УДК 004.89

A.S. Chupryna, Ogunniyi Oreoluwa

Kharkov national university of radioelectronics, Kharkov

MODELS AND METHODS FOR HEAT LOSS EVALUATION

The strategy of this work is to develop models, methods and software for heat loss evaluation. Firstly its necessary to compare different methods of segmentation and then create optimal method. Threshold segmentation method for brightness (corresponding to a certain temperature range in advance) and wave method for combining the pixels in the connected sets were proposed. On the basis of development model and method create an application whereby the system will evaluate the heat loss of a building. The system will be based on a personal computer, THERMO program use photos from infrared camera, which help to capture the infrared images of the wall.

Keywords: *quality evaluation, segmentation, metrization, anymals embryos, error, shape.*

Introduction

Heat Loss is the transfer of heat from inside to outside by means of conduction, convection, and radiation through all surfaces of a building. It may be useful to first start off by explaining the word heat and its meaning. Heat, for all practical purposes, is a form of energy. Like other forms of energy, e.g., mechanical, electrical, chemical, etc., heat energy obeys two laws of thermodynamics. The first law, entitled the First Law of Thermodynamics, simply states that energy is a conserved quantity. It may be transformed from one form to another, but it can neither be created nor destroyed. Another important physical law is the Second Law of Thermodynamics. Here, heat will always flow from a given region to another region of lower temperature. So for example, when one wants to heat an enclosure some of the heat will flow out toward colder regions. Another aspect is that when energy is transformed from one form to another, (when heat is involved), it changes in such a way that the amount of work that can be obtained from it decreases [1]. An example here would be the heat loss in a building where the house wall with a temperature is lower than the set. The flow of heat through a surface or object depends on the temperature on each side of the surface. No material can completely stop this transfer of energy which may be by one or several heat loss mechanisms [2]. In essence, the flow of heat depends on the temperature difference. Also, the amount of heat which passes through a given surface should be proportional to the time of flow. Heat can be lost in a variety of ways. The movement of heat energy into or out of a building takes place by one or more heat transfer processes: conduction, convection, radiation and evaporation.

Image segmentation is the first step in image analysis and pattern recognition. It is a critical and essential component of image analysis and pattern recognition system, is one of the most difficult tasks in image processing, and determines the quality of the final result of analysis. Image segmentation is a process of dividing an image into different regions such that each region is, but the union of any two adjacent regions is not, homogeneous.

Statement of the problem

The goal is to develop models, methods and software for heat loss evaluation. Active systems are easier for segmentation of the abnormal areas in an infrared image of a building. The main task of image segmentation is to partition an image into a set of disjoint regions with uniform and homogeneous attributes such as intensity, color, tone or texture. The purpose is to develop a system that would extract the abnormal areas in an infrared image of a building to detect heat loss from the building.

Model for heat loss evaluation

For effective monitoring of thermography in a wide sense, is a very urgent task of developing and putting into practice not only the techniques of termografhy and visual analysis of thermal images obtained at the qualitative level, but also specialized software for purposes of automating the processing of thermograms obtained from given speed and accuracy. Virtually all modern thermal imagers let you program in digital form. Therefore, it is advisable to automate the process of analyzing thermal images using the apparatus of the theory of pattern recognition [3], used for segmentation and identification of objects in the thermograms of their thermal radiation, thus providing an opportunity to obtain estimates of the characteristics of objects with high accuracy in real-time.

Initial photos of a building in infrared spectrum are taken via camera IRTIS-2000. The operation principle of this camera is based on scanning of thermal radiation in a field of view of a camera by an optic-mechanical scanner and single-element high repeatable IR-receiver with transformation of this radiation into an electrical signal by the analog-digital converter. The camera has mirror-lens optics with a small number of reflecting surfaces, which minimizes losses of the optical system and simplifies its adjustment. This makes it possible to obtain a high repeatability of the geometry of successive frames and uniform sensitivity over the entire frame field [4].

The basic model of the camera is provided with an IR-receiver cooled by liquid nitrogen. This ensures a high sensitivity of the camera (better than 0.05° C) even when the camera operates at low temperatures in the 3 – 5 microns range, allows the parameters of the IR-receiver to be stabilized regardless of the ambient temperature, and provides for accurate measurement of absolute temperatures. On request the camera may be provided with an IR-receiver with thermoelectric cooling [5]. The interface unit of the device is mounted inside the IR-scanner and can be connected to any computer (notebook) through a parallel printer port without any supplementary equipment, what makes higher effectiveness and obtains a market improvement of system and makes it possible to upgrade the device (if a new computer elaboration and programs will be made). The experience which we have gained during many years of research in the field of thermography indicates that for most practical applications it is enough to scan the frame because thermal processes of objects under investigation occur at much lower speed. The real-time which determines the operating speed of the system depends not only on frame scanning speed but also on the time required to display and analyze the information and record the thermograms.

Example of the photo, which was done with help of camera IRTIS-2000, shown on the fig. 1.

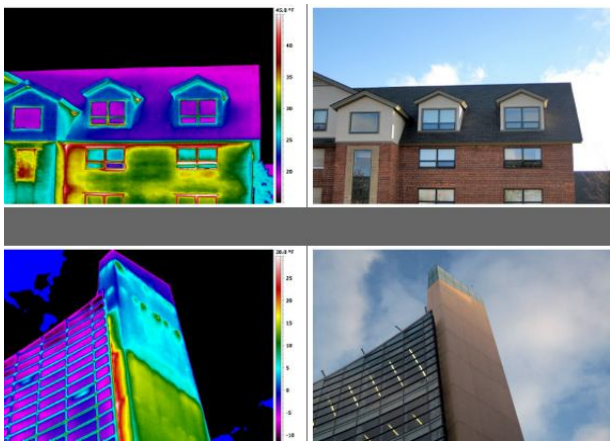

Fig. 1. Building in thermal imaging

Method for heat loss evaluation

Isolation of temperature zones in which we are interesting in the picture was done using threshold segmentation method for brightness (corresponding to a certain temperature range in advance) and wave method for combining the pixels in the connected sets [6].

Threshold methods are central method of image segmentation because of its simplicity and high computational efficiency in implementation. The threshold criteria as the main or auxiliary, used in almost all the methods of segmentation by brightness, color and contrast.

For example, segmentation of the image pixel (i, j) with the brightness f_{ij} with threshold criterion [2], the threshold T is given by

$$C = \begin{cases} 1, \text{ if } \quad f_{ij} \le T; \\ 0, \text{ else.} \end{cases}$$

The threshold criterion based on the use of a spherical approximation of the cluster color image in the feature space

$$D(z,a) = \left[(z_R - a_R)^2 + (z_G - a_G)^2 + (z_B - a_B)^2 \right]^{1/2}$$

often used for segmenting images by color pixels in the RGB color space has next form:

$$C = \begin{cases} 1, \text{ if } \quad D(z,a) \le T; \\ 0, \text{ else,} \end{cases}$$

where a – the center of the cluster corresponding to the color area of segmentable images of a certain class of objects in the color space RGB;

z – the color of the considered pixel.

The main idea of threshold segmentation method by luminance is to set the threshold value and, with respect to this threshold, split the pixels of the image into two subsets that belong to the object and the background.

In this case, if the input image contains multiple objects [7], the method of cross sections, when two thresholds are defined, and allocated the image pixels of the subject, the brightness of which lies between the specified threshold values by

$$C = \begin{cases} 1, \text{ if } \quad t \le f_{ij} \le T; \\ 0, \text{ else,} \end{cases}$$

where f_{ij} – the brightness of a pixel (i, j);

t, T – the lower and upper thresholds.

The same method was used in the work, because the temperature range in which we are interested in can be embedded in a temperature range of the image.

Wave segmentation method. After applying the threshold segmentation for further analysis highlighted set of pixels should be split into connected sets, identified with those or other objects of sight [8]. For this purpose, in this work the wave method is used.

Let us assume that after the threshold segmentation the matrix $A_{m \times n}$ was created. This matrix contains marks of pixels of input image, where selected in segmentation criterion pixels marked with 1, and the remaining pixels – 0.

In such circumstances, for the construction of connected sets of pixels implemented the following algorithm.

Step 1. The matrix $A_{m \times n}$ is viewed by rows $(j = 0, ..., m-1)$ and columns $(i = 0, ..., n-1))$. During this scan checked whether the label is one pixel. If the pixel is found with a non-zero label such that $a_{j,i} = 1$, viewing pixel matrix $A_{m \times n}$ is suspended, go to step 2 for the implementation capacity of the object wave.

Step 2. Creates a two-dimensional array B of object coordinates, and it is placed with coordinates (j,i) with non-zero pixel label. To do this, set the index introduced by the pixel $k = 0$ and coordinates and writes: $b_{k,0} = j$, $b_{k,1} = i$. The label of the pixel in the array A is reset $a_{j,i} = 0$.

After this, the array B index $p = k$ is given the examined pixel $a_{b_{p,0},b_{p,1}}$.

Step 3. Examination in the neighborhood of the pixel $a_{b_{p,0},b_{p,1}}$ matrix A. If the label of the pixel is equal to one: $a_{\eta\xi} = 1$, $\eta = b_{p,0} - 1,..., b_{p,0} + 1$, $\xi = b_{p,1} - 1,..., b_{p,1} + 1$, then the coordinates of this pixel put in the array B of the object's coordinates, in this case we assume that $k = k + 1$, $b_{k,0} = \eta$, $b_{k,1} = \xi$, and the label in the array A is equal to zero $a_{\eta\xi} = 0$.

Step 4. After inspecting the neighborhood of a pixel with the index p move to the next pixel in the array B, it should be $p = p + 1$.

Step 5. If $p > k$ then the object wave extensions ending, return to Step 1 to continue the view of the matrix $A_{m\times n}$; otherwise go to Step 3 to continue the extension of the object.

As a result of applying the wave method we obtain a system of coordinates array of pixels that identify with those or other objects of sight.

Conclusion

Used in the present analysis scheme thermo image is to get a shot and make a visual analysis of interesting objects or images. Quantitative analysis of thermal images is still not very effective now and quite expensive because of the use of manual labor specialists of high qualification and unacceptably rough in the calculation of the characteristics considered in the thermograms objects.

In this respect the urgency of automation of analysis of thermal images [9] on the basis of the use of the apparatus of the theory of pattern recognition applied for segmentation and identification of objects in the thermograms for their thermal radiation, and secured-down thereby allowing the applied analysis of objects with high accuracy in real time.

In this work were presented model and methods for image segmentation. Was proposed threshold segmentation method for brightness (corresponding to a certain temperature range in advance) and wave method for combining the pixels in the connected sets. Thermal images were analyzed with its temperature zones and their parameters. Input image were loaded to the system for analysis of heat loss in images taken with infrared cameras. After the segmentation of specified temperature zones of thermal image was solved, the system allows user to emphasize on the interesting temperature regions, get a dedicated space temperature regions and to assess their value stream. Then we set the boundaries of the temperature range (Whole Temperature Range), boundaries of the considered temperature range (Concerned Temperature Range) and the number of accumulated temperature ranges (Aggregative Ranges).The next step is to set the parameters to determine the size of area and flow (Thermal Source Calculations). Finally, we must make a metrization (Metrization 1D) at the thermal image. After this evaluation is performed automatically, the program estimates actual pixel size and the selected objects in the image. The proposed system defines the boundaries and area of temperature regions [10]. Overall efficiency of 95% was discovered for the system as the system has been tested with nearly 15 thermal images of different buildings. Even this efficiency is not acceptable generally, but the system can be used for analysis and evaluation of heat loss in images taken with an infrared camera. It can be concluded that the proposed system has been by and far successful.

References

1. Haralick R.M. Image Segmentation Techniques. Comput / R.M. Haralick, L.G. Shapiro // Vision Graphics Image Process. – 1985. – Vol. 29. – Pp. 100-132.

2. Pal N. A Review on Image Segmentation Techniques / N. Pal, S. Pal // Pattern Recognition. – 1993. – Vol. 26. – Pp. 1277-1294.

3. Bezdek J.C., Hall L.O., Clarke L.P. Review of MR Image Segmentation Techniques Using Pattern Recognition. Med. Phys. – 1993. – Vol. 20. – Pp. 1033-1048.

4. Jialin Gas, Mingchu Thole and Haimin Wang. A threshold and region growing combined method for filament disappearance area detection in solar image // Conference on information Science and System. – The Johns Hopkins University, 21 – 23 March, 2001.

5. Henstock R and Chelberg D. Automatic gradient threshold determination for edge detection, IEEE Trans Image Processing. – May 1996. – Vol. 5, No 5. – Pp 784-787.

6. Besl and Jain, 'Segmentation through variable-order surface fitting', IEEE Transaction on Pattern Analysis and Machine Intelligence. – 1998. – Vol. 10, No 2. – Pp 167-192.

7. Henstock R. and Chelberg. Automatic gradient threshold determination for edge detection. IEEE trans on Image Processing. – 1996. – May, Vol. 5, No 5. – Pp. 784-787.

8. Canny J. A computational approach to edge detection // IEEE Transaction on Pattern Analysis and Machine Intelligence. – November 1986. – Vol. 8, No 6.

9. Gonzalez R.C. and Woods R.E. Digital Image processing. Second Edition, Pearson Education Asia, 2002.

10. Krishna Kant Singh, Akansha Singh, A Study of Image Segmentation Algorithms For Different Types Of Images.IJCSI International Journal of Computer Science Issues 2010.

Надійшла до редколегії 3.07.2013

Рецензент: д-р техн. наук, доц. К.С. Смеляков, Харківський університет Повітряних Сил ім. І. Кожедуба, Харків.

МОДЕЛИ И МЕТОДЫ ДЛЯ ОЦЕНКИ ПОТЕРИ ТЕПЛА

А.С. Чуприна, Огуннийи Ореолува

Целью данной работы является разработка моделей, методов и программного обеспечения для оценки тепло потерь. Первая задача – это сравнение различных методов сегментации, а затем создание оптимального метода. В работе предложены метод пороговой сегментации по яркости (соответствующий определенному диапазону температур) и метод волнового объединения пикселей в связанные множества. На основании разработанных модели и метода было создано приложение, с помощью которого система будет оценивать тепло потери здания. Система устанавливается на персональном компьютере, программа THERMO использует фотографии с инфракрасной камеры, которые дают инфракрасные изображения стены здания.

Ключевые слова: *качественная оценка, сегментация, измерение, животные эмбрионы, ошибка, форма.*

МОДЕЛІ І МЕТОДИ ДЛЯ ОЦІНКИ ВТРАТИ ТЕПЛА

А.С. Чуприна, Огуннійі Ореолува

Метою даної роботи є розробка моделей, методів та програмного забезпечення для оцінки тепло втрат. Перше завдання – це порівняння різних методів сегментації, а потім на основі цього створення оптимального методу. У роботі запропоновано метод порогової сегментації по яскравості (відповідний певного діапазону температур) і метод хвильового об'єднання пікселів в пов'язані множини. На підставі розроблених моделі і методу було створено програму, за допомогою якого система буде оцінювати тепло втрати будівлі. Система встановлюється на персональному комп'ютері, програма THERMO використовує фотографії з інфрачервоної камери, які дають інфрачервоні зображення стіни будівлі.

Ключові слова: *якісна оцінка, сегментація, вимірювання, тваринні ембріони, помилка, форма.*