

## 基金项目论文

# 基于无线通信网络的食堂菜品动态称重系统研究与实现

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**摘 要:** 在日常生活中, 学校和企业具有严格的作息时间。食堂往往存在就餐人数集中拥堵, 排队时间过长等问题, 而且还会产生一些不文明的社会现象。为解决传统食堂点餐就餐的模式, 设计了一种无线称重监测食堂菜品剩余量的系统, 利用 NRF24L01 和 HX711 芯片的特点, 将自动称重控制技术与无线通信技术有机结合起来。通过 MySQL 制作菜品剩余量的数据库, 并由电脑、显示器和微信小程序向就餐人员动态实时的显示食堂所售菜品的各种信息。该系统的使用能够减少排队、等座时间, 提高就餐效率, 还能选择自己喜欢的菜品, 极大地提高了就餐效率和服务质量。

**关键词:** 嵌入式系统; 无线模块; 微信点餐; 电子称重

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## Research and Implementation of Dynamic Weighing System for Canteen Dishes based on Wireless Communication Network

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**【Abstract】:** In daily life, schools and enterprises have strict work and rest time. There are many problems in canteen, such as crowded dining population, long queue time, and some uncivilized social phenomena. In order to solve the traditional mode of ordering and dining in canteen, this article designed a wireless weighing system to monitor the leftover quantity of canteen dishes. Using the characteristics of nRF24L01 and hx711 chips, the automatic weighing control technology and wireless communication technology were organically combined. A database was established through mysql to show the leftovers of dishes, and display all kinds of information of the dishes sold in the canteen to the dining staff in real time by computer, display and wechat program. The use of the system can reduce the waiting time, improve the efficiency of dining, but also choose their favorite dishes, which can greatly improve the efficiency of dining and service quality.

**【Key words】:** Embedded system; Wireless module; Wechat ordering; Electronic weighing

### 0 引言

At present, in canteens of schools, factories and enterprises, diners basically go directly to the canteen to view the dishes, and then communicate verbally with the sales staff to complete the ordering and payment process. This model does not rely on the Internet and cannot transmit dish information to diners, causing congestion during peak dining periods and making the traditional manual dining process inefficient [1]. Moreover, traditional weighing system information transmission mostly uses wired communication for data transmission. However, the environment of the canteen is complex and it is not suitable to have too many lines, and it is troublesome to connect various components through wires [2]. Today, with the rapid development of wireless communication technology, computer

systems that apply this technology are also advancing day by day. In view of the various problems currently existing in canteens, this project designed a wireless weighing system to monitor the remaining amount of dishes in canteens. This system has simple hardware structure, low power consumption, and flexible software use.

Convenience and other advantages [3]. Through the wireless communication module, the collected data is transmitted to the host computer in real time. Through multiple data collections, MySQL is used to create a database of remaining dishes [4], and the WeChat applet is used to view and reserve meals. Diners can use this system to select dishes online and generate dining codes and payment information. It also helps the canteen to better provide services to diners based on the remaining dishes database and meal reservation information.

The wireless weighing control system mainly completes functions such as data collection, data display, data transmission, data storage, and signal conversion [5]. The wireless weighing control system mainly consists of three parts: the canteen front end, the main control room and the user service platform. The canteen front end includes the weighing platform, control part, display module and wireless communication module. The main control room consists of wireless communication module and host computer

## 1 系统总体结构

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composition. The user service platform is the front end of the WeChat applet. The overall structure of the system is shown in Figure 1. The weighing platform is mainly composed of two parts: the canteen dish plate and the weighing sensor. The weighing controller is composed of a digital-to-analog conversion circuit, a display circuit and a microcontroller communication circuit [2]. The function of the wireless communication module is mainly to forward data. Between the weighing controller and the canteen owner

Establish wireless communication connections between computers in the control room. The host computer collects the data of each weighing controller through the wireless communication module, and at the same time centrally manages the collected remaining weight data of various dishes [6], and transmits the data to the front end of the WeChat applet so that customers can understand the situation of the canteen that day. Have some understanding.

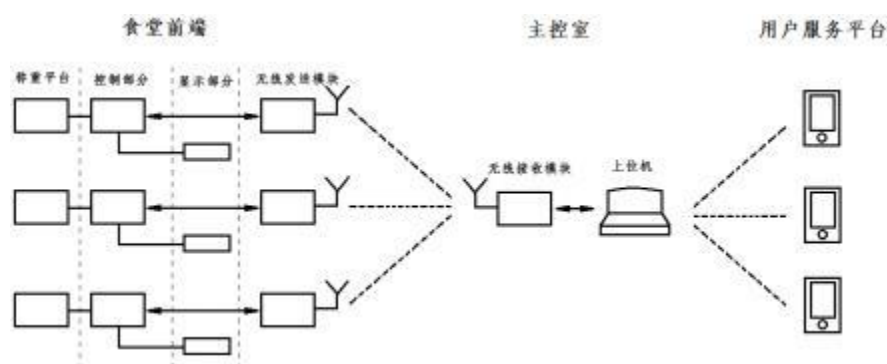


图1 系统总体框图

Fig.1 The system overall framework

## 2 系统硬件

### 2.1 称重控制结构

The weighing control structure takes the STC89C52 microcontroller as the control core, processes the digital-to-analog converted load sensor data, and outputs it through the display circuit and communication circuit. The structural block diagram is shown in Figure 2.

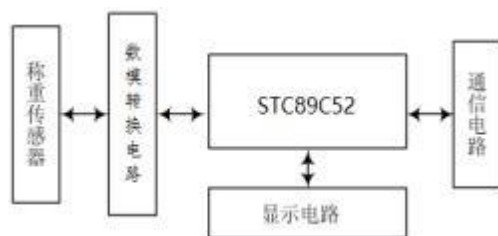


图2 称重系统控制结构

Fig.2 The weighing system control structure

The STC89C52 microcontroller is a domestically produced 8-bit microcontroller with low power consumption. It is cheap, has complete functions and is rich in resources. It is an ideal choice for system weighing controller [7]. The weight data collection mainly consists of sensors collecting and outputting continuously changing voltage values; the digital-to-analog conversion circuit is completed by the 24-bit A/D converter HX711 chip to convert the continuous analog voltage values into digital quantities, and then handed over to the microcontroller for processing. The display circuit mainly completes the data display of the remaining weight of the dishes. The communication circuit is to transmit the TTL level signal output by the microcontroller through the NRF24L01 chip, and at the receiving host end, the CH340T chip is used to realize the USB to serial port to establish a connection with the PC for data transmission.

### 2.2 称重传感器结构

This system uses the most widely used resistance strain parallel beam sensor. Parallel beam sensors have less stringent requirements on the measurement environment and can maintain normal operation under various harsh conditions. Their size is also generally small, making them very suitable for miniaturized civilian weighing equipment. The parallel beam sensor has a simple structure, good stability, high precision, large range, high sensitivity, and excellent frequency response characteristics [8].

The principle of parallel beam sensor: Parallel beams will cause damage due to external force.

Elastic deformation occurs, and the regularly distributed resistance strain gauges on the parallel beams also deform due to the action of this force [9]. Since the change in the internal structure of the strain gauge shape will cause the strain gauge resistance to change, the bridge circuit will not be able to balance the output and generate a differential signal. The parameters such as resistance and voltage in the sensor change slightly. After multiplication by the amplification circuit and conversion from analog to digital, the quality of the object to be measured can be obtained through internal calculations of the microcontroller [7]. The sensor structure is shown in Figure 3.

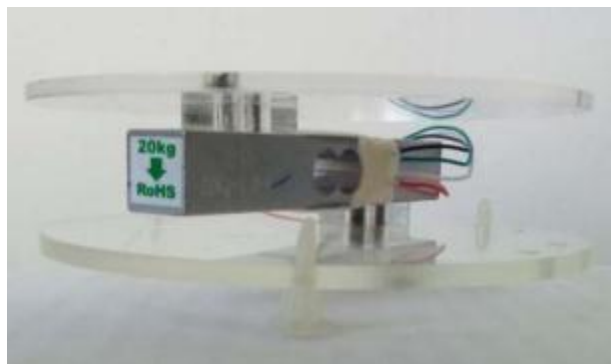


图 3 传感器结构示意图

Fig.3 The sensor structure diagram

The bridge circuit is a bridge arm composed of four resistance strain gauges. They all undergo elastic deformation under the action of external forces. They are in the same temperature field. When the materials, resistance values, and strain amounts  $\varepsilon$  of the four strain gauges are the same, due to  $R_1$  With  $R_3$ , the positive value of tensile strain is substituted, and with  $R_2$  and  $R_4$ , the negative value of compressive strain is substituted, the temperature effects cancel each other out, and the voltage output sensitivity is high. Then the following formula (1) can be derived:

$$\Delta U = \frac{EK}{4}(\varepsilon_1 - \varepsilon_2 - \varepsilon_3 + \varepsilon_4) = \frac{EK}{4}4\varepsilon = EK\varepsilon \quad (1)$$

During the use of this article, the sensor is placed at the geometric center of the plate containing the dishes. During the process of placing the dishes, try to ensure that the dishes on the plate are even and reduce the error of weighing and collecting data. Secondly, between the dish plate and the sensor, The space is insulated with an insulation layer to prevent the difference in hot and cold dishes from having an excessive impact on the sensor sensitivity.

### 2.3 称重 A/D 转换模块

Since the microcontroller can only recognize and process digital signals, but because the sensor outputs an analog signal, the microcontroller cannot directly process the data. Therefore, the analog signal needs to be converted into a digital signal through the A/D conversion module. At the same time, the output voltage of the sensor bridge is very weak. If direct processing will cause signal loss or distortion, it must be multiplied by the amplification circuit and converted from analog to digital, and finally the amount of data can be identified and processed by the microcontroller. In order to provide reliable signal amplification and digital-to-analog conversion, the integrated circuit HX711 module [10] was selected. As shown in Figure 4.

Digital-to-analog conversion accuracy requires higher system reference voltage. The internal A/D of the microcontroller is up to 12 bits. Artificially improving the accuracy will affect its reference voltage.

Accuracy requires an external A/D chip. HX711 is a 24-bit analog-to-analog conversion chip specially used

for high-precision weighing sensors. This chip has high integration, fast response, strong anti-interference, and high reliability, which can reduce the development cost of weighing systems [11]. The chip has integrated peripheral circuits, and the parallel beam sensor and the on-chip A/D converter are provided with regulated power by the chip, and the system does not need to provide a separate analog power supply [12]. The built-in clock oscillator can be automatically reset only after power-on, which simplifies the initialization process of power-on. Moreover, there is no need to program the internal registers of the chip, and the control signals are driven by the microcontroller pins, which greatly simplifies the development difficulty and improves the development efficiency. When programming, you can arbitrarily select channel A or channel B and connect it to the internal low-noise programmable amplifier to obtain different programming gains. Refer to Table 1 for channel selection.

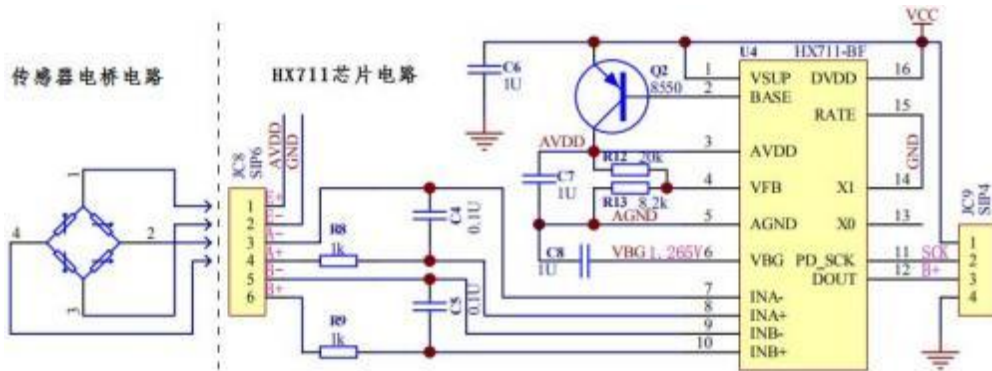


图 4 桥式配置电路  
Fig.4 The bridge configuration circuit

表 1 通道选择  
Tab.1 Channel selection

通道	可编程增益	输入电压(mv)
A	128	±20
A	64	±40
B	32	±80

### 2.4 称重显示结构

Currently, there are two main display methods: LED and LCD. Considering that the amount of data to be displayed in this system is relatively large, we decided to use an LCD screen with better performance. The common ones are LCD1602 ordinary screen and TFT true color screen. Although this system has a large amount of data, it has no requirements for color and does not need to display color

images. Using TFT will reduce the processing speed of the microcontroller. Moreover, the LCD1602 module has low cost and simple control, which can meet the actual needs. Require. Therefore, from the perspective of cost and practicality, this system chooses to use LCD1602 as the display device. LCD1602 can display a maximum of 2 lines and 32 characters. The LCD interface circuit is implemented in parallel communication mode, which can relatively reduce the I/O port resources of the microcontroller. The LCD1602 module can be directly connected to the microcontroller, and the circuit is simple. The hardware circuit is shown in Figure 5.

### 2.5 无线通信接口

This system uses the NRF24L01 wireless radio frequency transceiver module. The NRF24L01 produced by NORDIC is a wireless communication chip using FSK modulation. It has internally developed and integrated a customized Enhanced Short Burst protocol, which can realize one-to-many wireless communication [7].

The wireless communication speed can reach 2 bps, which can realize fast and real-time wireless information transmission function, and provides convenient and fast technical support for the construction of wireless communication in small microcontroller systems [13]. NRF24L01 Wireless

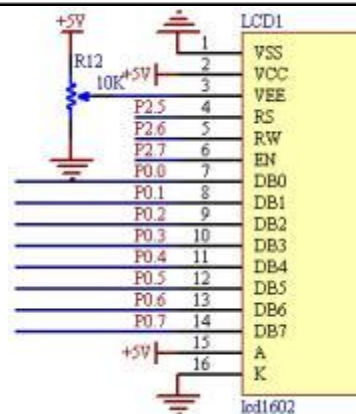


图 5 液晶显示部分电路图

Fig.5 The circuit diagram of LCD

The module is connected to the weighing controller and uses TTL level changes to read and write data to the serial port. Figure 6 is a schematic diagram of the connection between the NRF24L01 wireless module and the STC89C52 microcontroller. Communication between the PC and the wireless communication module requires level conversion. Here, the CH340T chip controlled by STC14W404AS is used to convert the TTL serial port into a USB serial port, so that the interface form can be recognized on the computer.



图 6 NRF24L01 无线模块与单片机接口连接图

Fig.6 Interface connection diagram of NRF24L01 wireless module and single chip microcomputer



### 3 后台软件

#### 3.1 无线通信模块软件系统

This article uses the NRF24L01 wireless module to transmit information between the weight acquisition end and the data reading end. The data transmission address is shown in Table 2. First, initialize the module, pull the LED, CE, and SCK pins low, and pull the CSN pin High, SPI completes initial setup. Set the SPI receiving and sending addresses according to the master and slave information. Set the working channel, data length, and transmission frequency. At this time the module enters standby state. Then set the working mode, set different modes according to the level change of pulling down the CE pin, and configure the SPI read and write register to complete the configuration of the working mode.

表 2 主从机地址  
Tab.2 Master slave address

传输地址	
主机	0xCF,0xCF,0xCF,0xCF,0xCF
从机 1	0x37,0x43,0x10,0x10,0xFF
从机 2	0x35,0x43,0x10,0x10,0x03

Sending end: Pack the data and send the data packet through the NRF24L01\_TxPacket () function.

Receiving end: Wait for the arrival of data through NRF24L01\_RxPacket(). The wireless transmission program flow chart is shown in Figure 7.

#### 3.2 后台软件系统

The data is uploaded and collected through the COM serial port, and the remaining weight data is saved to the database through MySQL. The user service platform is developed based on WeChat Mini Program. WeChat Mini Program is cross-platform, ready-to-use, and complete.

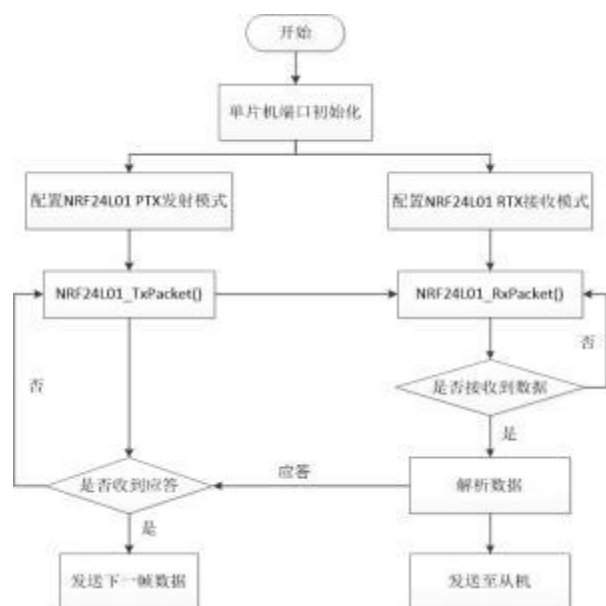


图 7 无线传输程序流程图

Fig.7 Wireless transmission program flow chart

It has the advantages of good documentation and efficient development framework [14]. The system background uses the Micro Engine framework and is coded using the Sublime editor. The front-end is a UI interface based on HTML+CSS technology. Developed using PHP language and database MySQL [15]. When the user determines his or her needs and submits an order by observing the price, name, and remaining quantity of the dish, the background event will be triggered and the program will be called for processing, a write-off QR code will be generated, and the reservation will be successful. The front-end and back-end display interface of the service platform software is shown in Figure 8.

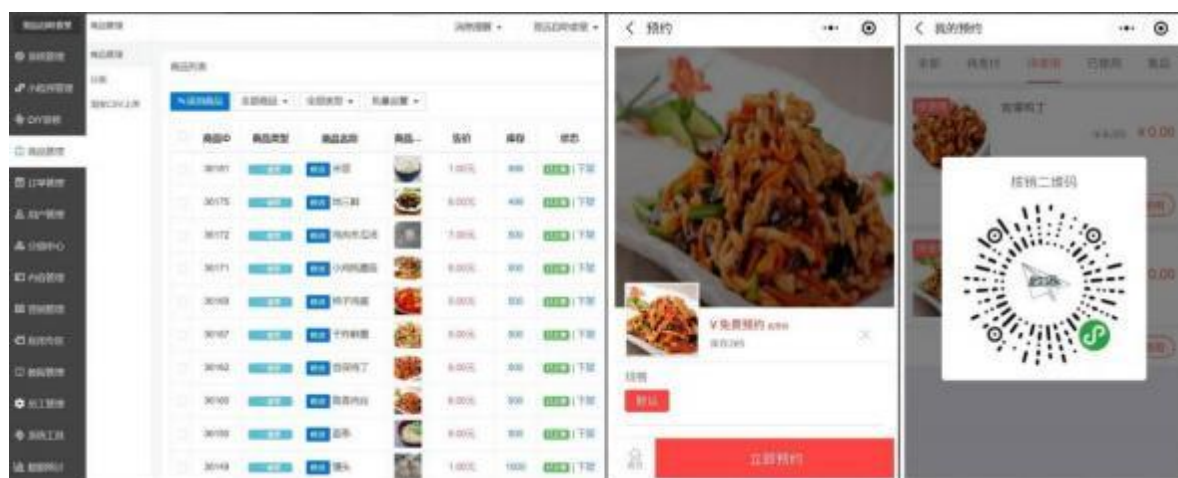


图8 服务平台前后端  
Fig.8 Front and back end of service platform

#### 4 系统功能的实现及应用

The wireless module of this system is a new single-chip radio frequency transceiver device working in the world-wide ISM frequency band of 2.4 G~2.5 GHz. The transmission distance can reach 100 m under the influence of many conditions and factors, and it can fully cope with the relatively complex environment of the canteen. Automatic weighing control technology and wireless communication technology are organically combined, and the collected data is transmitted to the remote server using wireless communication. Through multiple data collections, MySQL was used to create a database of the remaining amounts of dishes, and the database was

to view and order meals. The system can achieve the following functions:

- (1) Current dish information is displayed.
- (2) The remaining weight data of the dishes is displayed in real time.
- (3) Communication status display.
- (4) Historical data: historical data viewing, data output and printing.
- (5) User management: user identity information, user password modification, User consumption.
- (6) System management: window management, exiting the system. The system test running process is shown in Figure 9.





图 9 系统测试图  
Fig.9 The system test diagram

## 5 结语

This article uses the STC89C52 microcontroller as the processing chip of the wireless electronic weighing system platform, uses the NRF24L01 chip to form a wireless transceiver communication module, and uses the HX711 chip as the signal processing module to collect and control the data of remote weighing equipment through wireless communication. Automatic weighing control technology is integrated with wireless communication technology. The data is uploaded to the PC through the serial port, the remaining weight data is saved to the database through MySQL, and the viewing and meal reservations are controlled through the WeChat applet. This system provides users with a mobile campus food ordering platform. Users can not only check the remaining quantities of dishes, but also use it as reliable analysis data for canteen purchases. It can reduce queuing and waiting time, improve dining efficiency, and also choose your own. Favorite dishes greatly improve dining efficiency and service quality.

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## 4 结论

This paper designs a musical fountain control system based on the AT89C52 microcontroller, supplemented by the L298 chip. The system can control the height of the fountain water column and the changing frequency of the colored lights according to the music input through the USB interface. It has passed the proteus simulation experiment and the actual object. It has the characteristics of

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music-controlled fountain fluctuation effect, can meet the aesthetic needs of users, and has certain commercial value.

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