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Fine particles affecting human health monitoring method based on the internet of things and image processing

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ABSTRACT

In order to improve the environmental quality of atmosphere, Fine Particles monitoring work is of great significance. The Internet of things transmission technology and image processing technology, two advancing technologies, are used to monitoring Fine Particles data. Use Huawei MC509 wireless data transmission module of CDMA2000 1Xev-DO network structure and four direction of edge detection method, then by Yeelink platform to implement the collected a large number of particle image access management, data storage and data presented to the server computer at any time. Through the analysis of experimental results, there correlation coefficient is 0.9693 between the number of particles detected by the system and the official Fine Particles density. Because of the highly linear positive correlation, Fine Particles monitoring method has important practical reference value.

KEYWORDS

The Internet of things; Image processing; Fine Particles; Yeelink platform.

INTRODUCTION

The internet of things has the great significance in improve the environmental improvements like other aspects of the same. It can monitor the governance of the atmosphere and soil with Intelligence Sense information transmission, also can disposal of the information on climate change phenomenon and natural disaster. First, we adopt the use of closed-loop management in many aspects with the internet of things, such as monitoring, early warning and control of pollution sources. Secondly, it helps a lot in the green belt and wetland forests and other natural resources sensor construction. Moreover, once combined with geo-spatial databases can achieve real-time control of green resources. It can also consummate the aspects of monitoring, controlling and management to thermal energy and building temperature system. By means of intelligent sensing system, the internet of things can be a reasonable allocation of the use of electricity, natural gas, coal and any other resources.

There are many studies and research at home and abroad. But according to current information, detection rarely on aspects of tobacco leaf structure Dayefukao after, the testing equipment manufacturers at home and abroad has not yet produced. At present in our country, only Da-Shu Company in cooperation with Nanjing University of Aeronautics and Astronautics develops simple online detection equipment for removing and testing foreign body. But single layer is hard to detect, so it can not enlarge well and replace manual testing methods radically. Image acquisition, a large number of image transmission and image processing accuracy are the major problems on-line Fine Particles monitoring method[1]. Because of the lack of such equipment and sophisticated technology at home and abroad, so the first time with a combination of the internet of things and image processing methods to achieve online monitoring Fine Particles has been proposed by this paper.

THE EXPERIMENT CONTENT

Application of the internet of things in the Fine Particles monitoring

CDMA2000lXEV-DO standard was created by Qualcomm Company's high-speed data (HDR) technology, through continuous experiments, and was better improved through the experimental data. It was named CDMA2000lXEV-DO technical and was handed 3GPP2, in March 2000. At December 2000, CDMA2000lXEV-DO as a branch of the CDMA2000 family, which was adopted as one of the IMT-2000 standards[2].

Based on CDMA Network, the remote image and data transmitted system. Within a shackles of the transport cable by wireless propagation medium, so as not to be bound by the active area and limitations CDMA. Use of CDMA-based wireless communication network can be easily implemented wireless remote supervisory control CDMA[3]. The basic flow of the CDMA wireless transmission is shown in Figure 1.

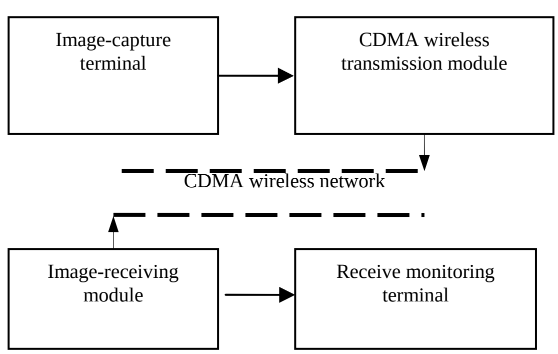

Figure 1 : Basic flowchart of CDMA wireless transmission system

THE BASIC PRINCIPLES OF MONITORING

The basic principles of monitoring Fine Particles by image processing as follows: First, impatient the collected particulate matter image by image de-noising method. Second, extract the suitable color channel images for further processing by color space conversion, using hole-filling technology[4,5] to fill the holes in the images. Finally, adopt an appropriate edge detection method to extract the image edge information particulate matter, and then do the calculation on its micrometer - size particle.

An edge detection algorithm in this paper

(1) Roberts Operator

Roberts Operator is a commonly used operator, which is used Local difference method to find edge, and adopts 2*2 templates.

The template of horizontal direction:

$$\begin{vmatrix} 1 & 0 \\ 0 & -1 \end{vmatrix}$$

The template of vertical direction:

$$\begin{vmatrix} 0 & 1 \\ -1 & 0 \end{vmatrix}$$

(2) An edge detection algorithm in this paper is the following:

1) Use four directions to extract the image of edge detection;

2) Use OR operate to the results detected in each direction above-mentioned.

In this paper, four directions as follows:

$$\begin{bmatrix} -1 & -1 & -1 \\ 2 & 2 & 2 \\ -1 & -1 & -1 \end{bmatrix} \begin{bmatrix} -2 & -1 & -1 \\ -1 & 2 & -1 \\ -1 & -1 & 2 \end{bmatrix}$$

$$\begin{bmatrix} -1 & 2 & -1 \\ -1 & 2 & -1 \\ -1 & 2 & -1 \end{bmatrix} \begin{bmatrix} -1 & -1 & 2 \\ -1 & 2 & -1 \\ 2 & -1 & -1 \end{bmatrix}$$

Examples were shown in these pictures. Figure 2 is the detection results of Roberts's operator algorithm. Figure 3 is edge detector algorithms in the paper.

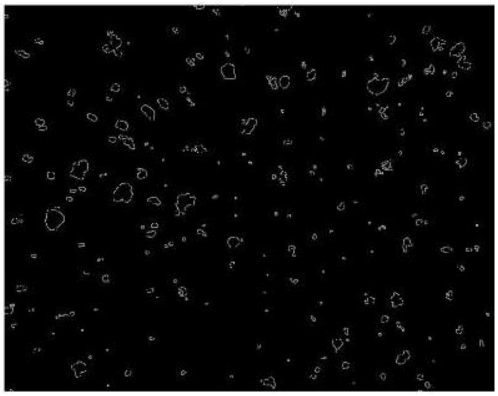

Figure 2 : The detection results of Roberts' operator algorithm

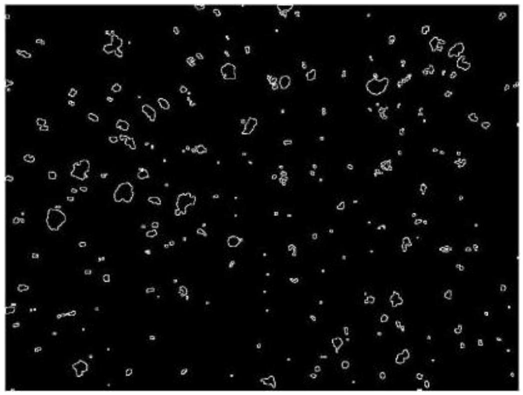

Figure 3 : Edge detector algorithms in the paper.

Method of calculation the fractal characteristic parameters

Further particles can be measured and analyzed the geometric characteristics after those particles were separated from the image[6]. The basic parameters by analyzing the particle size, perimeter size and other characteristics of the particles can be calculated on the parameters.

Area

(1) Pixel count area method

The most common count area method[7] is that calculation the statistical number of pixels within the boundaries. This method is much less computations and greater meaningful. Assuming that the image is f (x, y), then the area is calculated as:

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$$s=\sum_{x=1}^{N}\sum_{y=1}^{M} f\left(x \cdot y\right)$$

(2) Method to calculate the area using code boundary trip

By describing various closed boundary area can be more convenient to calculate the area. Generally divided into the following two situations:

1) Coding variety of known stroke region, an area that is the sum of the various stroke lengths;

If a closed graph boundary representation is informed, area surrounded by the outer boundary minus the area surrounded by within the boundaries is the corresponding area of connectivity.

(3) Coordinate border area calculation method

Green's Theorem has been shown that, in the area of a plane surrounded by the closed curve can be obtained by integrating the profile; simply follow the curve of the integral can be closed. Such discrete points can be obtained by calculating the final area.

Perimeter

Perimeter particles is that the particle lengths of the outer boundary region. Particles use shorter circumference to surround the pixel in its possession. The perimeter is the cumulative -and length of pixels around the outside border. Due to the presence of right-angle turn, circumference is inflated during the measurement. Different representation has different method to calculate the circumference. Commonly calculated as follows:

(1) If each pixel in the image having a small block as a unit area, the image of the target area and the type of background that can block both the components. The target area length plus girth background gap length is region perimeter. At this point, the boundary can be represent using gap codes[8]. Therefore, the calculation of the gap length code represents the perimeter length.

(2) If only the pixel as a point, the perimeter can be expressed through the chain code. Perimeter is calculated by obtaining the length of the chain code. At this time, when the value of chain code is an odd number, then**Error! Reference source not found.**in length, if the chain code value is even 1 in length. Therefore, the perimeter P can be calculated by the formula as follows:

$$p = N_e + \sqrt{2} N_0$$

Above formula, N_e represents the number of boundary chain code even number and No represents the number of boundary chain code odd number.

The diameter

If the boundaries of the particles already obtained, the easiest way is to use its external dimensions to describe the particles' basic rectangular shape. When calculating the circumscribed rectangles of each particle on the coordinate system, just consider the object boundary points are calculated with the minimum and maximum coordinate values, the levels and vertical span of the particles can be obtained. For the particles in any directions, it is necessary conditions for determining the spindle of the different particles. Calculate the width and length can reflect the characteristics of particle shape on the spindle, and then this time the external particle is actually the smallest rectangle circumscribed rectangle.

SCHEMATIC DIAGRAM OF THE OVERALL SYSTEM ARCHITECTURE

The overall implementation of the system as follows: First, place and open the microscope to capture location, then collect images by the image capture software to capture images on the local computer connected to the microscope; Then, through a local computer connected CDMA wireless data transmission module pass, with commercial telecommunications base stations, can be collected a large amount of image data uploaded to the cloud storage service center Yeelink[9,10]. Finally, by acquiring an image server software on the client computer experiment center, it will be acquiring the image data Yeelink platform onto the server computer, and its image analysis and calculation, and thus achieve the design goal of the system. Figure 4 is overall structure of the system.

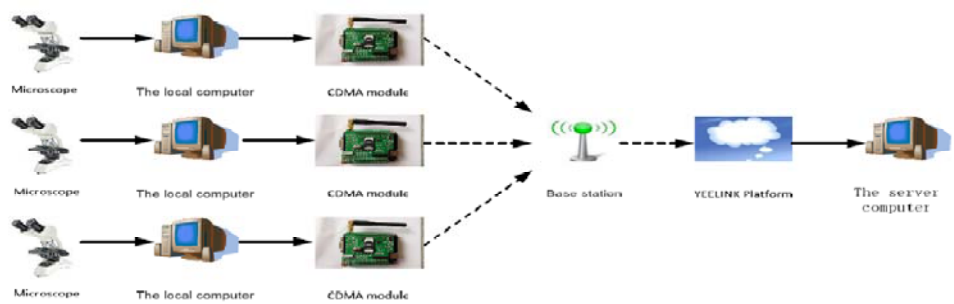

Figure 4 : Overall structure of the system.

This article is to collect particulate matter Fine Particles image data by Phoenix PH50 type of microscope. Place the microscope to captured location and open microscope camera, adjust to the best state imaging microscope and upload pictures to Yeelink platform, shown in Figure 5

Wireless data transmission module makes a guarantee for a large number of particle image data transmission applications through the CDMA2000 network via remote access[11]. This paper adopts Huawei CDMA2000 module 3G module EVDO MC509, this product can directly replace Huawei MC703 module.

RESULT AND DISSCUSS

The lower left part of the picture shows the results of the particle image edge detection. Using the method of image processing algorithms described in Chapter III. It shows the information of particulate matter, particle size and the total number. As can be seen from the figure 6, particulate matter edge information is not only continuous but also complete and clear by using this system edge detection algorithm. It creates favorable conditions for further particle counting, particle statistics, area calculation and lays a good foundation for the successful of the subject. 50um particle size of each image is divided into a range, statistics on the particle size of the image. The results shown in Figure 7, the horizontal axis represents the particle diameter and the ordinate is the number of particles. Most of the particle size distribution of particles in the range of 0 ~ 100um, and partly the distribution of particles in the range 100 ~ 200 um, 200 um or more and a particle size in only a few particles.

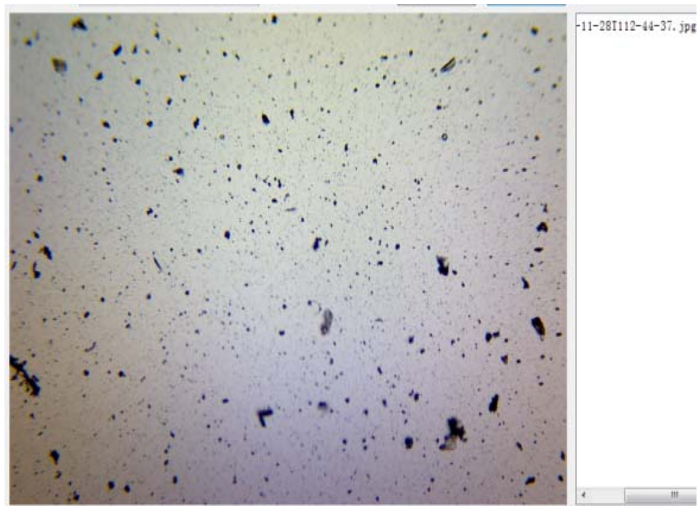

Figure 5 : Operator interface demo of Yeelink image data uploaded to the platform

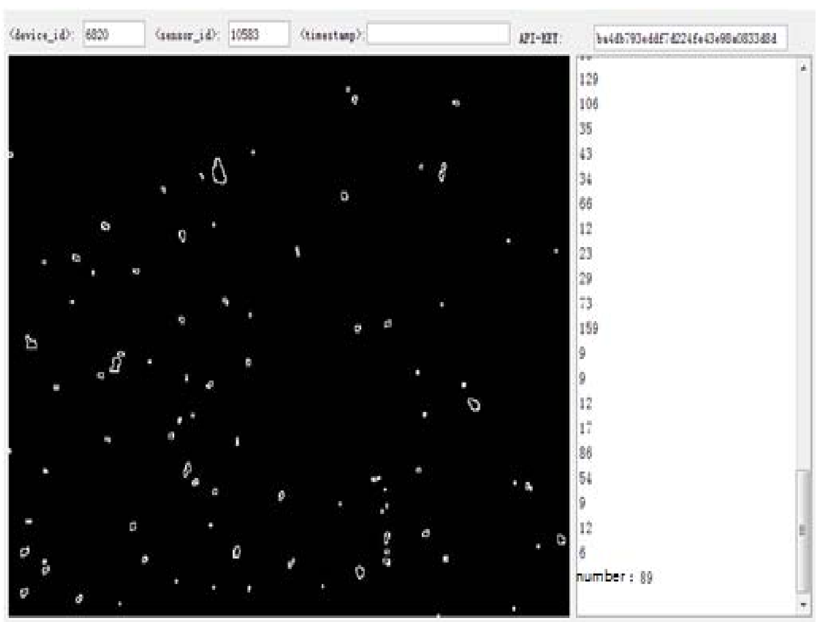

Figure 6 : The image analysis-completed interface

XiaoZhai, Xi'an as experimental sites in this paper, using a system designed in this paper. Experimental date was from December 2013 to early January 2014. Experimental monitoring data and official data are shown in TABLE 1.

Figure 8 is the change in trend monitoring data in TABLE 1 with the official data. When the low use of the system to monitor the number of particles, the official date of Fine Particles concentration is also low; higher use of the system when the number of particles detected, the official date of

Fine Particles concentration is higher; and there is no obvious lead or lag, meet the requirements of real-time air monitoring system.

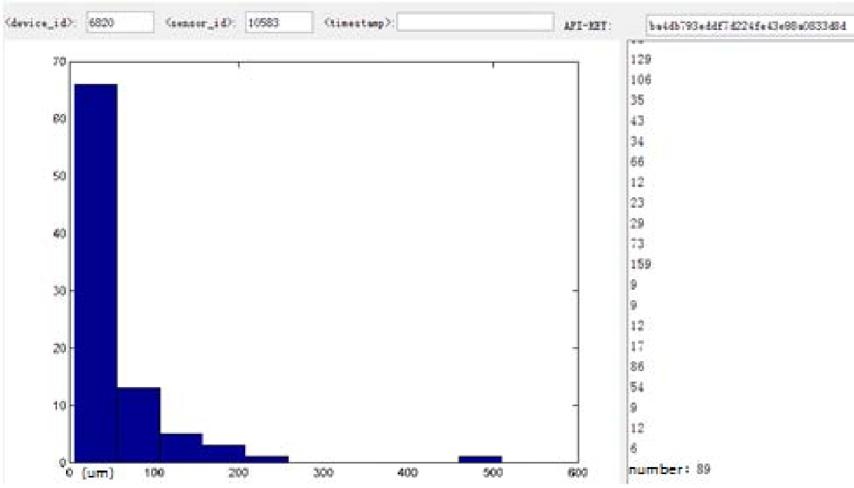

Figure 7 : Particle radius statistics

TABLE 1 Experimental monitoring data and official data

data	Experimental monitoring data (number)	official data (ug/m^{3})
2013-12-5	156	130
2013-12-7	130	155
2013-12-11	126	111
2013-12-13	153	175
2013-12-16	154	134
2013-12-19	352	500
2013-12-25	384	603
2013-12-29	105	203
2013-13-31	89	95
2014- 1- 2	93	121
2014- 1- 4	158	146

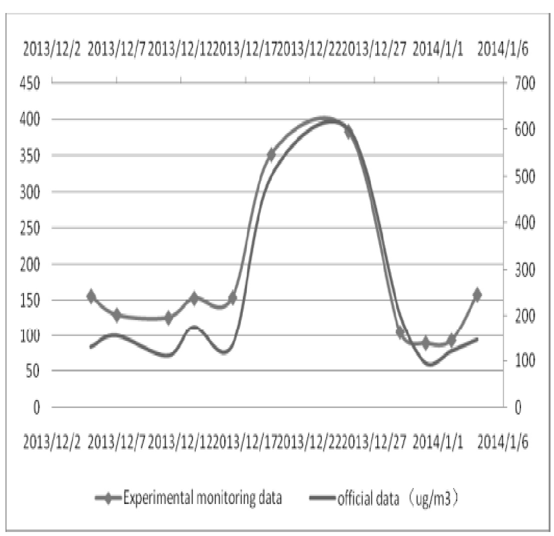

Figure 8 : The change in trend monitoring data with the official data

Figure 9 shows that the Relationship between the system monitoring results and official data graph. Among them, the horizontal axis represents the system to monitor the number of particles. Ordinate represents the official Fine Particles concentration values corresponding abscissa. When less monitored particulate matter, Fine Particles concentration is low, but this time the two are not highly correlated; while the number of particles greater than 160 when the monitored time, showing a concentration of Fine Particles with good correlation. When the Fine Particles concentration is low, the weather conditions are more favorable, small number of particles in the atmosphere. Therefore, the particles can be monitored and less. When higher Fine Particles concentration, the law between both can be well presented. To further illustrate the relation between the two, this paper uses a polynomial fitting method[12], the number of particles of the system will be monitored as the independent variable, the value at the date of the official Fine Particles concentrations were fitted. Curve obtained by fitting as shown in Figure 9. Fitting a polynomial expression is y=0.0057*x^2-1.1272*x+186.86. This polynomial can be calculated Fine Particles concentration value at the date of the system if putting the monitoring results by this system. R-squared value is 0.9693, illustrate that the use of the system to monitor the number of particles between the official dates of the Fine Particles concentration values are highly positive linear correlation.

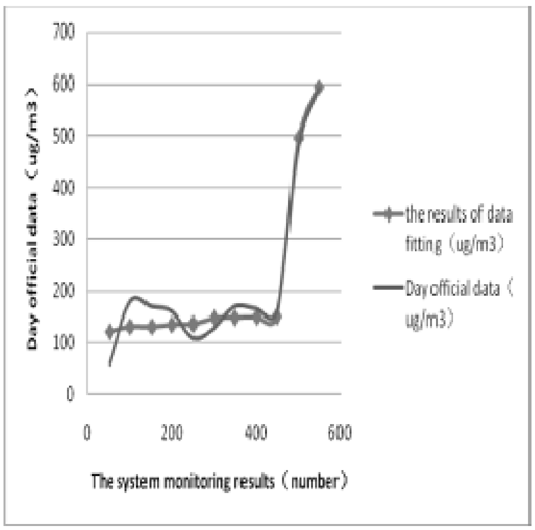

Figure 9 : The relation graph between the results of this monitoring system and the Official dates

TABLE 2 : Fitting error analysis results

date	The system monitoring results (number)	Day official data (ug/m^3)	the results of data fitting(ug/m$^{3)}$	error
2013-12-5	156	130	149.73	15.18%
2013-12-7	130	155	136.65	11.84%
2013-12-11	126	111	135.33	21.92%
2013-12-13	153	175	147.83	15.53%
2013-12-16	154	134	148.45	10.78%
2013-12-19	352	500	496.34	0.73%
2013-12-25	384	603	594.51	1.41%
2013-12-29	105	203	131.35	35.3%
2013-13-31	89	95	121.94	27.37%
2014-1-2	93	121	131.33	8.54%
2014-1-4	158	146	151.06	3.47%

To further illustrate the utility value of the system, the following results after fitting error analysis, the analysis results are shown in TABLE 2. As can be seen from the table, in addition to a very few days, the rest of the time the error remained within ten percent, the certain reliability description of the system has important reference value of Fine Particles monitoring.

CONCLUSIONS

This paper presents the overall design and operational details of Fine Particles monitoring methods. Realize of the hardware design and software platform design of the system and complete of the calculation of the total size and the particle image of the edge extraction and particle morphology, verify the accuracy of the analysis of the program by the accuracy of the correlation analysis of the program.

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