Application of Intelligent Cultivation System in Plant Growth

Song Ying1 and Cao Yuanping1,*
Business of School, Wuzhou College, Wuzhou, 543002, Guangxi
Email: 1113594073@qq.com

Abstract. Intelligent cultivation system based on Internet of things technology can improve the precision management and scientific management in the process of plant growth. This paper studies the application of intelligent cultivation system. Firstly, the functions and their demand of intelligent cultivation system are expounded, including the software development and its implementation environment. Secondly, it is pointed out that 51 chip microcomputer and Raspberry Pi Raspbian system are modules used to combine the whole system. The experimental results show that the optical sensor of the system can turn on the light supplement, which could form a better growth environment. The automatic irrigation and fertilization module can calculate the proportion of water in the soil. The plant growth recording function, after taking the image, can be processed by image warehouse configured on the server side.

1. Introduction
In order to improve the efficiency of farming cultivation and decrease the cost of human operation, it is urgent to change the traditional extensive farming methods. Agricultural information technology’s development facilitates the remote operation and control of agricultural industry and developing intelligent cultivation system.

Yu et al.(2016) design a remote monitoring system for intelligent irrigation based on ASP.NET technology to remotely monitor and intellectually supervise litchi garden. The average soil water component of the irrigated area is 17.85% higher than the lower limit of the optimum soil water content, which meets the growth of litchi. The stable system can realize real time remote monitoring of litchi horticultural environment, and can make intelligent irrigation decision by time[1]. Wang et al.(2016) suggest an intelligent control and agricultural expert system, which is multi-source identification and efficient recycling facilities. Solar energy can improve heat treatment of PCMs of cabin temperature, special ventilation windows designed to increase convection of air and reduce cabin temperature and save high energy consumption devices[2].

The favorable growth environment for plant growth could be automatically create by controlling the water replenishment system and fertilizer application device, which can turn on and off the light in a certain time. The system will also observe the change of plant growth process by setting Self-time function to show the planting results, obtaining the application effect of intelligent planting system.

2. Intelligent Planting Control System

2.1 51 chips microcomputer control system with low price and power consumption
51 type are the most famous in chip microcomputers[3]. Its prototype is Intel's 8031 Active Micro-controller, compatible with Intel's 8031 command system[4], the most popular Computer-on-a-Chip. It is cheap, large amount of data and stable performance, and widely used by
various industrial control systems.

51 series use 32 programmable I/O port lines and provide oscillation frequencies through externally
1.0592MHz crystals. The programming environment can realize various control operations of 51
micro-controller pins. Then set the plate and write it on the 51 micro-controller, and the expected
function of the micro-controller can be canceled\(^5\)\(^6\). The low cost control system of the system uses 51
chip microcomputer-on-a-Chip. Through C language programming in keil developing environment,
the functions, such as IIC bus communication and sensor call in timer are realized\(^7\). 

\[2.2 \text{Raspberry Pi (RPi)and OS}\]

RPi is microcomputer Main Board based on ARM. The network cable interface can be plugged into
the network cable and can be connected to the default network card driver. All electronic components
are built on a credit card-sized circuit substrate (Main Board). The latest version of Raspbian has Win
10 basic features, and supports Microsoft's Internet developing and networking platform\(^8\). The system
uses the latest models of RPi B+ Main Board and V miniature USB socket as the power supply mode,
and the current source above 700 mA can be maintained smoothly. 512M memory can execute
applications written by Raspbian into MySQL database\(^9\). 

**3. System Operating**

\[\text{3.1 System operating framework}\]
The hardware structure of the system in operation is divided into 6 modules.

- **Soil, air temperature module** When the detecting value of the temperature sensor is lower or
  higher than the plant growing suitable temperature, heating and cooling devices are used to regulate
  the planting environment.

- **Soil moisture module** Solenoid valves and pumps can be activated by FC-28 soil moisture
  sensor to replenish soil moisture. And according to the method of time and quantity, the organic
  fertilizer is added to the soil\(^10\).

- **Air humidity module** When continuously exceeds the threshold, the air humidity module
  perforates through a diamond film pump, sprays in the air through a atomizer or atomizing fan,
  opening device with sunshine shadowing.

- **Light module** The current light intensity is measured by the photoelectric register and GY-30
  light intensity module, and controls the operation of the shadow and light auxiliary devices. When
  the light is insufficient, the optical equipment is automatically opened regularly to meet the needs of
  plant growth\(^11\).

- **Carbonic acid gas module** In closed planting environment, carbon dioxide PPM is acquired by
  MG811 carbonic acid gas sensor. When low concentration, the carbonic acid gas is slowly exported
  along the refiner through the solenoid valve, replenishing carbon dioxide concentration.

- **System control module** Non-network and low cost 51 chip single microcomputer control
  and network optimization application could be controlled by RPi Development Board.

\[\text{3.2 Operational process}\]

51 microcomputer-on-a-Chip provides the function of the traditionally automatic implantation system.
Purchasing modules, technicians can analyze presently the soil, climate, temperature, greenhouse
effect equipment and so on, configure the appropriate equipment, connecting the 51
microcomputer-on-a-Chip to control functions of automatic implantation system. When needs more
complex and intelligent interaction patterns, the Internet design concept of Internet of things
technology is adopted to operate RPi, and then control the modules and connect data with the cloud
virtual machine server. Furthermore, the remote manual or timing control planting system module
provides the possibility for users’ remote monitoring data, abnormal status SMS and mail notification.
4. developing environment
The system adopts two control frameworks. Firstly, 51 microcomputer-on-a-Chip framework, which realizes low cost and low power sensor control and automatic implantation. Note that it is difficult to reach high-level functions like control camera and remote login. Secondly, the Raspbain one of Raspbain OS based on embedded Linux. The Raspbain framework can immediately operate sensors, cameras and remote login, and can be logged in with Python or C language.

5. Designing Illumination Module

5.1 Spectral effects of plant growth
The response of green plants to sunlight is very different from that of human eyes. The more sensitive spectrum of human eyes is the light between yellow and green, and the recognition of blue and red bands is low. In contrast, plants are most sensitive to red and blue light, but not to green. Among the solar spectrum, the most sensitive area of green plants is 400-700nm\(^3\). So photosynthesis is also in this region (Figure 1). This spectrum accounts for about 45% of the light energy. If auxiliary lighting is provided in an environment where light is insufficient to plants, it must be within this spectral range.

![Fig. 1. Effects of the spectral range of plants.](image)

The so-called fill light is the benchmark for determining the light intensity threshold in plant growth, and the auxiliary lights aim to rapidly collect of dry matter for plant photosynthesis. Filter lights mainly include red and blue light band. The color filtering rate of the red light (610~720nm) is about 80%. The red light band can promote chlorophyll biosynthesis. The color filter absorbing rate of blue-purple light (400~520 nm) is up 90%, which can accelerate the growth of root block, leaves and stems, and resist disease and pests.

5.2 Illumination time of Plants

Table 1. Illumination Time of crops.

| Crops        | Illumination time | Illumination Compensation Point | Light saturation point | Length of sunshine | Light intensity category |
|--------------|-------------------|---------------------------------|------------------------|--------------------|-------------------------|
| Tomatoes     | 12-16 hours       | 2KLX                            | 70KLX                  | Medium             | heliophilous            |
| Pepper       | 10-12 hours       | 1.5 KLX                         | 30KLX                  | Medium             | heliophilous            |
| Cucumber     | 8-11 hours        | 2KLX                            | 5.5-6 KLX              | Short              | heliophilous            |
| Eggplant     | 11-13 hours       | 2KLX                            | KLEX 4-5               | Medium             | heliophilous            |
| Celery       | >12 hours         | 2KLX                            | 45KLX                  | Long               | heliophilous            |
| Green onion  | 10-25 hours       | 1.2 KLX                         | 25KLX                  | Long               | heliophilous            |
| Ginger       | 8 hours           | KLX 0.5-0.8                     | 25-30 KLX              | Short              | light fugitive          |
| Chives       | 6-8 hours         | 12KLX                           | 40KLX                  | Short              | Medium                  |
| watermelon   | 10-12 hours       | 4KLX                            | 80KX                   | Medium             | heliophilous            |
When optical sensors detect that the intensity of light cannot continuously reach the point during plant growing in botanical gardens, such as continuous cloudy and rainy days, fill light can create a better growing environment.

6. Designing and Implementing Automatic Irrigation and Fertilization Module

6.1 Land moisture testing
The principle of DBT-1 soil moisture sensor is similar to that of FC-28 soil moisture sensor. The dielectric rate of soil is detected by probe and the general moisture content is the main index of soil induced electricity rate (figure 2) and the proportion of water in the soil can be obtained after testing. Field calibration is also necessary after sensor deployment, depending on the large differences in soil quality, PH and other indicators.

![Figure 2. Changes in voltage and humidity of soil moisture sensors.](image)

After comparing the local detection results with the detection voltage and humidity method respectively, gaining the relationship between them. The current soil moisture value is obtained by AD conversion chip in the next use.

7. Plant Growth Records
In RPi, SimpleCV library cameras regularly or manually control photographs (Figure 4). After imaging, the image can also be processed through the image processing database configured on the server side, such as changing the size of the photo, editing the photo, encoding the photo, changing the name of the photo, and changing other personalized services.

![Fig.3. Photographs collected regularly during cultivation.](image)

8. Conclusions
The application of intelligent planting technology control, light intensity detection, temperature control and so on in agricultural ecological garden, all is studied in detail in this paper. Solve the difficult problem of sensor data collection and transmission, including the system control device running on demand, the Web server under the single technology Internet. Server configuration and remote Web achieve remote control for single chip micro-standard operation and data access.

Acknowledgements
This research did not receive any specific grant from funding agencies in the public, commercial, or
not-for-profit sectors..

References

[1] G.X. Yu, S. Wang, J.X. Xie. Fujian J. Agri. Sci., 31, 7 (2016), 770-776
[2] H.L. Wang, P.P. Xu, J.D. Fan. Acta Agri. Zhejiangensis, 28, 7 (2016), 1224-1234
[3] Y.Y. Gao, X. Wang, Q.C. Feng. J. Agri. Mechanization Res., 4, 5 (2018), 98-104
[4] C.L. Li, K. Jiang, W. Ma. Spectroscopy and Spectral Analysis, 38, 1 (2018), 253-257
[5] Z. Wang, Y.K. Li, L.C. Wang. Chinese J. Agrometeorology, 38, 12 (2017), 771-779
[6] D. Li. Mod. Electr. Tech., 39, 23 (2016), 104-106
[7] J.L. Liu, G.L. Liu, L.G. Song. Hebei J. Forestry and Orchard Res., 30, 2 (2015), 206-210
[8] M. Li. Chinese J. Agri. Resour. & Regi Planning, 36, 5 (2015), 145-148
[9] H. Ke, J.B. Zhang, X.T. Wang. Envr. Sci. & Pollut. Res., 25, 3 (2018), 1-11
[10] Y. Zhen, D. Wu, X. Zhun. Asian Agri. Res., 08, 6 (2016), 75-79
[11] X. Ming, D. Nan, L. Xin. J. App. Ecol., 26, 8 (2015), 2571-2580.