Application of Computer Graphics in Cellular Material

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Abstract. Nowadays cellular materials have become a hot research topic because their special structure and unique properties. Computer graphic provides a new method to study the complex structure of cellular material. In this research, computer graphic was combined with the Visual Basic software to study the characteristic of cellular material. The hole ratio, aperture and form coefficient could be attained and the finite element model of cellular material could be also got from the established program.

Keywords: Cellular Material, Computer Graphics, Visual Basic, Finite Element

1. Theory of reference

The shape of hole in porous materials (except honeycomb materials) is very irregular [1], so computer simulation of irregular porous materials and manual modeling of porous materials usually cost a lot of time and energy. Therefore, it is necessary to obtain the finite element (FE) model of porous materials through computer technology, which could greatly improve efficiency. In addition, the basic parameters of porous materials include porosity, pore size and pore size distribution, hole shape coefficient, etc., which can be calculated through the fracture surface of porous materials.

In the image processing technology, the binary image processing is the most simple. The structure analysis software prepared in this paper is only for the binary image of porous materials. Photoshop software can be used to deal with the image of porous materials for pre-processing (binarization processing). The software mainly employs the following technologies: image binarization technology in computer graphics, connected region recognition technology, edge contour detection technology, line refinement technology, contour tracing technology. Besides, the secondary development technology of Auto CAD is also applied by Visual Basic software.

2. Software written
2.1. Image connected region recognition

For binary images, only black (0) pixels and white (1) pixels exist in the image. It is assumed that the holes in the image of the porous material are black pixels. The image is scanned linearly from left to right and from top to bottom. After searching for the first black pixel point, the flame is ignited at the pixel point to spread within the eight connected domains of the current pixel. The program is recursively executed until "Burning out" all points of the target (hole). Then the number of pixels in the hole is recorded and the number of holes is added. The algorithm is repeated until all the objects (holes) in the image are counted. After executing the algorithm, the pixel number in each hole and the number of holes in the scanning area are obtained, and the area of the hole can be calculated by pixel number. The microscopic analysis method to calculate porosity in previous research is given\(^2\). The first requirement for porous material to make the flat sample preparation section, such as porous metal cross section, can be polished smoothly. Then using formula (1) to get the porosity of porous body by the microscope observation of surface area S and pore area \(S_p\)[3].

\[
\theta = \frac{S_p}{S}
\]  

(1)

2.2. Contour tracking technology

Contour tracing is a common technique in the field of vectorization of dot matrix graphics and pattern recognition. Its purpose is to search along the boundary of the contour region of the graph, and the points on the searched boundary line (contour line) in the point column can be recorded. As a result, the point column represents a contour line. The 3x3 template is still used here. As it can be shown in Figure 1.

![Figure 1. Pels mark method](image)

Figure 1. Pels mark method

Firstly, the image is searched along the scanning direction to check whether the pixel is white or black. The first detected white pixel is used as the starting point for contour. This starting point is located at the top and left of the white image. Assuming the pixel is \(P_1\), then an \(P_1\)-centric 3x3 template is considered. And each pixel in the template is marked from 1 to 8 as shown in Figure 2.

![Figure 2. Template of outline pursue](image)

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After that, starting with the pixel with the serial number 1, whether the pixels are white pixels is
checked in order, and the first encountered white pixel is set as \( P_2 \). If the range from 1 to 8 is all black pixels, then \( P_1 \) are outliers and the tracking is aborted.

![Figure 3. Chain Code's directions code](image)

Assuming that \( P_n \) has been checked out, and \( P_n \) is the center pixel of the template, search for \( P_{n+1} \) in the same way. If the search results is \( P_n = P_1, P_{n+1} = P_2 \), it indicates \( P_1, P_2, ..., P_{n-1} \) had formed a closed loop, then the track outline in this article can be subtended. Point columns \( P_1, P_2, ..., P_{n-1} \), is the contour that we're looking for. After that, moving the search starting point to another part of the image and moving on to the next contour of the graph. At this point, it should be noted that the new search starting point must be outside the area of the obtained contour, so as to ensure that the contour found in the two searches is not the same.

In order to record the contour point and column data obtained after contour tracking, Freeman's Chain Code is useful. Chain Code is a method to record the connection direction of pixels on the curve with the 8-direction Code shown in Figure 3.

![Figure 4. Example of Chain Code record method](image)

### 3. Finite element simulation

After the structural analysis software is opened, its interface is shown in Figure 5 (section diagram of the opened porous material). There are four menus: file, image, edit and help. In the image menu, there are four sub-menus: zoom in, zoom out, scan area selection, and get the real size. The scan area selection can determine a program scan area, and get the real size is to make the image conform to the real porous material size when there are rulers in the image. The edit menu is the main body of the structure analysis software, including area identification, contour detection, further refinement, number of closed curves and image information acquisition.
Figure 5. Section of foam material open in the BWJ Scan soft

There are six submenus for drawing and scanning results in CAD. Region recognition is available. To obtain the area, number, porosity, pore size and pore size distribution of the pores. Contour recognition can extract the edge contour of each hole. Further refinement is to further refine the edge contour to prepare for the next statistical closed curve number and drawing in Auto CAD. The circular length of each hole and the hole shape coefficient of the whole porous material can be obtained by the number of closed curves and image information. The last menu is the help command, with instructions and notes for the structural analysis software. Figure 6 is the vector diagram obtained in Auto CAD by connecting Auto CAD in Figure 5.

Figure 6. Veto graph of foam material n Auto CAD

The vector quantity figure painted in the Auto CAD software is put into MSC. Marc finite element analysis software [4], a 2D simulation of the compression process of porous materials of aluminum is carried out. Figure 7 for local enlarged the equivalent von mises stress figure. The stress state of the color in the graph represents the material, which can be under the assumption of two-dimensional porous high should force deformation characteristics of the further research.

Figure 7. Equivalent Von Mises stress of cellular material in compressive process

4. Conclusion
Combined with the characteristics of porous materials, computer graphics and Visual Basic, a structural analysis software for binary images of porous materials is established. It can analyze the porosity, pore diameter, pore diameter distribution and shape coefficient of porous materials, and the finite element model of porous materials can be also obtained.

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