Indoor Crowd Density Monitoring System Based on WeChat Public Platform

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Abstract. To reduce the cost of crowd density monitoring in indoor space, facilitate supervisors to monitor crowd density in indoor space at any time. The article uses the characteristics of indoor temperature and humidity changes with the number of changes and combines WeChat Public Platform and design this indoor crowd density monitoring system. In order to improve the accuracy of the system, in this article, the collected temperature and humidity data were filtered and pre-processed, and then the approximate relationship between temperature and humidity and population density was found by linear fitting method. Through the experimental test of this system, the system is reasonable in design, easy to use, and can accurately monitor the indoor population density.

Key words: Crowd density monitoring; Temperature and humidity data; WeChat public platform.

INTRODUCTION

The WeChat public platform is an information transmission platform developed by Tencent for WeChat users and provides users with a development interface for the public platform. The WeChat public platform has attracted the attention of many markets and companies since its launch [1]. With the huge number of users owned by WeChat, it has gradually and comprehensively deepened its production and life.

With the rapid development of social economy and urban construction, more and more people are pouring into cities. In order to protect the people's happy life, effective crowd density monitoring for crowded places has become an urgent problem to be solved [2]. The traditional cameras, infrared and other monitoring methods can meet the monitoring requirements, but the cost is relatively high, and it is not easy to monitor the indoor crowd density anytime anywhere. The article uses the characteristics of human body temperature and exhaled gas to have a great influence on the temperature and humidity of the indoor space [3], makes a reasonable analysis of the temperature and humidity data, and designs this indoor crowd density monitoring system in conjunction with the WeChat public platform. Through the WeChat public platform, the system greatly reduces the development cost, reduces the difficulty of equipment installation, facilitates promotion and use among users, and can obtain crowd density information through the WeChat public number at any time.

OUR DESIGN

As shown in Figure 1, the system is mainly composed of a temperature and humidity sensor module, a power supply module, a main control module, a Wi-Fi module, a cloud server, a WeChat server, and a mobile WeChat client. temperature and humidity sensor use DHT11, main control module use SMT32, Wi-Fi module use ESP8266, cloud server use aliyun.
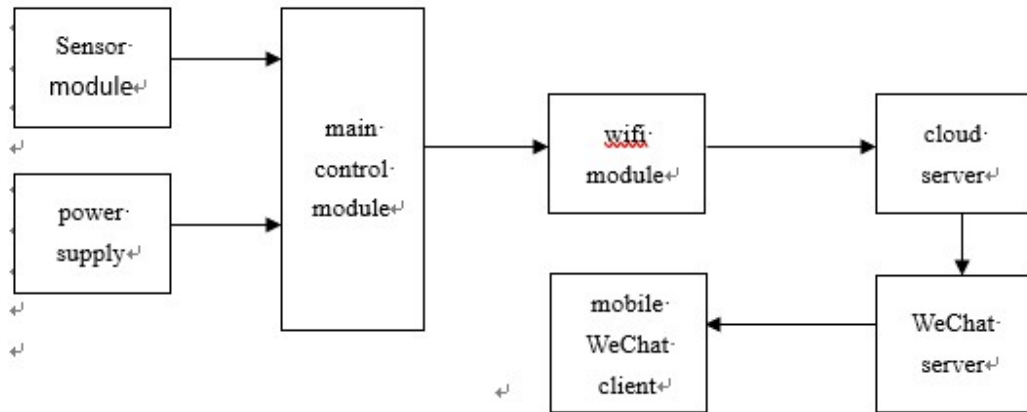
FIGURE 1. Structure of Whole System

PRE-PROCESSING OF TEMPERATURE AND HUMIDITY DATA

Pre-processing the collected temperature and humidity data in this section. Because the sensor is affected by the surrounding environment, the collected data will inevitably have a deviation from the real value [4], so the data needs to be preprocessed. We use the distribution map method [4] and the low-pass filter algorithm [5] to filter abnormal data. The basic process is as follows:

(1) Firstly, collect n data in succession, from small to large $(t1, t2, t3 \dots t_n)$, let t_m be the median:

$$t_m = \begin{cases} \dfrac{t_n}{2} & \text{n even} \\ \left(\dfrac{t_{n+1}}{2} + \dfrac{t_n}{2}\right) \Big/ 2 & \text{n odd} \end{cases} \tag{1}$$

(2)   Definition the median of $(t1, t2, t3 \dots t_m)$ is t_s, the median of $(t_{m+1} \cdots t_n)$ is t_x, followed by (1).

(3)   The value of the definition of abnormal data is d_t:

$$d_t = d_s - d_x \tag{2}$$

(4) Using a weighted mean filter algorithm to obtain the average of n samples

$$y(k-1) = \frac{1}{n} \sum_{i=1}^{n} C_i t(i) \tag{3}$$

(5) If $|t(k) - y(k-1)| \geq d_t$, low-pass filter algorithm for this sampling, the final algorithm is as follows:

$$y(k) = \begin{cases} t(k) & |t(k) - y(k-1)| > \beta d_t \\ \dfrac{T}{T+T_f} t(k) + \dfrac{T}{T+T_f} y(k-1) & |t(k) - y(k-1)| \leq \beta d_t \end{cases} \tag{4}$$

In the formula, t_k is the original data collected this time, $y(k)$ is the processed data, T is the sampling period, T_f is the time length, and β is the accuracy of the sensor.
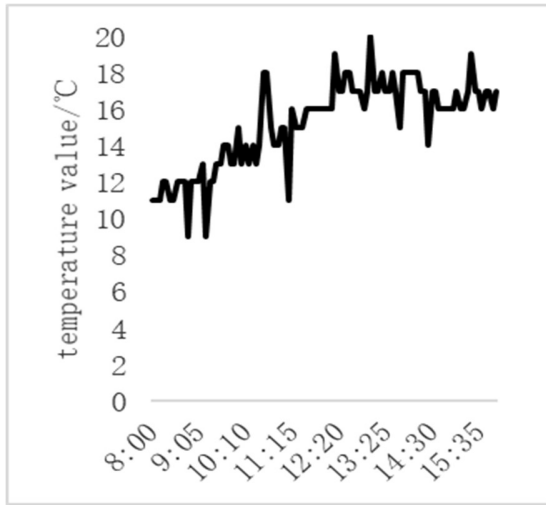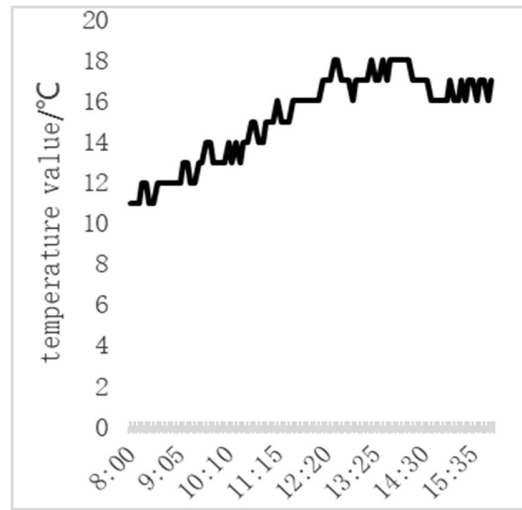
FIGURE 2. Pre-filter Temperature Data

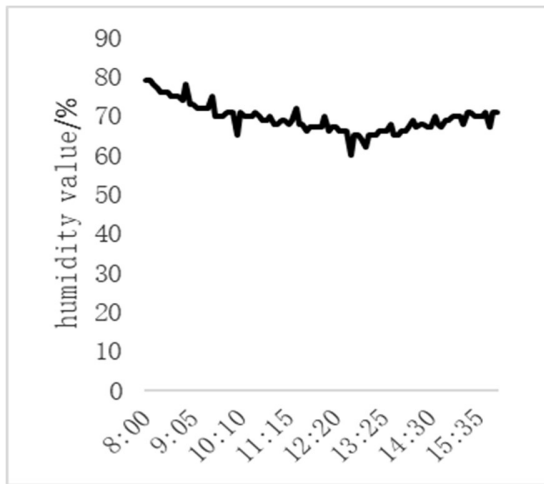**FIGURE 3.** Filtered Temperature Data
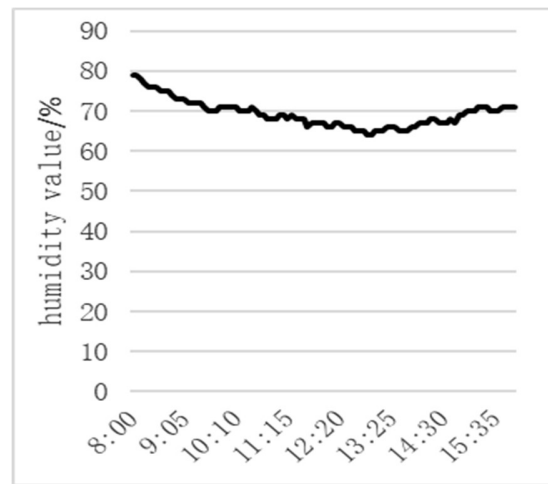

FIGURE 4. Pre-filter Humidity

FIGURE 5. Data Filtered Humidity Data

Temperature and Humidity Data Analysis

This section analyzes the collected data and estimates the population density in a confined space based on the collected temperature and humidity data [3]. According to the general population density level classification standard [2], data collection is performed for different numbers of diurnal space and analyzed.

The temperature and humidity data are shown in TABLE 1.

TABLE 1. Temperature and Humidity data

Persons	0	4	8	14	20
Humidity/%RH	68	69	70	74	79
Temperature/℃	17	17	18	19	21

The temperature and humidity data are zeroed and the normalized data are shown in TABLE 2

TABLE 2. Zero Data

Persons	0	4	8	14	20
Zero Humidity/%RH	0	1	2	6	11
Zero Temperature/℃	0	0	1	2	4
Normalized Humidity	0	0.09	0.18	0.55	1
Normalized Temperature	0	0	0.25	0.5	1
Model (x)	0	0.09	0.31	0.74	1.41

The densities of the population in the diverticulum space are shown in TABLE 3.

TABLE 3. Level Markup

Density Level	Very Low	Low	Medium	High	Very High
Servie Level	Free Flow	Constrain Flow	Dense Flow	Very Dense Flow	Block
Model Calibration	x < 0.09	0.09 < x < 0.31	0.31 < x < 0.74	0.74 < x < 1.41	x > 1.41

The results of the 3rd-order fitting of the vector modulus and the number of people are as follows:
f(x) = p1*x^3 + p2*x^2 + p3*x + p4
Coefficients (with 95% confidence bounds):
p1 = 9.784e-06 (-0.0005749, 0.0005945)
p2 =   0.002499 (-0.01514, 0.02014)
p3 =   0.01673 (-0.1213, 0.1547)
p4 = -0.003892 (-0.2779, 0.2701)
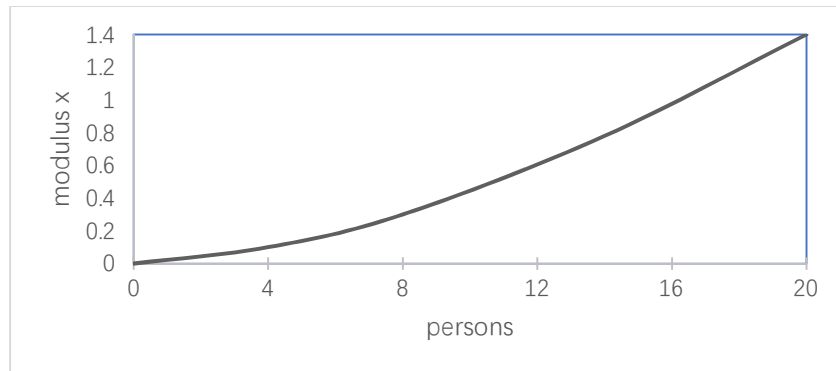The fitting curve is shown in Figure 6.

FIGURE 6. Fitting Curve

SYSTEM TESTING

The WeChat public number shows the indoor crowd density, as shown in Figure 7.
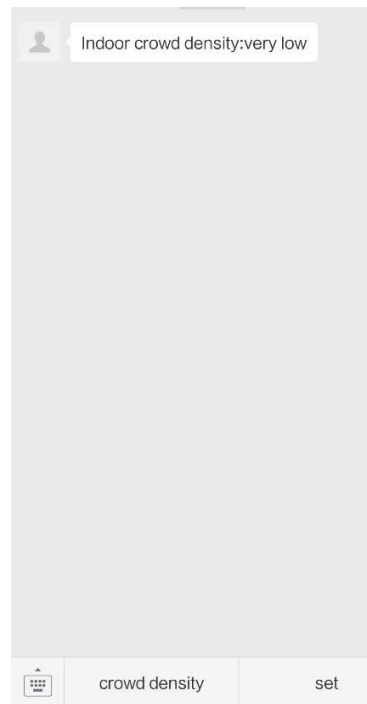
FIGURE 7. Wechat Public Account Screenshort

CONCLUSION

The article systematically collects and analyzes indoor temperature and humidity data and can effectively estimate the indoor population density. The system combines the WeChat public platform, which simplifies the development difficulty, reduces the cost [6], and facilitates the user's crowd density monitoring anytime and anywhere.

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