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Development of microstructure image feature analysis software based on Python

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ABSTRACT
The quantitative analysis of microstructure image must first go through a series of processing processes such as geometric distortion correction, image cutting, histogram correction, contrast enhancement, image smoothing, image sharpening, image binarization and image segmentation, and then extract three major feature parameters, including shape feature parameters, texture feature parameters and spatial relationship feature parameters. In view of the difficulty, large amount of data and strong repeatability of microstructure image processing, this paper presents a Python-based quantitative analysis system for microstructure image, which is characterized by mass processing and customizable functions. The main research object of the system is the microstructure image of metal alloy. The design goal, overall design, function module design and implementation principle of the system are described, and the implementation code of the key design part is given. The practical test and application show that the system can greatly improve the efficiency of quantitative analysis of microstructure images in materials and other engineering fields.

KEYWORDS
Python; microstructure; image; alloy; system development

1 Introduction

With the continuous progress of science and technology, quantitative analysis of microstructure image has been widely used in material science, metallurgy, product quality identification in industrial production and other fields. Digital image processing technology is mainly used to extract and analyze the feature parameters of microstructure images. Mao L T, *et al*. apply the "Analsis of Microstructure" system to the quantitative analysis of microstructure images[1]. Using VB as the platform, Zhang L Z, *et al*. developed a quantitative analysis system for soil microstructure, and obtained quantitative indexes such as particle morphology and particle arrangement[2]. Jin K S studied the curing characteristics and microstructure image characteristic parameters of Kunming laterite, and developed a parameter extraction software based on VB[3]. Yang Y *et al*. extracted fatty liver texture features based on ultrasound[4]. These processing methods are not perfect in extracting feature parameters, and the processing steps are too complicated. It is necessary to develop a simple and functional analysis system.

Python has obvious advantages in graphics and image processing :(1) the syntax is brief and easy to read, making the code of image processing easy to write and understand; (2) Has a rich image processing library, so that developers can easily carry out a variety of image processing operations; (3) It is very convenient to combine with many scientific databases, which greatly simplifies the operation of image processing; (4) The supported image file formats are rich, such as *.bmp, *.jpeg, *.gif, *.tif, *.pcx, *.HDF, *.xwd, *.png, etc.

2 System Design

2.1 System design objectives

The functions of the micro-structure image quantitative analysis system are as follows: (1) The operation is simple, the user only needs to enter the original file list, and the system will get the required micro-structure image parameters; (2) Mass, batch processing of fluid hydration during the system operation, automatically saving the processing results of each step in the digital image processing process, and statistic, sort out and store the feature parameters in the document; (3) The functions can be customized, and the functional modules are designed with a modular program. Each module interacts with the analysis system through the interface, and several image threshold calculation methods can be provided to calculate the image threshold of the microstructure image; (4) Strong scalability. Although the system takes alloy microstructure image as the main research object, the system architecture is an open structure with hierarchical component functional structure design, which is conducive to the expansion of the system; (5) The parameter extraction is complete, and the system can extract as many parameters of shape feature, texture feature and space feature of soil microstructure image as possible; (6) Wide range of application, the system is not only suitable for material engineering, but also for civil engineering, metallurgical engineering, medical and other fields of microstructure image processing and parameter extraction.

2.2 Overall system design

The microstructural image quantization processing system based on Python generally includes two parts: customer subsystem and processing subsystem. The processing subsystem is the core of the whole system, including: image reading unit, image processing unit, parameter extraction unit, data storage unit. The overall architecture of the system is shown in Figure 1.

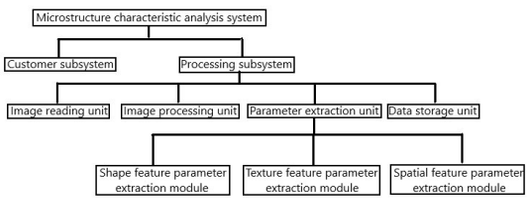

Figure 1 The overall structure of the system

The customer subsystem mainly interacts with the user. The user can complete the file list entry of the microstructure image file through the customer subsystem, complete the file name recognition of the image file, and sequentially call the processing subsystem for multiple microstructure image files to complete the batch processing of the image. The processing subsystem is the functional realization of the whole micro-structure image quantization processing system, whose goal is to process the original image, extract parameters and store data.

2.3 System Processing Flow

After the user enters the micro-structure image file to be processed into the file list of the customer's system and clicks Run, the system will first identify the first file in the file list, call the processing subsystem to sequentially perform the reading of the original image, digital image processing, shape feature parameter extraction, texture feature parameter extraction, spatial relationship feature parameter extraction, and advance after the extraction of various parameters Row data storage. The detailed processing flow of the system is shown in Figure 2.

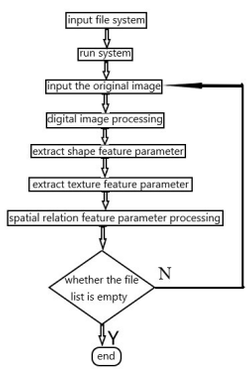

Figure 2 System processing flow chart

2.4 Development of system function modules

2.4.1 Customer subsystem

The client subsystem completed the entry of the list of microstructure image files, completed the identification of image file names, and sequentially called the processing subsystem for multiple microstructure image files to complete the batch processing task of images. The key code is as follows:

```
Image=['filename1.TIF','filename2.TIF', ……];
num=strfind(Image, '.TIF');
N=length(num);
i=1;
while(i<N+1)
close all;
pause(1);
[filename, rem] = strtok(image,'');
if ~exist (filename)
mkdir(filename)
```

```
end
paths=[pwd,['\',filename,'\']];
main(Image(num(i-1)+1:num(i)+3));
i=i+1;
end
```

2.4.2 Processing subsystems

(1) Image reading unit. Accept the files passed from the customer subsystem, use the Pillow function library to read the original image in matrix form, responsible for creating folders for the files currently processed, used to save the files in the process of image processing.

(2) Image processing unit. The OpenCV computer vision library was used to perform 8 steps of micro-structure image geometric distortion correction, image cutting, histogram correction, contrast enhancement, image smoothing, image sharpening, image binarization and image segmentation. The processing results were saved in the process for later data verification and analysis.

(3) Parameter extraction unit. The extraction of three types of feature parameters, shape, texture and spatial relationship, is completed by the following three modules: (a) Shape feature parameter extraction module. The Shapely function library is used to extract the shape feature parameters in the microstructure image, which provides the processing methods and operations of geometric objects, such as intersection, union, difference and symmetry difference. (b) Texture feature parameter extraction module. The texture feature parameters were extracted using scikit-image function library. (c) Spatial relation feature parameter extraction module. Among the characteristic parameters of spatial relations, the most important one is the fractal fractal dimension (SPFD), which can reflect the particle distribution and change characteristics of the image surface. The system realizes the calculation of fractal dimension based on the probability measure of box counting.

(4) Data storage unit. Use the NumPy library and Pillow library functions to store the parameters returned by the parameter extraction unit into a file.

3 Conclusion

This paper presents the design scheme and implementation code of the micro-structure image quantification analysis system, aiming to provide a practical and efficient system development template for engineers in the micro-structure image quantification processing work, so that engineers need not compile every link of the micro-structure image quantification analysis system when applying this template in a specific field. Just customize the required functional modules in the system or add a small number of functional modules to achieve their desired processing purposes. The practical test and application show that the system can greatly improve the efficiency of the researchers in the quantitative analysis of microstructure images.

This system takes Python as the platform is an open structure, hierarchical component functional structure design, which is conducive to the expansion of the system, and simple operation, mass processing, functions can be customized, parameter extraction is complete, wide range of application. The system has stable and reliable performance, good applicability and accuracy.

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