Development of the Platform-Type Aircraft Weighing System Based on the Internet of Things

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Abstract. For the area for the aircraft weighing is relatively large and the display terminal is placed near the aircraft, the operator can’t conveniently read the data on the display, so the platform-type aircraft weighing system based on the internet of things is developed. The system consists of three platforms, three digital modules, three 4G wireless modules and one cloud server. Three platforms containing sensors are placed under three wheels to measure the weight of an aircraft. The analog voltage signals of the sensors are converted to digital signals by digital modules and then uploaded to the cloud server by a 4G wireless module. A website with IP address consistent with the public IP address is established on the cloud server. The sensor data uploaded to the server is read by the ASP.NET Web Application program. A computer software is developed to log in to the website at any time to check the weighing data and calculate the position of the gravity center of the aircraft according to the formula for calculating the gravity center. The experimental results show that the weighing system is not limited by distance, has good real-time performance, stable operation and reliable calculation.

1. Introduction
The area for aircraft weighing is relatively large, and the display terminal used in different weighing types such as the platform type, the suspension type or the Jack type [1-3] need to be placed near the aircraft, otherwise the data wire will bring the error to the measurement results. It is better for the operator to obtain three weighing data of the three wheels at the same time when the plane is weighted. With the development of the Internet of Things and the level of automation, the intelligent weighing system has become an inevitable trend. The Internet of things as a new technology which connect all kinds of sensors and the Internet has been widely used in many fields [4-6]. The user application extends from the information exchange and communication between people to people and things, things and things, things and people. At present, the widely used wireless technologies are 433, Zigbee, Bluetooth, as well as WiFi [7-9], but these are short distance wireless communication methods, and easily affected by the environment. One of the obvious advantages of the Internet of things is that it is not limited by distance and space, and users can monitor weighing data at anytime and anyplace.

The intelligent platform weighing system designed in this paper is a wireless weighing system based on Internet of Things. The weight of the aircraft is measured by three weighting platform with sensors under three wheels. The voltage signals of the sensors are converted into digital signals through the digital modules and uploaded to the server through the 4G wireless module. The computer reads the measurement data of the sensors in real time by logging in to the server program, then calculates the total weight of the aircraft and calculates the position of gravity center according to the formula of the aircraft gravity center. The system can be applied to weigh various aircraft.
2. Introduction of the Weighing Platform
The appearance of the weighing platform is shown in Figure 1. The size of the aircraft weighing platform is 1000×1000×40mm, the maximum range can reach 50t. The aircraft weighing platform is made of aluminium alloy and it is easy to detached and convenient to carry. The weight of one platform is about 15kg. Five weighting sensors are placed inside of the weighing platform and the overall arrangement (as shown in Figure 2) strengthen the platform. The range of each sensor is 1/5 of the total weight. The four-corner error is adjusted to improve the accuracy of the measurement. The voltage output of each platform is converted into digital signals through the A/ D digital modules and uploaded to the server through the 4G wireless module.

3. Hardware Design
The hardware of the intelligent platform aircraft weighing system mainly includes A/ D digital module and 4G wireless module.

3.1. A/ D Digital Module
The principle of the digital module is shown in Figure 1. The bridge circuit, the clock circuit, the reset circuit, the power supply circuit and RS485 circuit are controlled by a micro-controller(STM32) and the analog voltage output of the strain bridge is converted into a digital signal through the signal amplification, filtering and the A/D(24-bit CS5530) processing, so that the measurement data can be transmitted to the server through the 4G module. Finally, the digital signal is output by the RS485 serial port.

![Figure 1. Working principle of digital module.](image)

3.2. 4G wireless module
The 4G module contains a 32-bit communication processor, an industrial-level wireless module and an embedded real-time operating system. It has the minimum power consumption at 5mA/12VDC. The 4G module is provided with an intelligent data terminal which can enter the data transmission state when it is powered on. The 4G module has an RS485 interface and transparent data transport protocol, which is easy for the data transmission. The 4G module with a TCP server can connect with 4 modules with TCP/IP protocol. The working principle diagram for the intelligent 4G module is shown in FIG.2. Some working parameters such as RS485 serial port character should be configured before work. The baud rate and the data format should be consistent with the A/D module introduced last section. The IP address of the central server in the 4G module should be consistent with the cloud.
server. By this way, the measurement data of the sensor could be uploaded to the cloud server by 4G module.

![Diagram](image)

**Figure 2.** Working schematic diagram for wireless terminal of Internet of things

### 3.3. Cloud Serve

If there is no public network IP available, a cloud server need to purchase to obtain a fixed IP address. The operating system of the cloud host is Microsoft Server2010. The working principle of the whole system is shown in Figure 3.

![Diagram](image)

**Figure 3.** Design of aircraft weighing system based on Internet of things

### 4. Software Design

The system software includes the software running on cloud server which is responsible for the communication between 4G module, the website built on cloud server which is used for visiting and getting weighing data by computer software and the computer client software for acquisition of sensors’ data, the linearity compensation of sensors, the calculation of aircraft total weight according to the value from each platform and the calculation of the gravity center for aircraft according to the formula for gravity center.

#### 4.1. Communication between server and 4G module

The software runs on cloud server is developed to realize the communication between Internet of things wireless terminal (4G module) and the cloud server. The development language is .net. As we
know that the API of the TCP/IP protocol is Socket, which define many API functions for network development. The program loads the WinsockGroup (i) control group and the number of i depends on the number of weighing platforms. Each 4G module can upload data actively to the server after being powered on. The server determines the data coming from which platform by the unique ID number of the 4G module in each platform. The real-time weighting data is uploaded by 4G module to the sever and the software stores the weighing data on the hard disk in the format of text and the data will be refreshed every time that 4G module uploads data so that the memory of the server is not occupied.

4.2. Establishment of Server Website and the Development of Web Program
IIS is a server management system of the Windows Server2010. After adding roles and functions on the server manager on the cloud server, a host with homepage named iZmtuqiesxnj5ZA by default is built. Right-clicking the host, a menu will appear, then select adding website, a website which has the same IP with the public network IP but different port ID will be built. After the website is built, an ASP.NET Web Application running on the server is developed to read the data saved on hard disk of the server. Default.aspx is the default web page interface, which can be changed according to the actual needs by code so that the web service page can have appearance containing the content of the total weight of the aircraft and the gravity center of the aircraft. A web service program named ReadSensor is built by adding WebService1.asmx to the project. Enter the web address and port number which is consistent with the website that built before on the cloud server to URL. The project will establish a connection automatically and make the web service application point to the website. By this way, the measurement data uploaded to the server by 4G module can be read by Web Service program.

4.3. Development of Computer Client Software
A software is developed on operator ’ s computer. The main function of the software are reading data from the cloud server, calibrating the sensors by linear correction and calculating the gravity center of the aircraft. A Windows Form Application is built, then add a web reference to the project, enter the same web address and port number as the website on server to the URL. By using a Timer event, the data saved on the hard disk of the server is read regularly. What the computer read is the digital output voltage value of the sensors, which is related to the weight on the platform. The software will calculate each platform ’ s real force value by recording the standard force value from the force standard machine and the corresponding digital voltage value of the platform ,so that the actual force value of the platform can be acquired by the voltage value of the sensors. In order to ensure the accuracy of the measurement , linear correction is made for each platform. The interface for linear correction program is shown in Fig.4. There are ten-point linear correction for each platform and the correction coefficient is calculated by Newton interpolation method and saved in computer for later calculation. In addition to displaying the force value, an alerter is designed to turn green to red when the value of the platform exceed the limit value set before to remind the operator that the platform is overloaded. If the server is in communication with the 4G module, the weighing data will be uploaded to the server constantly. The operator will view the weighing data on his computer at any time(shown in Fig.5).

Figure 4.Linear correction interface
Figure 5.Weighing interface
5. Test verification
Calibration tests for the platforms are carried out to verify the communication between the web program and the computer client program and the linearity program for the platform. The calibration results are shown in Table 1. The measurement uncertainty of the whole weighing system is Ur=0.3% (k ≤ 2). There is no offline or disconnection or data delay in the whole test process. Therefore, it is verified that the design of the hardware and software is reasonable.

|                | Front platform | Left platform | Right platform |
|----------------|----------------|---------------|----------------|
| kN  | kg  | kg  | kN  | kg  | kg  | kN  | kg  | kg  |
| 0   | 0.00| 0.00| 0   | 0.00| 0.00| 0   | 0.00| 0.00|
| 10  | 1020.26| 1019.72| 20  | 2040.52| 2039.43| 20  | 2040.52| 2039.43|
| 20  | 2040.52| 2040.45| 40  | 4081.04| 4078.87| 40  | 4081.04| 4078.87|
| 30  | 3060.78| 3061.19| 60  | 6121.56| 6118.30| 60  | 6121.56| 6118.30|
| 40  | 4081.04| 4081.92| 80  | 8162.09| 8156.71| 80  | 8162.09| 8157.73|
| 50  | 5101.30| 5101.64| 100 | 10202.61| 10196.14| 100 | 10202.61| 10197.16|

|                |                |
|----------------|----------------|
| Repeatability | 0.1%           |
| Relative error | 0.1%           |
| Uncertainty   | Ur=0.3%(k=2)   |

6. Conclusion
For the space of the weighing site is very large, it is inconvenience for the operators to read and monitor the display terminal placed near the aircraft. By the wireless terminal of the Internet of things, each weight data of the platform is uploaded to the server in real time. By developing the software on the cloud server and computer terminal software, the real-time data can be obtained by visiting the website at any time. The gravity center of the aircraft is calculated according to the coordinates of the aircraft. This not only avoids the problem that many wireless communications are limited by distance, but also realizes remote and real-time monitoring of weighing data.

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