_2 gas with the ten closest parameters. Sensor positions are fully updated when measuring parameters as the values change. In Figure 11 chart of parameters measuring H_2S gas concentration with the 10 most recent measurements is shown. When the system has an integrated online monitoring system (with motion and sound detection) so that when there are unusual phenomena at the pig farm, the system has a full range of phone warning devices. through AI smart surveillance camera system as Figure 12 and Figure 13.

Method of monitoring on the Website via phone or computer. The research team has chosen the Web Hosting provider: *https://www.000webhost.com/*; to conduct testing. This is a long-standing reputable Web Hosting provider, with data capacity of 300 MB, monthly bandwidth of 3 GB, number of files and folders (Inode) up to 10,000.

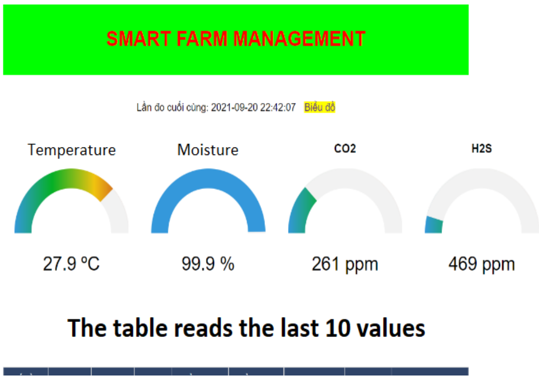

Figure 6. Interface when accessing from computer

The table reads the last 10 values

Number of measurements	Place	Temperature	Moisture	CO2 concentration	H2S concentration	Ventilation fan	Fan heaters	Reading time
7539	Farm 1	27.90	99.90	261	469	100	0	2023-09-20 22:42:07
7538	Farm 1	27.50	99.90	265	402	100	0	2023-09-20 22:42:01
7537	Farm 1	27.30	99.90	253	449	100	0	2023-09-20 22:41:55
7536	Farm 1	27.30	99.90	258	501	100	0	2023-09-20 22:41:50
7535	Farm 1	27.20	99.90	257	245	100	0	2023-09-20 22:41:44
7534	Farm 1	27.40	99.90	281	490	100	0	2023-09-20 22:41:38
7533	Farm 1	27.40	99.90	263	490	100	0	2023-09-20 22:41:32
7532	Farm 1	27.40	99.90	255	501	100	0	2023-09-20 22:41:27
7531	Farm 1	27.30	99.90	275	479	100	0	2023-09-20 22:41:21
7530	Farm 1	27.40	99.90	271	706	100	0	2023-09-20 22:41:15

Figure 7. Measurement statistics table reads the last ten reading values

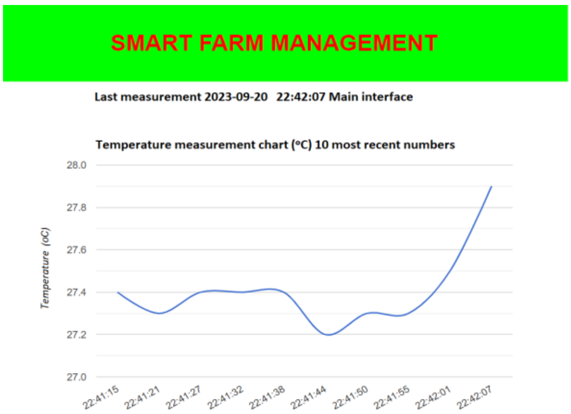

Figure 8. Temperature parameter chart with 10 most recent measurements

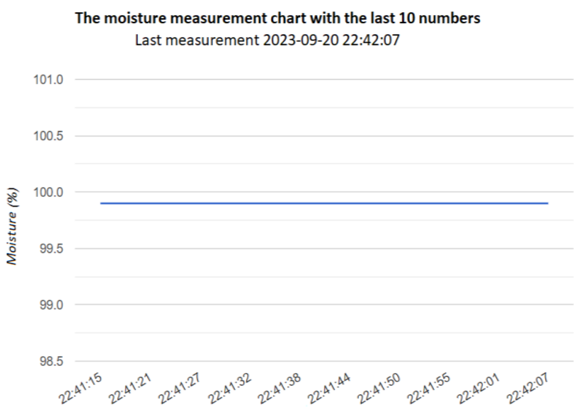

Figure 9. Moisture parameter chart with 10 most recent measurements

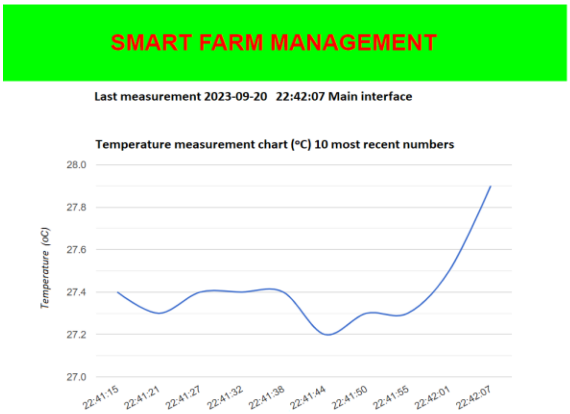

Figure 8. Temperature parameter chart with 10 most recent measurements

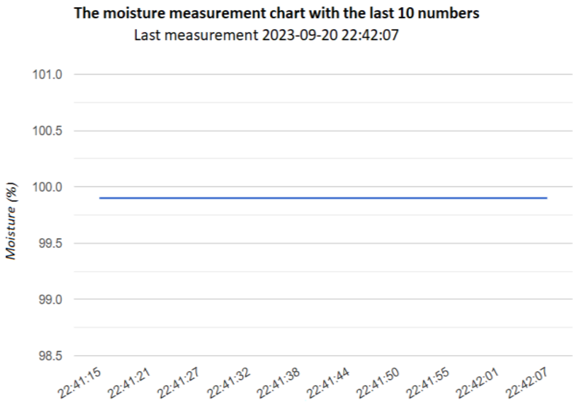

Figure 9. Moisture parameter chart with 10 most recent measurements

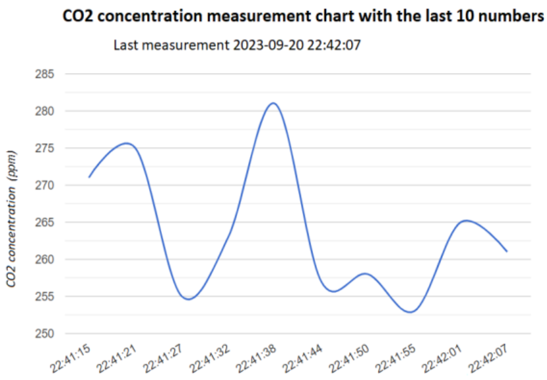

Figure 10. Chart of CO_2 gas concentration with the 10 most recent measurements

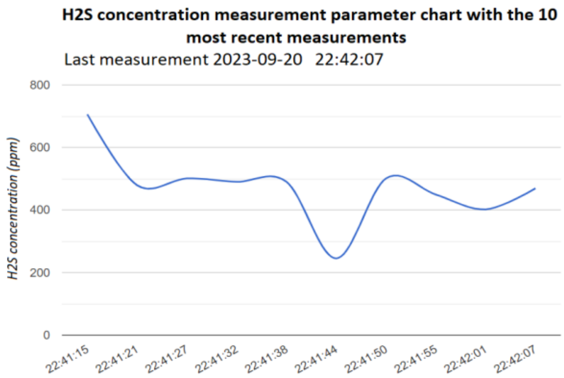

Figure 11. Chart of parameters measuring H_2S gas concentration with the 10 most recent measurements

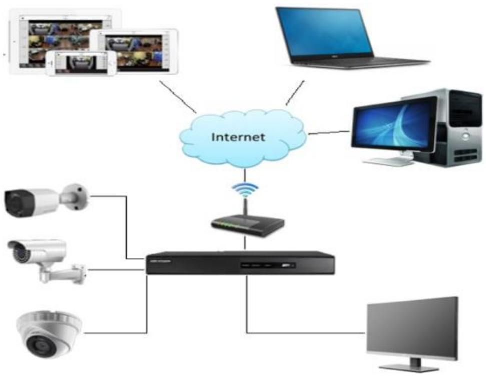

Figure 12. Diagram of image processing system using AI Camera for farms 1

Figure 13. Image of a corner of farm 1A used for raising sows with online supervision

The authors also tested the monitoring and control electrical cabinet product at a part of the livestock farm 1A of Bach Phuong Production, Trade and Services Joint Stock Company (Address: Vinh Hao Commune; Vu Ban District; Nam Dinh Province; Vietnam Country). The goal is to monitor gas environmental parameters, automatic temperature and humidity control, controls the air filtration system and biogas pressure. These equipment installation trials have brought satisfaction to the company. Aiming to install it to monitor and control the company's pig farms [7], [8].

Comments on the performance of the system: The supervision and control system tested in practice has proven the correctness of the design, manufacturing and monitoring control algorithm models. The optimal parameters have many practical implications for application in the field of smart agriculture today. In fact, the research team is working on large-scale livestock farms in Nam Dinh province; using the internet and smart sensors to collect data for monitoring, control and forecasting and supervision of control. Therefore, the research team has been applying this new technology to improve system quality. Data is continuously collected from sensors transmitted to the user application on smartphones. Parameters in the gas environment for supervision control (temperature, humidity, NH_3 gas, CO_2 gas, and H_2S gas) are measured by sensors of the monitoring unit and specialized meters at the same time as a basis for comparing measurement results. This shows that the measured parameters have an insignificant difference (0.02%) between the monitoring set and the specialized meter. Most parameters in the system monitoring control model are within allowable thresholds. In cases where parameters exceed the threshold, the system promptly warns users to have appropriate treatment plans to ensure the livestock farm system operates stably and brings economic benefits to the field green and sustainable agriculture.

4. CONCLUSION

The content of the article presented the research on the pig farm monitoring and control system based on IoT technology. The system allows monitoring farm gas environmental parameters such as: temperature, humidity, NH_3 gas, CO_2 gas, H_2S gas, biogas gas, and at the same time gives warnings when the allowed threshold is exceeded. Besides, the system can be controlled automatically according to pre-set parameters or users can control it themselves with buttons on the smartphone application. The system is designed according to each hardware module and firmware then integrated into a monitoring and control unit. Design user applications on mobile phone, smartphones used via app and Android operating system. The supervision and control system are tested in practice at Bach Phuong Production; Trade and Service Joint Stock Company. Measurement results from the sensors of the monitoring and control system are compared and evaluated with measurement results from specialized measuring machines. This shows that the difference in parameters is insignificant between the monitoring set and the specialized meter. The monitoring and control system meets the requirements of the pig farming model in Vietnam. This is a solution that contributes to increasing productivity and quality of agricultural and livestock products, eliminating manual intervention and minimizing production costs compared to manual supervision and control methods that cause problems causing many losses to the livestock sector.

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