International Journal of Future Generation Communication and Networking
Vol.6, No.5 (2013), pp.65-72
http://dx.doi.org/10.14257/ijfgcn.2013.6.5.07

Distribution Center Calculation for Metrology Data Collected from Wireless Sensor Network

Huang Junhui[1] and Ding Zuchun[2]
Guandong AIB College, Guangzhou, China
[1]JhHuang@gdaib.edu.cn, [2]zucding@tom.com

Abstract

This paper proposes a useful algorithm to count the metrological parameter center in wireless sensor network. By setting assigned threshold in Mean shift iteration, this algorithm lessens the computation load and can control the center points to be extracted. Experiments verify the efficient center finding algorithm and the control factors in center finding. This algorithm can be extended to more wide range for application. Because the mean shift is robust in convergence, the WSNs is utilized in many metrological area, the algorithm can be used widely in these domains. For the stability of image data, we use color space transform to decrease the illumination influence.

Keywords: *wireless sensor network; mean shift; metrology data; color space*

1. Introduction

In the supervision of metrology parameters, such as humidity, local temperature, and in some cases insect and worm distribution, the sensor network have its advantage of easy to deploy, fast to transfer information, low energy consumption. When the information of each sensor is transferred to the center control, the most important transaction is to compute the distribution feature of relative information. The statistics algorithms of today usually depend on the decision of people according to their experiences.

Sensor network has its generality nowadays, and the security of wireless sensor network becomes more and more important [1-3]. ERMAN proposes a method to guarantee the confidentiality, authenticity and availability in WSNs despite of the limitation of resources [1]. For the effective information and communication, ANDREAS etc. propose an effective pSPIEL [4], which is data-driven, polynomial algorithm to construct efficient location selection.

The center of WSNs is the information transferred in networks. In metrology, the key work is to acquire the distribution of such data.

In this paper, we will introduce an automatic algorithm to find the center of the metrology information to compute the contour line of parameters. Section II introduces the theory of mean shift algorithm, which is used in image signal processing, Section III introduces the feature of sensor networks, Section IV proposes the method to calculate the distribution of metrology information, and Section V gives the experiment and result to validate the effect of our algorithm.

2. Feature Extraction using Mean Shift

Because the data of metrology is always numerous, the center is the most important area of the information retrieved by sensors. Figure 1 and Figure 2 is the pictures of cloud cluster. In fact the information can be gathered by different wireless sensors. This information will

ISSN: 2233-7857 IJFGCN

update by time. The difference of the two figures is mainly that the observing directions are not the same, one from above and another from beside.

We can see the information has its feature that the center has the greatest gradient than the other place does.

To extract the center place in metrological graphs, we use Mean Shift [5-7] to extract the center position, where there will be the most important information because there will be the most serious rain, wind or other information, the iteration will converge to the local maxim point. This is also an advantage because in some cases, the global maxima are not the only position interested by researchers.

We design a descriptor to depict the data distribution as Eq.1.

$$\mathrm{D}(x,\mathrm{y}) = \begin{cases} p, p \geq thr \\ 0, else \end{cases} \tag{1}$$

The *D(x,y)* is the strength pitch of the sensor data gathered. To lessen the influence of noise, tiny data that is less than threshold *thr* will be ignored. This preprocess will accelerate the procedure to converge to the data center.

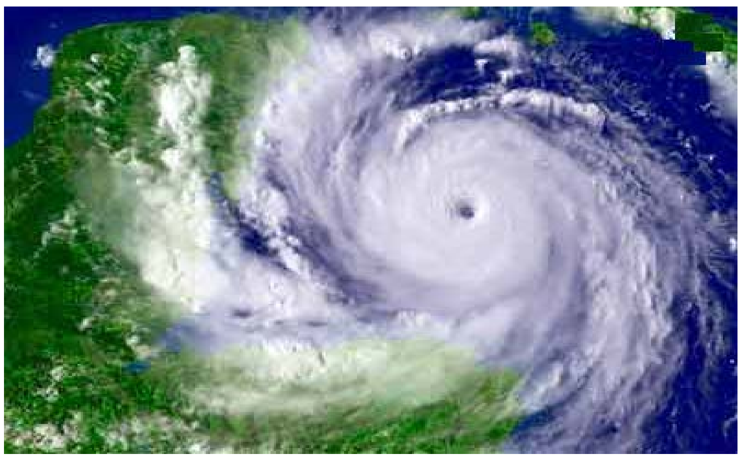

Figure 1. Metrology Information Graph from above

Figure 2. Metrology Information Graph from beside

To decrease spurious noise, in preprocess, Gaussian filter is utilized to de-noise. When we use mean shift to extract the pitch center of the gathered information, the tilt of distribution will not influence the center finding process because from different direction the density of data distribution is the same.

Gaussian kernel is more suitable for metrology data in Mean Shift iteration, which is shown as Eq. 2.

$$K(v) = c\exp(-\frac{1}{2}\|v\|^2) \tag{2}$$

Here, c is a constant and v is the variety to be processed, in this case pitch of metrology data delivered by sensors.

In the space spanned by metrology parameter, the mean is calculated by computing one step deviation iteratively until it converges to a threshold. This deviation can be expressed by Eq.3.

$$m(x) = \frac{\sum_{i=i}^{n} x_i g(\left\|\frac{x-x_i}{w}\right\|^2)}{\sum_{i=i}^{n} g(\left\|\frac{x-x_i}{w}\right\|^2)} - x \geq threshold \tag{3}$$

Here x is the parameter of metrology information. x_i is pitch of points corresponding to specified sensors which is located in the region of the window with width w. The function m(x) is the deviation of the current position of parameter density, the first item of the right side is the current position in iteration. When the deviation is low than the assigned threshold, the iteration stops.

Because there are many center points in a metrology parameter distribution data in some cases, the start point should be selected randomly guarantee the center points is extracted in every side. The center number can be controlled by setting $threshold$

3. Experiment and Analysis

We use the metrology temperature graph center finding progress as an example of this algorithm.

Because the original metrology graph has noise, which will influence the color gradients in mean shift, we will perform a low pass filtering before the gradients are computed.

We use the average filtering model in Eq.4 to denoise the Metrology temperature graph. This can lessen the influence of noise effectively.

$$A = \frac{1}{9}\begin{pmatrix} 1 & 1 & 1 \\ 1 & 1 & 1 \\ 1 & 1 & 1 \end{pmatrix} \tag{4}$$

This average filtering is very useful to salt and pepper noise, which may produce local false position maxima.

To form the temperature gradients, we enumerate the colors according to their color degree. The color is divided into 5 colors, *i.e.*, cyan, blue, green, yellow and red indicating the temperature degree of 1 to 5. The sequence is also the direction from low temperature to the higher one. The density of each widow is calculated in a fixed widow. In our experiment, this window size is 200 x 200.

The block diagram of our algorithm is depicted in Figure 3. The preprocessing is also included in this figure.

In this example, although we display the temperature graph according to their color temperature, in fact, because this graph is only the illustration of the data gathered, the algorithm will not be influenced by the color sequence utilized. The colors are persudocolor, which make the center finding process can be executed by image processing.

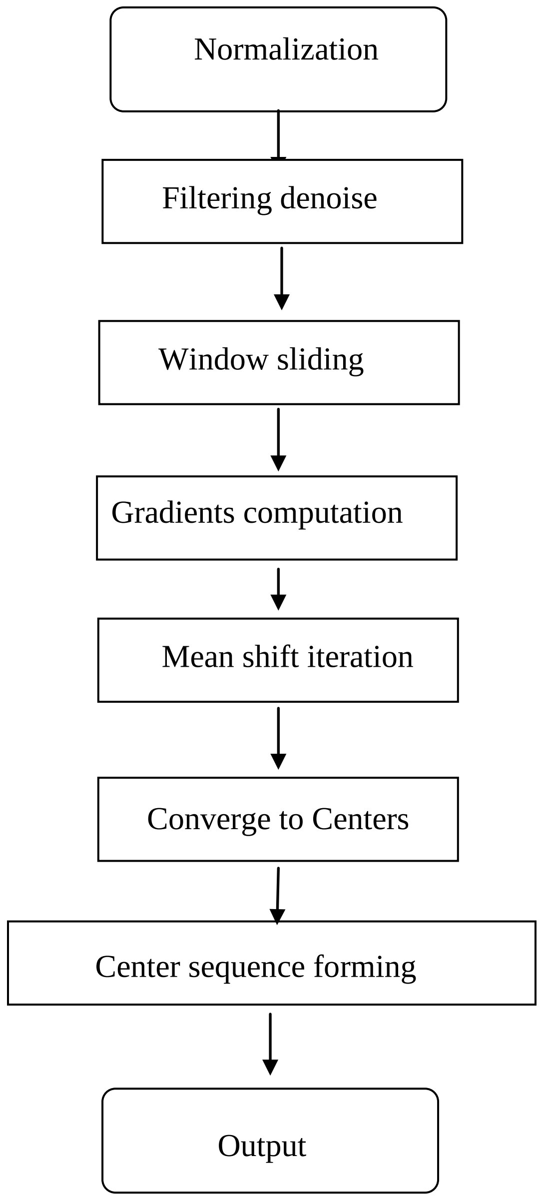

Figure 3. Metrology Distribution Center Finding Block Diagram

Because the number of the centers in a graph may be more than one, many local maxima position may exist in a single graph to express the multicenter phenomenon of the observed territory. To avoid the loss of some maxima, the beginning points are set evenly in the metrology graph. When all the local maxima are detected, the values in these points are ordered according descend sequence. The first one is the center point in this graph. This process can be expressed by Figure 4.

To verify this algorithm, a data distribution is illustrated by Figure 5, and the colors are used to express the temperature in this data distribution graph. After iteration, the iteration stops at each black spot, which indicates the local high temperature position.

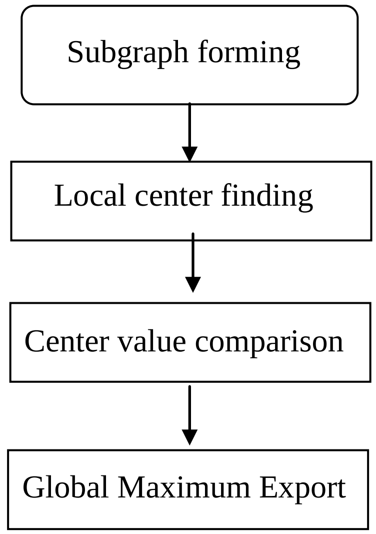

Figure 4. Local Center Finding Block Diagram

The graph is normalized to guarantee the image has the same size to be treated with. An image is resized to the solution 1000x 3000. The interpolation utilized the neighbor weighting method to make the image more continuous.

Each iteration process is conducted in each window, namely subgraph. In general, only the first several maxima are the position we searched for, as the black dots depicted in Figure 5.

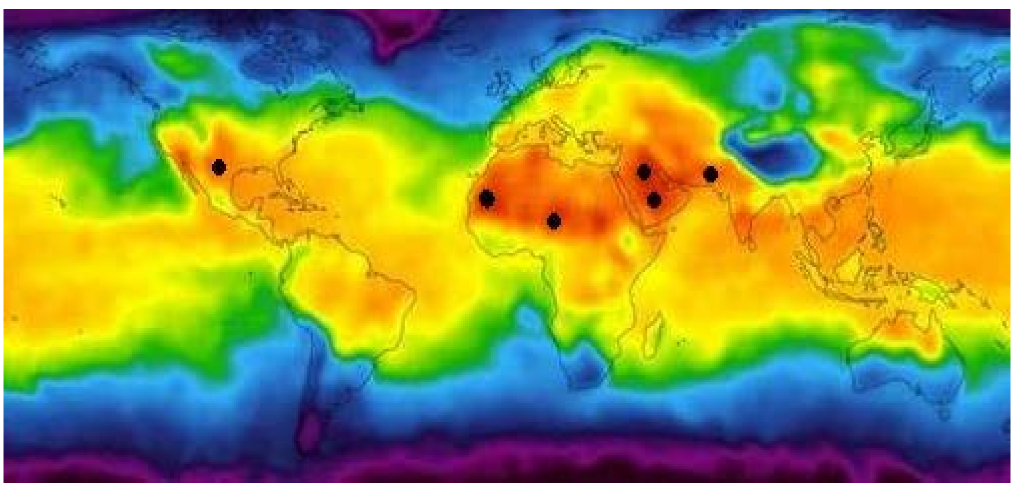

Figure 5. Metrology Temperature Graph Center Finding

In this experiment, some local maximal points are ignored when the pitch value is less than 2/3 of the total maximal values to extract the center interested by us.

By this means, we can find more local centers when we decrease the limitation when which is bigger than the pitch of the center point, this point is ignored.

When iteration begins, the start points are selected evenly in this distribution graph by split this pictures into 200x200 cells, and the iteration points are selected at the cross points of cell border lines. The aim of this is to decrease the iteration load in center finding.

We can find from Figure 5 that the algorithm find the local centers above assigned threshold, except the point at the right side of the third spot counted from left. This is because the iteration is not computed from every point of this figure but from the assigned points in the cross place of cell borders. The shortcoming can be decreased when the cells become less.

In some cases, the original metrology data are not easy to get, we can directly analyze the graph data. For pictures get in this case, more attention should be paid to ensure the brightness which will not impact the pictures. In this case, in preprocess, we should change the color space from RGB to YCbCr space, because the later one are more stable to illumination. These can be illustrated by Figure 6 to Figure 8. In YCbCr space, we can also ignore the component Y to decrease the computation load.

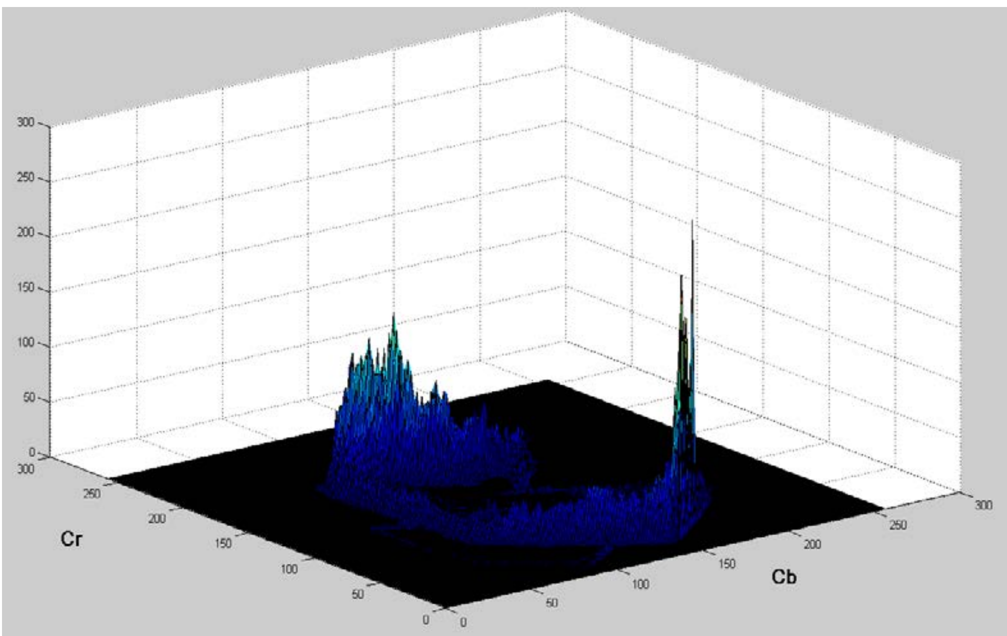

Figure 6. Cr and Cb Component in the Metrology Temperature Graph

The transform from RGB space to YCbCr can be expressed by Eq.5

$$YCbCr:\begin{cases} Y = 0.299R + 0.587G + 0.114B \\ Cb = 0.56(B - Y) = -0.169R - 0.331G + 0.5B \\ Cr = 0.71(R - Y) = 0.5R - 0.419G - 0.081B \end{cases} \quad (5)$$

From Figure 6 we can also find that the graph is plenty of Cb components. This can indicate that the temperature is higher in this graph in statistics.

From Figure 7 we find a peak in the Cb and Cr distribution graph. It's because that the number of white pixels in this image is numerous, so in the position around (cb, cr) = (100,100), the number of same characteristics can approach about 10000.

As Figure 7, from Figure 8 we find a peak in the Cb and Cr distribution graph. It's also because that the number of white pixels in this image is numerous, so in the position around (100,100), the number of same characteristics can approach about 30000.

The number of pixels in Z axis is summed according to the original image, not computed by resized images.

4. Conclusions

This experiment shows that the algorithm is effective when it's utilized to process temperature data. In fact, for other metrology data, this algorithm is also useful.

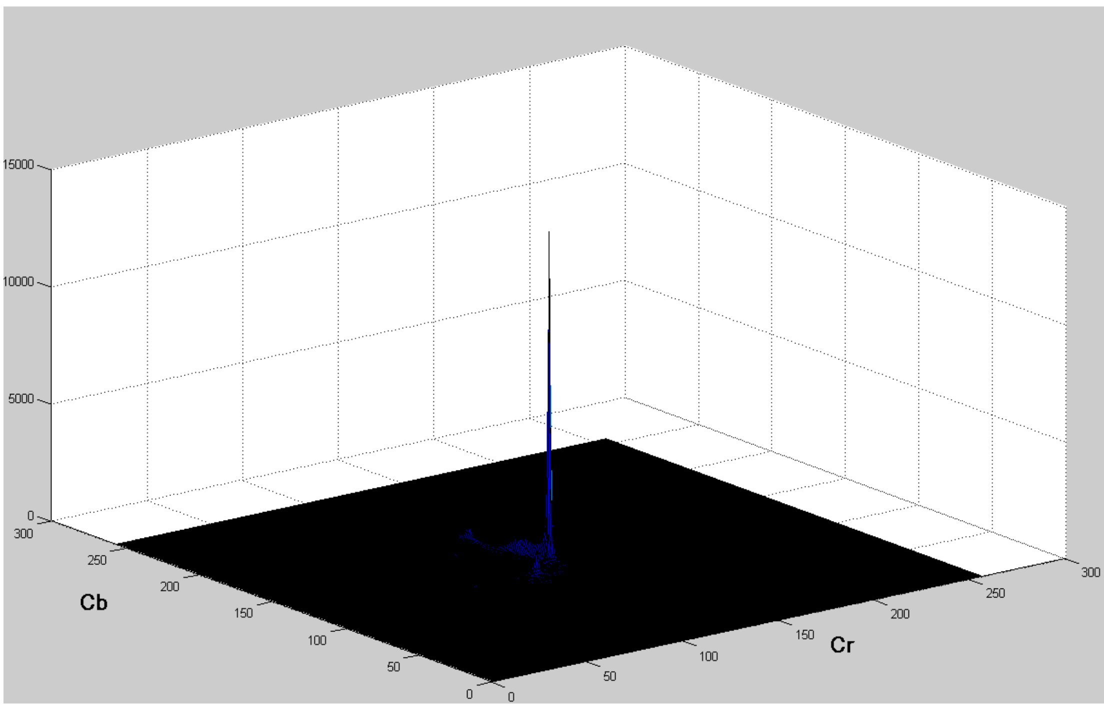

Figure 7. Cr and Cb Component in the Metrology Graph Figure 1

The data center finding algorithm in this paper can be extended to a more wide range such as insect prevention, disease distribution statistics, earth pitch distribution measurement and soil contamination survey *etc*, where the data gathered by WSNs are collected to process totally. In these cases, all the data is transformed to be processed by threshold setting and center finding to get the densest of the distributed measured data.

Metrology data have the feature that the quantity is numerous, the change is violent, therefore many data are illustrated by psuodocolors is a good choice. By mean shift, we can compute the local center and eventually the global maximum to find the center point visibly. In this process, we change the analysis procedure of metrological or WSNs data from pure digitals to the image clustering analysis.

This method can also be extended to other kind data gathered by WSNs network. In the environment monitoring, a large number of data is gathered by different sensors, if we cope with these data traditionally, the shortcomings of complicity and huge amount are difficult for us to solve. If we use the algorithm above, we can express the problem by graph and find the key positions, where the problems may be the most serious. In this meaning, original sensor data treatment is transformed to image center finding.

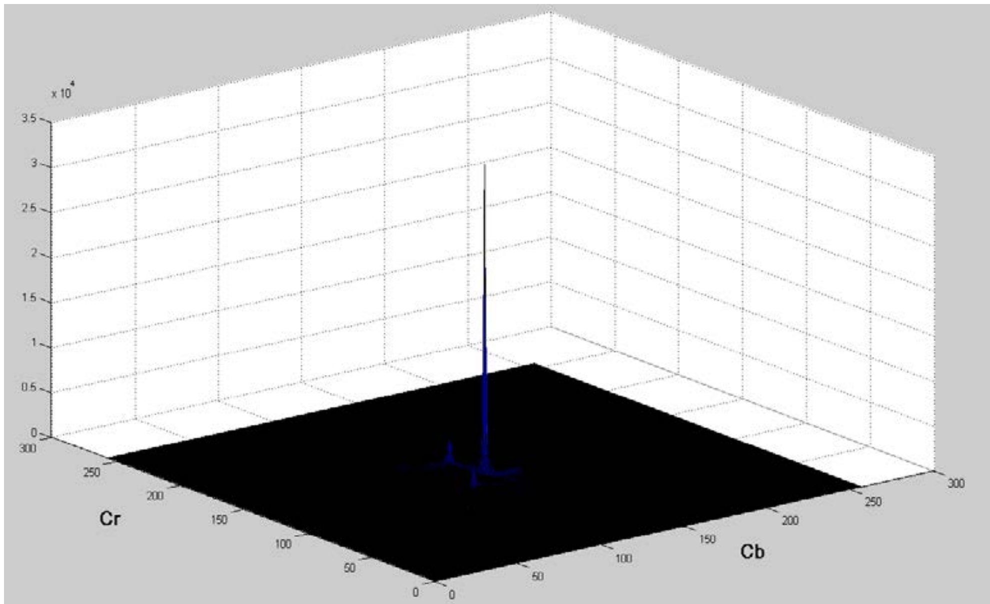

Figure 8. Cr and Cb Component in the Metrology Graph Figure 2

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Author

Jun huihuang, associate professor, was borned in May,1969. He got the Master degree on the domain of telecommunication in South China University of Techonoty for him. Now he is devoted to communication network and signal processing research.