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PRODUCT QUALITY MONITORING USING THE INTERNET OF THINGS

Abstract
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INTRODUCTION

Quality monitoring is a technical means of monitoring whether the quality of a product meets the requirements, it is also an effective means of ensuring that the company or individual carrying out the production activity can produce effective productive labor. Production quality monitoring is an important technical guarantee that a product will go from 0 to 1 and from 1 to many. And there are many technical methods to achieve production quality control, which also involves all aspects. For example, data collection, processing and analysis in the production process, where data collection in turn includes data collection from products, production instruments and testing instruments, and on the other hand, analysis and processing of several different data. And each of these aspects has an important impact on quality control.

The Internet of Things (IoT) is a collection of multiple technologies, which includes sensors, communication networks, device information security, device compatibility and data processing. Therefore, for the multiple and large amount of data generated in the production process, IoT will become an effective technical tool in quality control.

Currently, relevant researchers have used IoT technologies for quality control of production. For example, an IoT-based water quality monitoring system was developed by Moparthi, an air quality monitoring platform based on IoT was created by Aamer. And Shin proposed a smart manufacturing system engineering (SMSE) approach to design a smart product quality monitoring system (SmartPQMS) with a practical application in steel production process as an example. Rutayisire proposed an IoT-based coffee quality monitoring and processing system. As a result, IoT technology plays a very important role in the quality control of production.

However, for more complex production environments, such as large dairy farms, the effectiveness of IoT technology for data analysis and integration between different areas still needs to be studied. In this case, it is necessary to re-study the model, structure and network construction of the Internet of Things.

Therefore, the main work of this thesis will focus on specific scenarios, such as milk production in dairy farms, to conduct IoT-based quality control research on the production process, and the basis of the research significance of this paper.

GENERAL DESCRIPTION OF WORK

Relevance of the subject

The work corresponds to paragraph 1 «Digital information and communication and interdisciplinary technologies based on them production» of the

priority areas of scientific, technical and innovative activities for 2021 - 2025. The work was carried out in the educational institution Belarusian State University of Informatics and Radioelectronics. Dissertation research was carried out within research work SB 21-2033 «Processing, coding and transmission information in network-centric systems».

The aim and tasks of the work

The aim of the work is to use the Internet of things for product quality control. To achieve this aim, the following tasks in the dissertation were solved:

1 Analyzing the basics of the Internet of things.

2 Constructing IoT model and structure for the management of production quality control.

3 Development of IoT network elements for production quality control on cloud platform bases.

Personal contribution of the author

The content of the dissertation reflects the personal contribution of the author. It consists of the use of hierarchical analysis for the selection of IoT networks, the construction of IoT algorithms for managing dairy farms, the selection of IoT cloud platforms, the development of IoT network elements and the implementation of quality control of milk products, formulation of conclusions.

Task setting and discussion of the results were carried out together with the Supervisor Doc. of Sc., Professor Vishniakou Uladzimir Anatolievich.

Testing and implementation of results

The main provisions and results of the dissertation work were reported and discussed at international conference: Telecommunications: Networks and technologies, algebraic coding and data security (Minsk, November - December 2021); international seminar: Coding and digital processing of signals in infocommunications (Minsk, March - April 2022).

Author’s publications

According to the results of the research presented in the dissertation, 4 author’s works were published, including: 4 articles in conference and seminar proceedings. One article was sent in journal «Reports of BSUIR».

Structure and size of the work

The dissertation work consists of introduction, general description of the work,

three chapters with conclusions for each chapter, conclusion, bibliography, list of author's publications.

The total amount of the thesis is 80 pages, of which 57 pages of text, 19 figures on 17 pages, 7 tables on 5 pages, a list of used bibliographic sources (77 titles on 7 pages), a list of the author's publications on the subject of the thesis (5 titles on 1 pages), graphic material on 9 pages.

Plagiarism

An examination of the dissertation «Product quality monitoring using the internet of things » by Hu Zhifeng was carried out for the correctness of the use of borrowed materials using the network resource «Antiplagiat» (access address: http://users. antiplagiat.ru/) in the online mode 31.03.2022. As a result of the verification, the correctness of the use of borrowed materials was established (the originality of the thesis is 96,68%).

SUMMARY OF WORK

In the first chapter the basic concept of IoT, the model of IoT, the architecture of IoT, the interaction of IoT and the application of IoT in production quality monitoring are analyzed.

In section 1.1 the origin of the IoT concept is introduced and the four main components of the IoT, such as IoT devices, communication technologies, networks, and data storage and processing, are analyzed. In this section, the main features of IoT are also introduced and an information function model of IoT is constructed.

The concept of an IoT reference model is presented and defined in section 1.2. In the framework of this reference model, the IoT domain model is defined, which is the basic model of IoT. The sub-model of IoT also contains the information model and the functional model, where the information model is used to define the information structure of IoT and the functional model is used to define the functions of the modules in the IoT system. At last, four typical IoT models are described.

The concept of IoT reference architecture is introduced and defined in section 1.3. The basic requirements of IoT reference architecture, such as scalability, autonomous functionality, security, and privacy performance, are introduced, followed by the construction of a generalized three-layer IoT network architecture that meets the relevant requirements. A technical architecture for the IoT is constructed from the perspective of IoT technology, a knowledge architecture for the IoT is built from the perspective of IT knowledge system, and finally, the reference architecture model for the IoT based on IP protocols and its application prospects are investigated.

In section 1.4 the advantages and disadvantages of three basic IoT interaction methods, such as direct access, access through a gateway, access via the server are discussed. Moreover, the main characteristics of human-object interaction methods in IoT systems, such as touch screen interaction, sound interaction, virtual reality interaction, information recognition interaction, and keystroke interaction, are explored.

In Section 1.5 the application of IoT in quality monitoring is reviewed, as well as IoT applications in water resources, agriculture, automobile manufacturing and medical device manufacturing. The applications and prospects of IoT in milk production quality control are explored in particularly to offer a foundation for further research.

In the second chapter the IoT model in dairy farms is explored, an IoT structure for managing dairy farms is constructed and an IoT algorithm for managing dairy farms is proposed.

In the 2.1 two types of dairy farm management are reviewed, as well as the current research status of IoT technology in dairy farm management, the relevant network protocols currently applied in IoT networks are analyzed and the IoT model of multi-agent structure is constructed.

A four-layer IoT architecture model for dairy farm management is built in section 2.2, which involves a sensing layer, a network layer, a service layer and an application layer. In order to optimize the network structure in IoT, a hierarchical analysis method is utilized to analyze network performance, with transmission rate, band width, communication range, and security being selected as four network performance indicators. Therefore, a low-power wide-area network which is both energy-efficient and long-range is considered. The 4th generation LTE network is chosen to transit the data parameters of milk quality [5-A].

The current state of research on some generic algorithms, such as machine learning and artificial intelligence algorithms in the IoT, is reviewed in Section 2.3. The prospect of digital twin algorithms in dairy farm management is discussed, and a generic IoT algorithm for milk quality control is proposed [1-A].

In the third chapter an IoT network architecture model based on milk quality control is constructed, the parameters of the milk analyzer are presented. Further, the port structure of the IoT and its performance are analyzed. The current IoT cloud platform is analyzed and five IoT cloud platform selection indicators are proposed. The IoT cloud platform to the processing and analysis of milk data quality is applied.

In 3.1 based on the generalized IoT network model in chapter 2, an IoT network structure for milk production to provide guidance for subsequent applications is shown. In section 3.2 the current status of milk analysis technology is reviewed, several typical milk analyzers are presented along with their typical

features. The port structure of IoT devices for milk quality control is examined in 3.3, and two IoT gateway converters are shown. The current major IoT cloud platforms are reviewed in section 3.4. Five major metrics to evaluate the IoT cloud platform are proposed, including scalability, equipment control capabilities, over-the-air firmware update capability, security, and data management. In 3.5 the selected Aliyun cloud platform is applied to the quality control of milk production, and the proposed algorithm and MQTT protocol are combined to achieve the transmission and processing of milk quality data, and the obtained results can be used to discriminate the quality of milk [4-A].

CONCLUSION

1 In thesis is analyzed the basic concepts of IoT, such as the definition of IoT, the components of IoT, the model of IoT, the architecture of IoT, the interaction of IoT and the current status of research related to production quality control using IoT. Through these analyses, the feasibility and necessity of IoT technology applied to milk production quality control are determined [1-A].

2 An IoT model and structure based on dairy farm management is constructed. In order to rationalize the use of network resources and reduce production costs, in the available network protocols are selected using hierarchical analysis method [5-A]. A low-power Wide area Net-work -energy-efficient long-range network is considered, the 4th generation LTE network is chosen [2-A].

3 Elements of the IoT network were developed for quality control of milk parameters, specifically the selection and analysis of milk quality analysers, the study of the port structure, the selection of the IoT cloud environment and the proposal of the selection criteria. The network algorithm based on Aliyun cloud IoT platform is developed. The application for milk quality detection in Android studio is developed using an emulator. The communication smartphone with Aliyun cloud IoT platform is realized [3-A, 4-A].

LIST OF AUTHOR'S PUBLICATIONS

1-A. Vishniakou, U.A. Model, structure and algorithm of the internet of things for the management of production quality control / U. A. Vishniakou, Hu Zhifeng // Телекоммуникации: сети и технологии, алгебраическое кодирование и безопасность данных : материалы Международног о научно-технического семинара (Минск, ноябрь – декабрь 2021 г.) Telecommunications: Networks and Technologies, Algebraic Coding and Data Security. – Минск: БГУИР, 2021. – P. 75 – 78.

2-A. Vishniakou, U.A. IoT network: models, structure, communications, problems / U.A. Vishniakou, Du Zongqi, Liu Zhenhua, Hu zhifeng, Yu Chunyu // Телекоммуникации: сети и технологии, алгебраическое кодирование и безопасность данных: материалы Международног о научно-технического семинара (Минск, ноябрь – декабрь 2021 г.) Telecommunications: Networks and Technologies, Algebraic Coding and Data Security. – Минск: БГУИР, 2021. – P. 57 – 61.

3-A. Chuyue Yu. Design of smart code lock / Yu Chuyue, Xia Yiwei, Zhao Di, Hu Zhifeng // Телекоммуникации: сети и технологии, алгебраическое кодирование и безопасность данных : материалы Международного научно-технического семинара (Минск, ноябрь – декабрь 2021 г.) Telecommunications: Networks and Technologies, Algebraic Coding and Data Security. – Минск : БГУИР, 2021. – P. 72 – 74.

4-A. Visniakou, U.A. Development of IoT network elements for production quality control / U.A. Vishniakou, Hu Zhifeng, Fengshou // Coding and digital processing of signals in infocommunications: Materials of the Intern. scientific study. conf. (Republic of Belarus, Minsk, April, 2022) / Redaction: V.C. Konopelko, V.Y. Tsykkov, L.A. Shicko. - Minsk: BSUIR, 2022. – P. 21 – 24.

5-A. Visniakou, U.A. Development and optimization of the Internet of Things network for product quality monitoring / V.A. Vishnyakov, Hu Zhifeng // Reports of BSUIR. 2022 ((in publishing).