Luo Wenhua
Associate Professor in School of Automotive Engineering; *orcid.org/0000-0002-7604-3379*
Yancheng Polytechnic College, Jangsu Yancheng 224000

DEVELOPMENT OF THE TEMPERATURE AND HUMIDITY INTELLIGENT CONTROL SYSTEM FOR FIG ORCHARD BASED ON RFID TECHNOLOGY

Abstract. *For increasing the fig production and quality, and saving the labor cost, a kind of management fig garden intelligent system is designed combining the research on the fig tree cultivation situation and growth period. In this system the RFID tags which are equipped with sensors are installed on side of fig trees and will sense and save the temperature and humidity in Real Time mode. Data will be sent to a small Server trough the LAN from the Readers of RFIDS which are installed in different parts of the orchard. The Server will save the data and analyze them based on its software. If the humidity or temperature is not in a good condition, a tractor equipped with watering and poison tank, air conditioner and humidifier will be activated and sent to the tree. The intelligent gardening software system include tree guarding software(TGS) and path finding software(PFS). The TGS is installed on the Server, and investigates all data of each tree. If any tree needs watering or temperature change, it will indicate the amount and the type of the requirement. The server will send the information to the interfacing circuit and the tractor will receive the information, head to the tree and take the necessary steps. The PFS is also installed on the Server and receives the identification code of the nearest tag via the Reader which is connected to Server for recognize tractor coordinates. Then modified route base on inter database and identification code, finally move to the goal tree.*

Keywords: RFID; temperature and humidity; Sensor; fig orchard; intelligent control system

Problem Statement

The fig belong to the Moraceae Ficus L. variety which native to Southern Mediterranean coast, it is a type of health fruit, it contain 18 amino acid, plenty of pectin and cellulose, the fresh fruit has heat 3094.7 KJ, Sugar 162.6g, Protein 14.1g, Fat 4.0g, Calcium 0.54g, Phosphorus 0.32g, VC 15mg, Iron 6mg, Niacin 5.5mg and VB 1mg per kilogram [1 – 3]. Recently in China the major cultivation provinces is Xinjiang, Jiangsu, Shandong, Hunan, Zhejiang, Yunnan andFujian et al. In 2009, China's fig production is in the top 20 in the world, in 2012, the planting area is arrival 2500hm^2, in 2014, the planting area is 5000hm^2 [4; 5].

The fig tree has strong adaptability to the environment, it can resistant drought and barren, it can grow in sandy and sandy loam soil, the most suitable soil is the neutral sandy loam soil that is the deep soil, water and fertilizer conservation. Relevant studies shown that during the fig growing process, the temperature and humidity has great influence on the fruit quality. It is necessary to supply the suitable temperature and humidity for fig tree's healthy and high yield. Above all, the temperature and humidity setting of the tree guarding software (TGS) should be depended on the growing season periodicity [6; 7].

Radio Frequency Identification (RFID) technology is a kind of technology that through radio-frequency signal to realization of contactless recognition and obtain the needing data, it can apply during complex environment including agricultural environment detection, it has some merit such as low energy consumption, convenient control, easy arrangement and installation, communication flexible, it is very enthusiastic about the future [8; 9]. The paper research's foundation is based on the radio frequency intelligence identification, designing a kind of a fig orchard temperature and humidity intelligence conditioner system, this system has some function that saving-water, auto-spraying, temperature and humidity conditioner, it can improve the fruit yield and quality, especially in improving water utilization.

Basic material

System Design

This system's implement is: the tags which are installed on the fig trees with temperature and humidity sensors, the temperature and humidity data will be received and saved under the real-time mode, then the RFID readers which are decentralized installed around the orchard send the temperature and humidity data through the network to the small server, the server analyze the data through related strategies. If the temperature or humidity is not in a good condition, the field management machine equipped with watering and poison tank, air conditioner and humidifier will be

activated and sen to the tree. The field management machine that is controlled by the server, will receive the tree's location and by the guidance of the tags in the area will find its route toward the tree. The tractor will arrive to the tree and then optimize the condition by watering or air-conditioning or humidifying. The field management machine will stay there until the next mission.

Hardware Facilities

The hardware facilities of the intelligent temperature and humidity control system including: navigation circuit, server, RFID sensor-tag, RFID reader and WLAN.

Navigation Circuit

This circuit will be installed in field management machine, and its electricity will be provided by the laptop through a USB cable and will be controlled through a RS232 port by the server (laptop), they are both use the same port which is the RS232-C port. Then the orders will be transmitted to relay controllers of field management machine in order to guide the field management machine forward, backward, toward left or right like a robot. Then orders can turn on or off the watering pomp, spray, air conditioners of the field management machine.

Server

Server in field management machine cabin which receives all the data transmitted by RFID Readers through the WLAN and records them on its hard disk. It needs to have a fast processor to analyze the received data in a short time. After analyzing the data of tree's condition by the tree guarding software, will send the proper orders to the field management machine. The laptop also has a RFID tag Reader and whenever the tractor crosses a tree this Reader will read the tree's identification tag and sen the data through the RS232 port to the laptop. The Server uses the navigation system and its data base to identify the field management machine location to amend and control the field management machine's route. In addition, the data recorded on the hard disk will be stored permanently for future usage in order to data analysis and more precise decision for increasing the orchards efficiency.

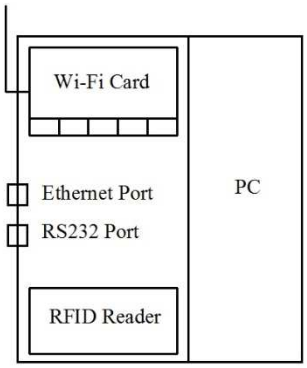

Figure 1 – The diagram of the Server

It is possible to make a connection between the orchard manage, who is in another geographical location, and the Server through the WLAN or MAN. In this way the manager could access to the Server and add the necessary data to the system based on the orchards requirement. For example, the necessary information and the 6-digit code of the trees that needing the spray will be sent to the Server by the manager, so then the Server will order the field management machine to operate.

RFID Sensor-Tag

The paper use RFID technology which can receive the orchard's physical information through a large number electronic tags. The electronic tag not only cheap, simple structure, high reliability and can connect various sensors. The electronic tags combine with temperature and humidity sensor, so the electronic tags have the ability to receive temperature and humidity data [10; 11]. The RFID sensor tag which integrated temperature and humidity sensor install on the tree or near the tree, can save and transmit data information. The sensor put the environment condition data save in the tag and through RFID wave send to the nearest reader, and then the reader send the data to the field management machine.

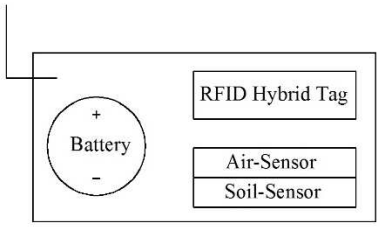

Figure 2 – The diagram of the Sensor-Tag

RFID Reader

RFID reader has the chemical or solar batteries, is one of the infrastructures of the RFID technology, including radio frequency module, reading module and aerial, through standard protocol use non-contact mode to recognise RFID sensor tag's data. The RFID reader is installed in different position of the orchard, and transmitting signal, if the identifiable tag inside the signal range, the temperature and humidity information which is saved in the tag can be read, and then send the field management machine's server through WiFi. After installing reader, the aerial send the signal can cover and receive several tags data. In the process installing reader and tag make sure every tag can be covered by the reader, and every reader should be covered by the WiFi[12,13].

WLAN

The WLAN is covered the whole orchard. If the orchard has large area, for make sure each reader can connect the server more WLAN are needed.

Software System

The intelligent horticultural system is contained two parts: Tree Guarding Software(TGS) and field management machine Path Finding Software(PFS) system.

Tree Guarding Software (TGS)

The Tree Guarding Software is installed in the server, use to analysis and handle the tree's data from each tag. If one tree need watering or the temperature out of proper range, the system will implement method and work parameter. Server sends the message to the port circuit, the field management machine receive the order and then drive to the goal tree and take the necessary action, the flow chart as shown in Fig. 3 [14].

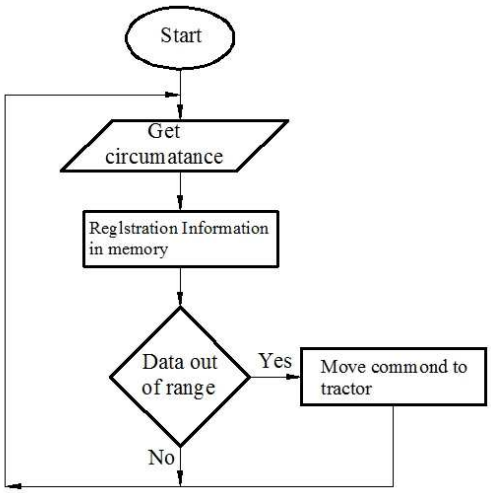

Figure 3 – Tree Guarding Software flow chart

Path Finding Software(PFS) System

The field management machine Path Finding Software system is also installed in the server, and receives the identification code of the nearest tag via the Reader which is connected to Server for recognize field management machine coordinates. Then PFS based on its internal database and identification code of target that has been given by TGS, indicates field management machine's route and amends it if necessary. Then it orders to the interfacing circuit for control the field management machine toward the tree [15; 16].

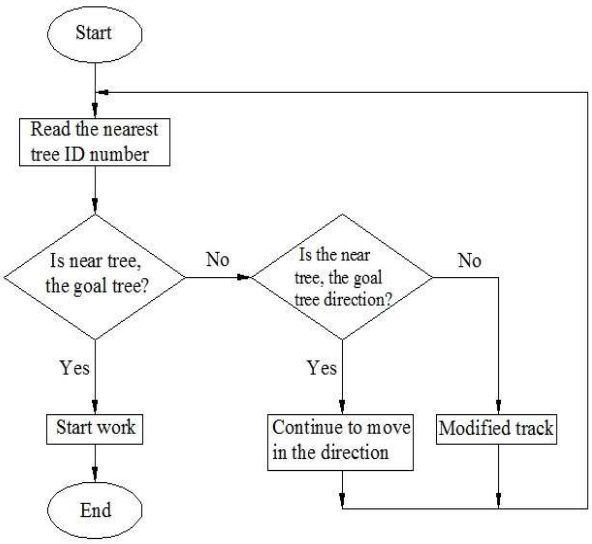

Figure 4 – The diagram of the Path Finding Software

Implementing

Intelligent horticultural system equipment Selection and Arrangement

Tag Selection and Arrangement

Considering the tree spacing and the system budget allocation, for each 9 trees in the orchard one tag is installed, shown as Fig. 5.

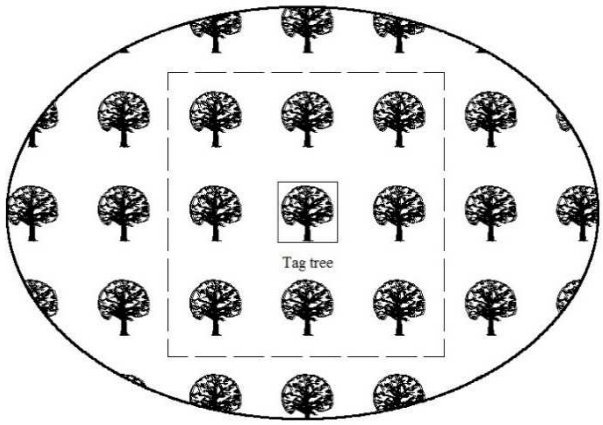

Figure 5 – The schematic diagram of the tag arrangement

There are 60 tags in the orchard, the environment data will be measured in every 5 minutes. These tags are equipped with SHT75 temperature and humidity sensor which is reliable accuracy and can quickly detect the temperature and humidity vary, connect data with the tags through I/O port, working temperature range: -45℃ to -85℃, working humidity range: 0% to 100%.

Reader Selection and Arrangement

For assuring the reader signal can cover all tags, installing 2 readers in the middle of the orchard, installing 1 reader on the field management machine, make sure each reader can receive 30 tags data. The Thingmagic M6 ultrahigh frequency RFID reader is selected, it has WiFi function, and can transmit data to server through WiFi.

Temperature Conditioner and Humidifier Selection

The field management machine which equipped with server, air conditioner, humidifier and water tank. The server is a laptop, the flow of the air conditioner is $1m^3/h$, the humidifier can supply 80% atmosphere humidity for $30m^3$ space, the water tank store water for three hours of usage, and able to be connected to water tap.

Control System Composition

The port circuit connect with 3 relays. One of the relay trigger is installed on the server of the field management machine which handling the data depend on the private path finding software. The other two relay trigger control air conditioner and humidifier, it working depend on the tree guarding software. Moreover, the port circuit connect with the server, and the server is installed the fig tree guarding software and field management machine path finding software.

Intelligent horticultural system Parameter Setting

The intelligent horticultural system including two software and field management machine which contain server, air conditioner, humidifier and water tank, the prototype system show as Fig. 6.

Figure 6 – Intelligent horticultural system machine

These two software are both developed basing on the C language. The PFS system can receive nearest tag's ID code which sending from the RFID reader, and it can supply the goal ID code through that the field management machine can ascertain the movement route. The TGS system analysis the every tree data from each tag, if one tree's temperature or humidity out of the suitable range, the system will cue the need to implement the type of measure and working parameter, the temperature and humidity setting of the tree guarding software should be depended on the growing season periodicity. The fig tree will fall in dormant time in winter, the temperature just need between 3℃ to 5℃; after germination period in spring, the temperature need between 15℃ to 25℃, the air relative humidity need above 80%; during the growing time in summer, the temperature should maintain between 25℃ to 30℃, the temperature relative humidity should control between 60% to 70%, till fruit ripening and last to late autumn, and then gradually fall into dormant time. Therefore, it is necessary to develop a kind of fig orchard temperature and humidity intelligent conditioner system, to save the labor cost, improve the production efficiency, reducing loss course by nature condition vary and improve the fruit quality [17; 18].

Operation Testing

For deeply research the system practicability, the orchard in Yancheng city Jiangsu province China is selected to implement the project, the plant fig variety is Blan Rick, the orchard area is 2 mu, row spacing is 3m×2m. The testing team about 540 trees in 1.1mu, the comparing team is the tree of 50m outside, the monitoring and collecting temperature and humidity began at 00:00 16 June 2007, monitoring time is 24 hours each day.

The Intelligent Horticultural System Affecting on the Fig Orchard Atmosphere Temperature

As shown in Fig.7, the intelligent horticultural system significant reduce the temperature value the temperature peak in a day, the testing temperature value maintain below 30℃, the total temperature vary is calm, the highest temperature is lower 8.7℃ than the comparing temperature, it can make sure fig growing in the suitable temperature.

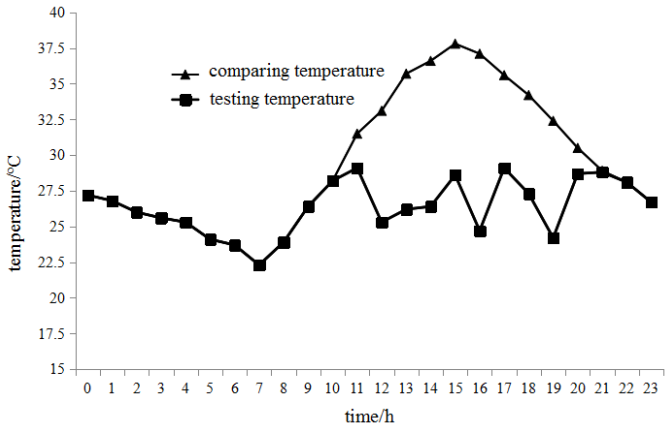

Figure 7 – Intelligent horticultural system machine effect on the surrounding temperature

The Intelligent Horticultural System Affecting on the Fig Orchard Atmosphere Humidity

As shown in Fig. 8, the intelligent horticultural system obviously improve the humidity value of the whole day air humidity bottom period, the testing team humidity value main maintain over 60%, and the total air humidity vary tendency relatively stable, the lowest air humidity 29% more than the comparing team, it can let the fig growing in the suitable air humidity.

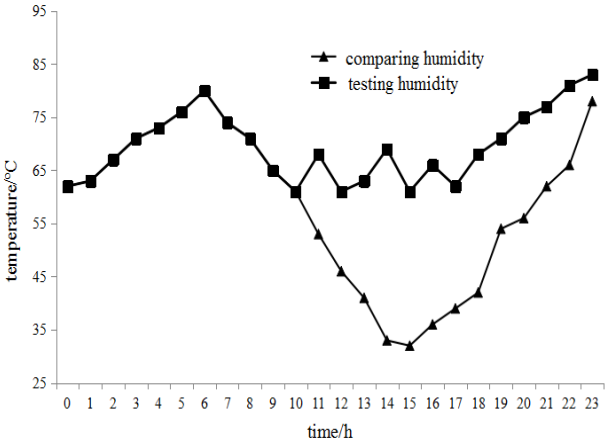

Figure 8 – Intelligent horticultural system machine effect on the surrounding humidity

Conclusion

The temperature and humidity intelligent conditioner system which available for fig orchard can analysis real-time accurate data from sensor and then manage the orchard's temperature and humidity, it can rapid regulate the orchard temperature and humidity which save the labor cost, improve the production efficiency, reducing loss course by nature condition vary, this technology can popularize to the other plant's productive process.

References

1. Genru, He, Shihua, Zhang, Li, Zhu, et al. (2017). The Commercialization of the Fig and Its Fresh-keeping and Processing and Utilization [J]. Farm Products Processing, (14), 53-56.

2. Xuedan, Zhang, Miao, An, Qian, Zhang, et al. (2013). Research Advances in Postharvest Physiology and Preservation of Fig Fruits [J]. Food Science, 34(23), 363-369.

3. Youyou, Pan, Pei, Hua, Yunxiang, Wang, et al. (2016). Recent Advances in Ficus carica L. Polysaccharides: Extraction, Isolation and Purification and Bioactivities [J]. Food Science, 37(17), 289-295.

4. Zhifen, Ling, Kai, Ma, Hongmei, Du, et al. (1998). Source and Outbreak Character of Fig Shoot [J]. Jiangsu Journal of Agricultural Sciences, (4), 44-48.

5. Rui, Sun, Ming, Jia, Lei, Sun. (2015). World Figs Resources Development and Applied Research [J]. World Forestry Research, 28(03), 31-36.

6. Zhiming, Zheng, Xuerong, Zhao. (2004). The Figs Introduction and High Yield Planting Technology [J]. Practical Forestry Technology, (3), 23-24.

7. Peng, Huang, Xiaoming, Ling. (2005). The Figs Excellent Varety and Efficient Planting Technology [J]. Practical Forestry Technology, (7), 33-35.

8. Jianping, Qian, Beilei, Fan, Xiang, Zhang, et al. (2017). Temperature Monitoring in Cold Chain Chamber Based on Temperature Sensing RFID Labels[J]. Transactions of the Chinese Society of Agricultural Engineering, 33(21), 282-288.

9. Qinglin, Huang, Lixin, Zhang, Yucong, Jiao, et al. (2016). The Cotton Seed Quality Safety Origin System Based on RFID Technology [J]. Jiangsu Journal of Agricultural Sciences, 5, 395-400.

10. Lei, Wang, Fangming, Deng, Xiang, Wu, et al. (2017). Design of an Integrated Temperature Sensor for RFID Application Tag [J]. Transducer and Microsystem Technologies, 36(6), 102-104.

11. Yucong, Jiao, Lixin, Zhang, Qinglin, Huang, et al. (2017). The Meat Product Quality Safety Original System Based on RFID and QR Code [J]. Jiangsu Agricultural Sciences, 5, 215-218.

12. Qiong, Xiong. (2017). Autonomous Positioning and Navigation Design of Fruit and Vegetable Picking Robot-Based on Information Fusion of RFID and WSN [J]. Journal of Agricultural Mechanization Research, 39(10), 223-227.

13. Li, Li, Haihua, Wang, Hongbo, Yuan, et al. (2013). Development of Yield Monitoring System in Solar Greenhouse. [J]. Transactions of the Chinese Society for Agricultural Machinery, 449(z2), 205-208.

14. Yineng, Chen, Kui, Fang, Xinghui, Zhu, et al. (2016). The Research the Manner of the Improving Original Precision Based on RFID[J]. Jiangsu Journal of Agricultural Sciences, 6, 426-429.

15. Xin, Li, Lingyan, Li, Nan, Li, et al. (2017). Autonomous Positioning and Navigation Design of Picking Robot Based on RFID and WSN[J]. Journal of Agricultural Mechanization Research, 39(9), 215-218,268.

16. Shenghui, Li, Chunhua, Xia, Changying, Ji, et al. (2017). Simutaneous Localization and Mapping for Autonomously-navigating Agricultural Vehicle Based on Panoramic Vision[J]. Jiangsu Journal of Agricultural Sciences, 3, 598-609.

17. Bo, Wang, Guanghui, Di, Zhongqiang, Pan, et al. (2016). The figs Biological Habit and Planting Technology [J]. Deciduous Fruits, 48(03), 47-49.

18. Shijun, Chen, Guihong, Yu, Hongjiang, Chen. (2013). Facilities Figs Planting Technology [J]. Deciduous Fruits, 45(05), 49.

Стаття надійшла до редколегії 03.10.2018

Рецензент: д-р техн. наук, проф. В.Д. Гогунський, завідувач кафедри управління системами безпеки життєдіяльності Одеського національного політехнічного університету, Одеса.

Ло Венхуа
Доцент кафедри автомобільної інженерії, магістр, *orcid.org/0000-0002-7604-3379*
Яньченский політехнічний коледж, Янчу Яньчен 224000

РОЗРОБКА СИСТЕМИ ІНТЕЛЕКТУАЛЬНОГО УПРАВЛІННЯ ТЕМПЕРАТУРОЮ І ВОЛОГІСТЮ ДЛЯ ФІГОВИХ САДІВ НА ОСНОВІ ТЕХНОЛОГІЇ RFID

Анотація. *Для збільшення виробництва і якості інжиру, а також заощадження вартості робочої сили, розроблено різновид управління інтелектуальною системою фігурного саду, який поєднує дослідження з ситуацією обробки фігового*

дерева та періоду росту. У цій системі теги RFID, які обладнані датчиками, встановлені на бік фігових дерев і будуть відчувати і зберігати температуру та вологість в режимі реального часу. Дані надсилатимуться на невеликий сервер через локальну мережу від читачів RFIDS, які встановлені в різних частинах саду. Сервер зберігає дані та аналізує їх на основі програмного забезпечення. Якщо вологість або температура не перебувають у хорошому стані, активується трактор, обладнаний поливними і отруйними танками, кондиціонерами та зволожувачами, і спрямовується на дерево. Інтелектуальна система програмного забезпечення для садівництва включає в себе програмне забезпечення охорони дерева (TGS) та програмне забезпечення для пошуку шляхів (PFS). TGS встановлюється на сервері та досліджує всі дані кожного дерева. Якщо будь-яке дерево потребує поливу або зміни температури, це буде показувати кількість та зміст вимоги. Сервер надсилає інформацію до схеми інтерфейсу і трактор отримає інформацію, відправиться до дерева і вживатиме необхідних заходів. PFS також встановлюється на Сервері та отримує ідентифікаційний код найближчого тегу через Reader, який підключений до Сервера для розпізнавання координат трафіку. Потім модифікована база маршрутів на базі даних та ідентифікаційний код, нарешті, спрямовує до потрібного дерева.

Ключові слова RFID; температура і вологість; Датчик; фігурний сад; інтелектуальна система управління

Link to publication

APA *Luo, Wenhua. (2018). Development of the temperature and humidity intelligent control system for fig orchard based on rfid technology. Management of Development of Complex Systems, 36, 170 – 175.*

ДСТУ *Ло Венхуа. Розробка системи інтелектуального управління температурою і вологістю для фігових садів на основі технології RFID [Текст] / Ло Венхуа // Управління розвитком складних систем. – 2018. – № 36. – С. 170 – 175.*