Two-Dimensional Wavelet Transform De-noising Algorithm in Collecting Intelligent Agriculture Image

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***Abstract*—The paper puts forward an image de-noising method based on 2D wavelet transform with the application of the method in agricultural data collection system. As the there are influences of various factors in the collection process through wireless image sensor network, the detail signals of each scale are obtained from multi-scale analysis to replace the original signals with smooth low-frequency signals by applying 2D wavelet transform in de-nosing the images collected. The experiment result shows that the application of 2D wavelet transform image de-noising algorithm can achieve good subjective and objective image quality and help to collect high quality data and analyze the images for the data center with optimum effects.**

***Index Terms*—agricultural image collection, de-noising, 2D wavelet transform, wireless sensor**

I. Introduction

With the development of the scientific technology and urbanization reform, the automation process of the agricultural production status concerns with the image collection, process, transmission, analysis and recognition. During image acquisition and transmission, digital images are always contaminated by noise. So it is necessary to remove noise before the images data is used or analyzed. While noise is suppressed, images are also distorted inevitably. In fact, image de-noising is a trade-off between noise suppression and the preservation of actual image discontinuities such as edges. Frequency domain image de-noising methods are popularly used because of simplicity.

Frequency domain filtering assume that Fourier coefficients of original image are mainly concentrated in lower frequency so noise is suppressed by remove the higher frequency coefficients using a low pass filter. Theoretically, if only few coefficients of images are high-magnitude and most coefficients are close to zero (the image is sparsely represented in the transform domain), the performance of transform domain de-noising methods would be better. But the sparsity of representation depends on both the transform and the original image's property. The great varieties in natural images makes impossible for any fixed transform to achieve good sparsity for all class of images.

For example, Two-Dimensional wavelet transform is effective in representing textures and smooth transitions of an image but would perform poorly for singularities such as image edges. The strength of the wavelet domain is that it sparsely represents classes of signals containing singularities and sharp transitions. So the de-noising has been a necessary process in the intelligent agricultural production. This paper also proposes the transformation of 256 image into gray scale image, binaryzation and normalization in the development of internet of things and image pre-process [1]. A new non-linear threshold function is presented to obtain the optimum effects on the basis of wavelet transform, and the function takes into account of both optimum threshold and the threshold function which are two de-noising factors [2]. An image thinning method is proposed in the process of binary image with the description of the algorithm of serial operation in the thinning method and the image thinning technology is applied in determining the regular and abnormal plant germ [3]. A 3D image processing method [4] for the internet of things is put forward to provide an atomized monitoring system [5] for the image information of crop pests on the basis of internet of things. The use of two-dimensional wavelet and wavelet packet technology can achieve the perfect compression and de-noising with liver image [6]. An approach of image de-noising in multi-wavelet domain based on particle swarm optimization was proposed [7]. To remove noises without blurring the image edge, an adaptive method for image

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de-noising with non-decimated wavelet and edge preservation is proposed [8], and a method for image de-noising with multi-scale edge detection and adaptive threshold is proposed. [9].

This paper uses the signals of each frequency range to reconstruct the image after the segmentation of the multi-scale signals with 2D wavelet transform with high similarity between the low frequency image and original image and the high-frequency range is the redundant noise part.

II. Images De-noising with 2D Wavelet Transform

The image processed with 2D wavelet transform is a 2D signal, for example, there is a gray scale $f(x,y)$ of image signal which is correspondent to a random point (x,y), the continuous changes of a point coordinates (x,y) will make a 2D signal $f(x,y)$. The 2D multi-wavelet transform can be achieved by two methods: one method is separation which uses two times of 1D multi-wavelet transform to obtain the 2D multi-wavelet transform, which takes the 2D multi-wavelet transform as a tensor product of 1D multi-wavelet transform; the other is the direct method, which directly applies the matrix filter to the 2D data to obtain 2D multi-wavelet transform. The 2D wavelet transform is widely used as the tool to process the signals and images for its local characteristics.

A. Image Noise

Noise can be understood as various factors which lead to the obstruction for human visual organs or sensors to receive image information for understanding or analysis. Noises are generally unpredictable random signals, which can only be recognized by the method of probability and statistics. Noises can influence each step of inputting, collecting and processing the images and the whole process of outputting the results. Therefore, the noise de-noising is always the main aim of a good image processing system, whether the analogue process or computer process is applied, the noises de-noising has been a critical step in the image processing. The model of noise image is built before the start of image de-noising, and the noises and signals can be divided into additive noise model and multiplicative noise model [10].

The additive noise model is to add a random noise to the original image.

$$g(x,y)=f(x,y)+N(x,y). \quad (1)$$

in this formula, $f(x,y)$ is the original image, $g(x,y)$ is a noise image, $N(x,y)$ represents noise. This kind of noise is irrelevant to the input image signal, for example, the regular electronic linear amplifier noise .

The multiplicative model, this kind of noise is relevant to the input image signal, and the relationship between the original image and the noise image can be represented as

$$g(x,y)=f(x,y)(1+N(x,y)). \quad (2)$$

The formula shows that the second item is noise which is directly influenced by the signal $f(x,y)$, and the bigger $f(x,y)$ is, the bigger the second item is, that is, the noise is modulated by signal, e.g. the Quantum noise and film grain noise increase with the amplification of the signals. The analysis and calculation of the multiplicative noise model are complicated, and the additive noise model can generally be used, when the change of signal is small and the second item is nearly the same. In most cases, the noise which influences the image is the additive noise and most of them are similar with the Gaussian noise.

B. The Basic Concept of 2D Multi-resolution Analysis

Let F and G be two linear space, and their funduses are $\{f_j\}_{j\in z}$ and $\{g_j\}_{j\in z}$. As linear space H whose fundus is $\{f_j g_l\}_{j,l\in z}$ is regarded as a tensor product space of F and G, we register as

$$H=F\otimes G. \quad (3)$$

The multi-resolution analysis of a 2D image is determined by the same wavelet function, scale function, approximation description space and detail description space, which is represented as

$$\{\phi(\mathrm{x}),\Psi(\mathrm{x}),\{\mathrm{V}_\mathrm{i}^2\}|_{\mathrm{i}\in\mathrm{z}},\{\mathrm{W}_\mathrm{j}^2\}|_{\mathrm{j}\in\mathrm{z}}\}. \quad (4)$$

The scale function [11] is

$$\Psi(x,y)=\psi(x)\psi(y). \quad (5)$$

And wavelet function is

$$\begin{cases}\varphi^1(x,y)=\psi(x)\varphi(y)\\ \varphi^2(x,y)=\varphi(x)\psi(y)\\ \varphi^3(x,y)=\varphi(x)\varphi(y)\end{cases}. \quad (6)$$

i.e.

$$\phi(x,y)=\{\varphi^n(x,y)\,|\,n=1,2,3\}. \quad (7)$$

Space $\{V_i^2\}$ is

$$V_{i-1}^2=V_{i-1}\times V_{i-1}=V_i^2+W_j^2. \quad (8)$$

Space $\{W_j^2\}$ is

$$W_j^2=(V^i\times W_j)+(W_j\times V_i)+(W_j\times W_j). \quad (9)$$

This formula shows the formula

$$\phi(x,y)=\{\varphi^n(x,y)\,|\,n=1,2,3\}. \quad (10)$$

And

$$W_j^2 = (V^i \times W_j) + (W_j \times V_i) + (W_j \times W_j). \quad (11)$$

is correspondent with each other. $\left|\varphi^1(\omega_1,\omega_2)\right|$ is big, when the point is at the low horizontal frequency ω_1 and the high vertical frequency ω_2. And $\left|\varphi^3(\omega_1,\omega_2)\right|$ is big, when the point is at high horizontal and vertical frequency ω_1 and ω_2.

C. A Fast Algorithm of 2D Wavelet Decomposition

$$\forall f(x,y) \in L^2(R^2). \quad (12)$$

define projection operator:

$$P_j\text{:}\ \ P_j f \to V_j. \quad (13)$$

$$Q_j\text{:}\ \ Q_j f \to W_j. \quad (14)$$

$$V_{j+1} = V_j \oplus W_j. \quad (15)$$

i.e. W_j is the orthogonal complement of V_j in V_{j+1} [12].

And

$$P_j f(x,y) = \sum_{k,l\in z} C_{j,kl}\phi_{j,kl}(x,y). \quad (16)$$

$$\phi_{j,kl}(x,y) = 2^j \phi(2^j x - k, 2^j y - l). \quad (17)$$

is the fundus of V_j. $C_{j,kl}$ can be represented as

$$C_{j,kl} = < f, \phi_{j,kl} >. \quad (18)$$

is the projection coefficient of f in $\phi_{j,kl}$, and

$$\Psi^{(1)}_{j,kl}(x,y) = 2^j \Psi^{(i)}(2^j x - k, 2^j y - l). \quad (19)$$

is the fundus of $W_j^{(i)}$. $d^{(i)}_{j,kl}\ (i = 1,2,3)$ can be registered as

$$d^{(i)}_{j,kl} = < f, \Psi^{(i)}_{j,kl} > . \quad (20)$$

is the projection coefficient of f in $W^{(i)}_{j,kl}$, and

$$Q_j^i f = \sum_{k,l\in z} d^{(i)}_{j,kl}\Psi^{(i)}_{j,kl}(x,y) = \sum_{k,l\in z} < f, \Psi^{(i)}_{j,kl} > \Psi^{(i)}_{j,kl}(x,y). \quad (21)$$

Thus we can get the 2D wavelet decomposition algorithm [13]:

$$C_{j,kl} = < f, \phi_{j,kl} >= 2\sum_{p,q\in z} \overline{h^x_{p-2k} h^y_{q-2l}} C_{j+1,pq}. \quad (22)$$

$$d^{(1)}_{j,kl} = < f, \Psi^{(1)}_{j,kl} >= 2\sum_{p,q\in z} \overline{h^x_{p-2k} g^y_{q-2l}} C_{j+1,pq}. \quad (23)$$

$$d^{(2)}_{j,kl} = < f, \Psi^{(2)}_{j,kl} >= 2\sum_{p,q\in z} \overline{g^x_{p-2k} h^y_{q-2l}} C_{j+1,pq}. \quad (24)$$

$$d^{(3)}_{j,kl} = < f, \Psi^{(3)}_{j,kl} >= 2\sum_{p,q\in z} \overline{g^x_{p-2k} g^y_{q-2l}} C_{j+1,pq}. \quad (25)$$

i.e.

$$\begin{cases} C_{j,kl} = \sum_{p,q} h^x_{p-2k} h^y_{q-2l} C_{j+1,pq} \\ d^{(1)}_{j,kl} = \sum_{p,q\in z} \overline{h^x_{p-2k} g^y_{q-2l}} C_{j+1,pq} \\ d^{(2)}_{j,kl} = \sum_{p,q\in z} \overline{g^x_{p-2k} h^y_{q-2l}} C_{j+1,pq} \\ d^{(3)}_{j,kl} = \sum_{p,q\in z} \overline{g^x_{p-2k} g^y_{q-2l}} C_{j+1,pq} \end{cases}. \quad (26)$$

After adding constraint conditions, 2D wavelet decomposition algorithm can be registered as [14]:

$$\begin{cases} C_{j,kl} = \beta\sum_{p,q} h^x_{p-2k} h^y_{q-2l} C_{j+1,pq} \\ d^{(1)}_{j,kl} = \beta\sum_{p,q\in z} \overline{h^x_{p-2k} g^y_{q-2l}} C_{j+1,pq} \\ d^{(2)}_{j,kl} = \beta\sum_{p,q\in z} \overline{g^x_{p-2k} h^y_{q-2l}} C_{j+1,pq} \\ d^{(3)}_{j,kl} = \beta\sum_{p,q\in z} \overline{g^x_{p-2k} g^y_{q-2l}} C_{j+1,pq} \end{cases}. \quad (27)$$

The correct constraint conditions of 2D wavelet transform are:

$$\beta = 2. \quad (28)$$

$$\sum_{k\in z} h_k = 1. \quad (29)$$

$$\beta = \frac{1}{2}. \quad (30)$$

$$\sum_{k\in z} h_k = 2. \quad (31)$$

$$\beta = 1. \quad (32)$$

$$\sum_{k\in z} h_k = \sqrt{2}. \quad (33)$$

D. A Fast Algorithm of 2D Wavelet Reconstruction

It's easy to get reconstruction formula from the process of decomposition [15]. So we can make a use of the orthogonal decomposition

$$P_{j+1} f = P_j f + \sum_{i=1}^{3} Q_j^i f \,. \qquad (34)$$

$$C_{j+1,kl} = < P_{j+1} f, \phi_{j+1,kl} >$$
$$= < P_j f + \sum_{i=1}^{3} Q_j^i f, \phi_{j+1,kl} > . \qquad (35)$$

Finally, we can get a fast algorithm of 2D wavelet reconstruction [16]:

$$C_{j+1,kl} = \sum_{m,n \in z} C_{j,mn} h_{k-2m}^{x} h_{l-2n}^{y} + \sum_{m,n \in z} d_{j,nm}^{(1)} h_{k-2m}^{x} g_{l-2n}^{y} +$$
$$\sum_{m,n \in z} d_{j,nm}^{(2)} g_{k-2m}^{x} h_{l-2n}^{y} + \sum_{m,n \in z} d_{j,nm}^{(3)} g_{k-2m}^{x} g_{l-2n}^{y} \,. \qquad (36)$$

In order to facilitate the formulation, $C_{j,kl}$, $d_{j,kl}^{(1)}$, $d_{j,kl}^{(2)}$, $d_{j,kl}^{(3)}$ can be expressed as A, $D_3^2 f$, $D_3^1 f$, $D_3^3 f$. Among them, A is the low frequency component, and D can be taken as the high frequency component in directions of horizontal, vertical and opposite angle, so the wavelet segmentation of 2D signals can be expressed as Figure 1.

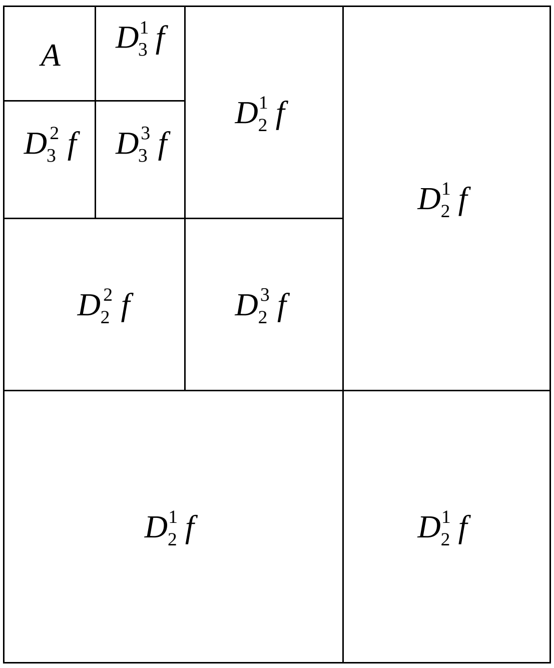


Figure 1 Structure diagram of 2D Wavelet Transform

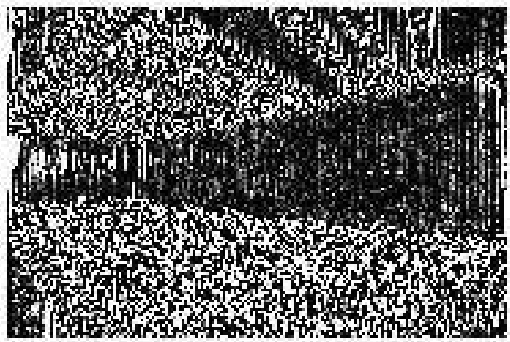
The result of the wavelet transform is to decompose the image into four sub-images. Figure 1 is the image produced in three-time transformations of the wavelet. In which the sub-images at the same decomposition level are called the same scale sub-images (in different directions). The sub-images at different decomposition level whose frequency range transform proportionally are called the same direction sub-images. This is because they correspond to the same direction texture and edge structure as the original image. It can be seen through direct observation that there is strong geometric similarity among these sub-images, especially those in the same direction. Moreover, these sub-images are also similar to the original image.

The emulation experiment is carried out with the wavelet segmentation of multi-scale 2D signals for the images of the growing state in agricultural warm house, and a random 2D color image is taken as the object to be analyzed with sym8 wavelet to conduct the 3 scale 2D signal wavelet segmentation. The experiment results are shown in figure 2.

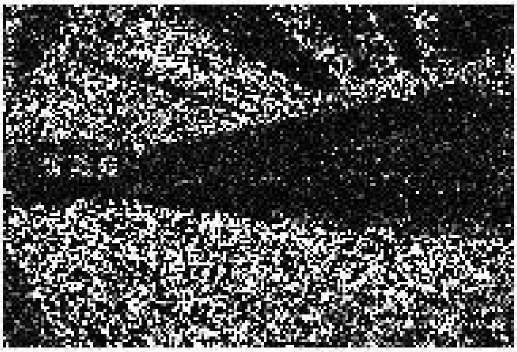
Figure 2 clearly shows the images produced in the reconstruction of the signals in various frequency ranges after the segmentation of dual wavelet. It can be noticed that the low frequency image is very approximate with the original image, and the high frequency range may also be taken as the redundant noise. After passing through two conjugate filters, the signal of the original image obtains both the high frequency range signal and the low frequency range one.

(a) Low frequency signal smoothing

(b) Horizontal high frequency signals



(c) Vertical high frequency signals



(d) Diagonal high frequency signals

Figure 2 Two Scale 2D Wavelet Transform of Warm House Image

Assuming that the original signal is extracted 256 points involved in the calculation, we will get 512 frequency data, and it is apparently redundant too much. Therefore, after filtering, further sampling is necessary in order to reduce redundancy. The prevailing method is to discard a number every other number, thus to ensure the same length of the data between the original signal and the two signals after filtering.

III. Intelligent Agriculture System

In the process of modern agriculture production operations, the parameters which affect the crop growth are managed to meet the requirements of refined management with the labor force liberated and the labor costs decreased continuously, and the advanced agriculture technology will be promoted widely. Agriculture Intelligent is a high new technology which applies the artificial intelligence technology in agricultural areas. Intelligent agricultural system covers the influence from agricultural production natural parameters of the acquisition, to utilize the knowledge reasoning and computer technology in parameter analysis. Finally, through the agricultural expert system guide in the whole production management chain of agricultural production, agriculture Intelligent is mainly involved in image acquisition technology, image processing technology, image analysis and image recognition technology, etc.

A. System Features

Intelligent agricultural system is essentially the automatic control system, a closed loop control system, which has the following two properties [17].

- feedback control

To control the system stably and reliably, and automate the key technology, intelligent agricultural system, in the system structure, also must be feedback control system, and be negative feedback control system, formed closed loop control. From processing agricultural parameters of the acquisition to the MCU control, it should form a negative feedback loop system, or will lose the characteristics of intelligence and the automatic control characteristic.

- Independent control

The core control system has adaptive adjustment ability, including self-learning abilities and self-setting abilities. Agricultural system itself is a nonlinear system and there are no rules in its external disturbance and inner disturbance while in establishing these irregular parameters to realize control system, independent control ability will be needed to deal with nonlinear data in real time.

B. System Design

In order to have a remote-guide and real-time monitoring role on agricultural production, intelligent agricultural system will have to monitor and control the influential factors of main agricultural production. The system mainly based on wireless sensor technology, wireless communication technology and computer processing technology to realize its function.

Based on wireless sensor to collect different influential factors of the signal after preliminary treatment and data analysis and management through computers, it will surely construct preliminary perfect expert’s data platform which can benefit the agricultural production. Meanwhile, a set of complete slave computer management system will still be needed for adjusting the factors that are not suitable for agricultural crop growth, realizing the adjustment and perfection of the monitored parameters. The whole component composition diagram of intelligent agriculture monitoring and controlling system is shown in Figure 3 at the end of the paper.

The sensor used by the intelligent agricultural system needs to meet the requirement of agricultural production and achieve real-time acquisition and processing of the data. In this paper the real-time noise reduction of agricultural image data makes the wireless module to transmit data with high precision and small capacity and the effect is significant in the practical application of the process. Wireless communication is used for the communication part, the open space of the agricultural base provides convenience for the realization of wireless communication while wired communication will bring an impact on agricultural production. M2M sink mode as the focal point of all parameters uses 32-bit ARM processor and a TINYOS operating system which is more stable to manage the resources. A PC host computer monitoring and management system is realized by using the current newer Silver light component.

IV. Simulation Experiment Results And Discussion

Dimensional wavelet transform is to divide the image into low and high frequency parts. The low frequency part corresponds to the approximation of the image with the energy of the original image signal; the high frequency part corresponds to the details of it. Therefore using the wavelet decomposition to remove high frequency part of it directly and only using the low frequency part to reconstruct is the most direct kind of image noise reduction method. Of course not all the high frequency part is noise so we generally use a threshold judgment, and the high frequency coefficients that are lower than the threshold are all noise and should be discarded. For image noise production the threshold equals to $s \times \sqrt{2} \times \lg^{n}$. *S* is the level of the noise and *n* is the number of pixels of the image matrix

Simulation experiments complete the image noise reduction and automatic noise reduction for the input RMB plant growth image with the two-dimensional wavelet transform method and gain high frequency threshold. The percentage and result of noise reduction is tested with sym8 small wave and a threshold =2 for ten images, the results are shown in Figure 4.

(a) Original image with noise

(b) Image after de-noising

Figure 4 Wavelet decomposition noise reduction results in intelligent warm-house image

V. CONCLUSIONS

The paper proceeds noise reduction for the noise image of collecting the intelligent agricultural image and compares the noise reduction algorithm with experiments.

Through the comparison of parameters of the percentage of high frequency coefficients setting to zero and the percentage of energy after the noise reduction, image size and the threshold of noise reduction image, the comparison experiment result of two-dimensional wavelet transform noise production of agricultural image is shown in Table I.

TABLE I.

THE COMPARASION EXPERIMENT RESULT OF TWO-DIMENSIONAL WAVELET TRANSFORM NOISE PRODUCTION OF AGRICULTURAL IMAGE

No	Original image (kb)	De-noising image (kb)	The percentage of high frequency coefficients (%)	Percentage of energy after the noise reduction (%)	Quantization noise reduction after threshold
1	171	27.6	80.3845	99.3005	0.0630
2	35.2	15.4	88.0989	97.9614	0.2156
3	214	75.2	86.9829	98.3439	0.1233
4	58.9	33.5	88.9918	97.5629	0.1945
5	196	20.4	90.1848	98.2943	0.1909
6	89.7	40.7	90.8376	97.2728	0.2856
7	134	26	90.2702	98.9397	0.1491
8	68.3	25.3	88.6834	99.2612	0.1332
9	41	26.2	88.3705	98.9657	0.1483
10	21.7	17.6	88.8678	97.4387	0.1929

From the result we know the way used in the passage is effective.

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REFERENCES

[1] S. l. Yang, "Image Preprocessing and Feature Extraction in Networking Smart Home System," *Public Communication of Science & Technology*, vol. 23, pp. 233-234, July 2011.
[2] Y. Q. Liang, Z. M. Li and J. Sun, "Application of a New Method of Wavelet Image De-noising in Agriculture Picking," *Journal of Anhui Agricultural Sciences*, Vol. 38, no. 4, pp. 2061-2063, Oct. 2010.
[3] Z. L. Xun, Y. Chen, G. Q. Yang and X. C. Zhu, "An image thinning Algorithm and its application to agriculture image," *Journal of Shandong Agricultural University* (*Natural Science Edition*), vol. 35, no. 3, pp. 446-450, Sep. 2004.
[4] R. Z. Liu, Z. D. Yan and W. M. Yin. "3D Image Processing Method on Internet of Things," *China Patent CN102122239A*, July 13, 2011.
[5] M. M. Xiao and Y. Liu, "On the Automatic Monitoring System of the Networking Crop Pests Image Information," *China Patent CN101938512A*, January 5, 2011.
[6] L. P. Gai, L. L. Tan, J. L. Wu, X. D. Ding, Y. X. Chen, L. Wang, F. B. Sun and G. L. Wang, "Two-dimensional wavelet versus wavelet packet technology in de-noising processing at different compression modes," *Journal of Clinical Rehabilitative Tissue Engineering Research*, vol. 14, no. 39, pp. 7336-7339, September 2010.
[7] J. X. Li, J. H. Lin, C. Q. Yin and W. Jin, "Image De-noising in Multi-wavelet Domain Based on Particle Swarm Optimization," *Opto-Electronic Engineering*, vol. 38, no.11, pp. 119-123, Nov. 2011.
[8] Z. G. Zhao, C. H. Guan and H. X. Lv, "Non-decimated Wavelet Image Adaptive De-noising with Edge Preservation," *Journal of Optoelectronics ·Laser*, vol. 18, no. 11, pp. 1374-1377, Nov. 2007.
[9] Z. G. Zhao and C. H. Guan, "Wavelet image de-noising based on Multi-scale edge detection and adaptive threshold," *Chinese Journal of Scientific Instrument*, vol. 28, no. 2, pp. 288-292, Feb. 2007.
[10] Y. Zhou, J. D. Zhao and M. Kong, "Image De-noising Based on Wavelet," *Journal of West Anhui University*, vol. 23, no. 5, pp. 51-53, Oct. 2007.
[11] L. N. Wang and H. G. Zhang, "The application and technique of information concealing," Wuhan, China: *Wuhan University Press*, pp. 95-96, Oct. 2003.

[12] A. Cohen, I. Daubechies, O. Guleryuz and M. Orchard. On the importance of combining wavelet-based non-linear approximation with coding strategies. Submitted to *IEEE Trans. Info. Theory*, 1999.
[13] N. Delprat, B. Escudié, P. Guillemain, R. Kronland-Martinet, P. Tchamitchian and B. Torrésani. Asymptotic wavelet and Gabor analysis: extraction of instantaneous frequencies. *IEEE Trans. Info. Theory*, vol. 38, no. 2, pp. 644-664, March 1992.
[14] P. P. Vaidyanathan and P. Q. Hoang. Lattice structures for optimal design and robust implementation of two-channel perfect reconstruction filter banks. IEEE Trans. Acoust., Speech, and Signal Proc., vol. 36, no. 1, pp. 81-94, January 1988.
[15] R. Gribonval, P. Depalle, X. Rodet, E. Bacry and S. Mallat. Sound signals decomposition using a high resolution matching pursuit. *In Proc. Int. Computer Music Conf.* (ICMC'96), pp. 293-296, August 1996.
[16] G. W. Wornell and A. V. Oppenheim. Wavelet-based representations for a class of self-similar signals with application to fractal modulation. *IEEE Trans. Info*. Theory, vol. 38, no. 2, pp. 785-800, March 1992.
[17] S. H. Li and C. H. Xiao, "Discussion on the Intelligent Agriculture System Based on the Internet of Things," *Science Mosaic*, vol. 21, no. 7, pp. 73-75, 2011.

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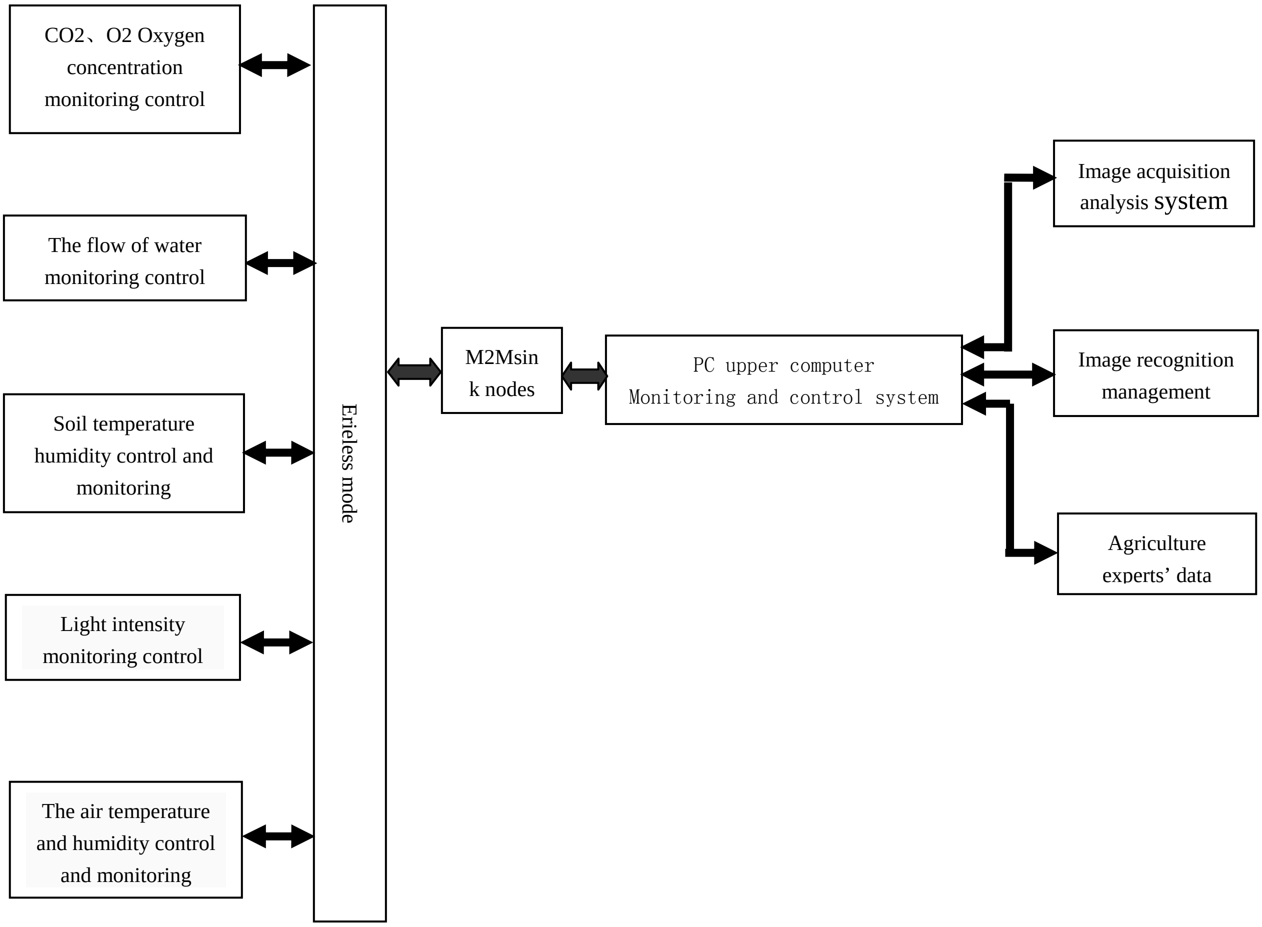

Figure 3 Intelligent Agricultural System