Concrete Management Monitoring System Based on Particle Swarm Algorithm

Dongying Pan\textsuperscript{1,*} \\
\textsuperscript{1}Shandong Institute of Commerce and Technology, Jinan, China, 250103 \\
*Corresponding author e-mail: pandy2021@sict.edu.cn

Abstract. With the rapid development of the national construction infrastructure industry, concrete structures often have various problems such as cracks in the early and later operations. The further development of these problems may endanger the structural safety of the entire building. The particle swarm algorithm is simple to operate, less parameter settings, easy to implement, etc., which can solve the problem of concrete monitoring. Based on this, the purpose of this article is to study the concrete management monitoring system based on particle swarm optimization. This article first summarizes the basic theory of particle swarm algorithm, and then extends its core algorithm technology. Analyze the existing problems and deficiencies in the current concrete structures in our country. And use particle swarm algorithm to research and analyze the concrete management monitoring system. This paper systematically describes the outline design and detailed design of the concrete management monitoring system based on particle swarm optimization. And by comparative method, field survey method and other research forms to carry out experimental research on the main body of this article. Research shows that the maximum absolute error of the crack width measured by the particle swarm optimization-based concrete management monitoring system W2 and the actual crack width W1 measured by the crack width comparison ruler is 0.232mm, which is less than 0.3mm, and the maximum relative error is 4.59%, to meet the system design requirements, which proves the rationality and effectiveness of the system.

Keywords: Particle Swarm Algorithm, Concrete Management, Monitoring System, Application Research

1. Introduction 
At present, the main defect of concrete lies in cracks. Concrete cracks reduce its bearing capacity and integrity, accelerate the aging of the structure, thereby affecting the safe use of the structure [1-2]. Therefore, monitoring concrete management and clarifying the form of concrete cracks play an important role in crack repair and the application of concrete structures [3-4].

Since the 1990s, with the continuous improvement of my country's national strength and rapid economic development, many domestic researchers have begun to enter the field of concrete prosecution in the engineering sector and have achieved a series of gratifying achievements. The state-
supported concrete crack monitoring instrument can detect metal cracks with debris or water, and the inspection range is not less than 6 meters, and the monitoring error is not more than 9%. It can be used for hidden cracks, vertical and horizontal cracks, etc. Cracks can also detect the internal structure of buildings and the surface of concrete.

The purpose of this paper is to monitor various problems such as concrete cracks, and to study the concrete management and monitoring system based on particle swarm algorithm. By measuring the concrete crack width, the machine vision measurement value of the concrete crack width under different shooting distance conditions is obtained, and the actual value of the concrete crack width is compared with the machine vision measurement value, and the absolute and relative errors of the measurement results are obtained, which verifies this article Establish the accuracy and practicality of the system [5-6].

2. Application research of concrete management monitoring system based on particle swarm algorithm

2.1. Research on the preprocessing and realization of concrete monitoring images based on particle swarm optimization

(1) Particle swarm algorithm

The update of the speed and particle position of each iteration of the classic particle swarm algorithm is completed by the following two formulas:

\[ v_{id}(t+1) = \omega \cdot v_{id}(t) + c_1 \cdot \text{rand} \cdot (p_{id}(t) - x_{id}(t)) + c_2 \cdot \text{rand} \cdot (p_{gb}(t) - x_{id}(t)) \] 

(1)

\[ x_{id}(t+1) = x_{id}(t) + v_{id}(t+1) \] 

(2)

(2) Collection of concrete images

With the rapid progress of remote sensing technology and microscopy technology, especially the gradual improvement of image processing technology, the use of image recognition in industry and technology has also increased a lot. Mainly, through the image recognition and processing in the computer, the efficiency of the previous image detection system can be greatly improved, and more importantly, the occurrence of errors is reduced, which is very helpful to reduce the cost of work and improve the accuracy [7-8].

(3) Image preprocessing

Before the image is subjected to a series of analysis, the processing of image segmentation, patchwork, extraction and processing is the preprocessing, which is very effective in improving the final definition, removing the redundancy in the image, and enhancing the detection ratio of the image, so that the image It is easier to identify and analyze during analysis. So, this operation includes image enhancement (grayscale change, contrast enhancement, smoothing, sharpening, etc.), restoration, digitization, geometric transformation and normalization [9-10].

1) Grayscale transformation of digital image processing

According to the rules of the particle swarm algorithm, the pixel tones in the graphics are modified, and through continuous debugging, the effect of higher picture clarity is finally achieved, which is conducive to a series of subsequent processing and use in real life applications. Therefore, grayscale conversion is the grayscale change of each pixel. By storing the tone value of each pixel in a matrix, and then using mathematical functions such as logarithmic conversion to process the tone, and then corresponding to each pixel of the image, in this way, the sharpness of the image is increased, and the contrast of the picture is also improved. In addition, grayscale conversion uses each point to adjust the tonal value of each pixel. Only in mathematical methods, will the relationship between the various points of the graph be changed, so the conversion can also be regarded as adjusting the points. The expression is:
\[ g(x, y) = T[f(x, y)] \]  

In the expression, \( T \) is the conversion method, that is, the realization of the process of grayscale change of the image, and \( T \) represents the realization of pixel grayscale conversion, so once \( T \) is determined, the entire conversion method is determined [11-12].

2) Linear conversion

If the gray value of the first image is in the range of \( a \) to \( b \), and the gray scale of the last conversion is changed to that of \( c \), through the above description, the \( f \) function will start to be positioned, and the end will be defined as the \( g \) function. The linear conversion formula is as follows:

\[ g(x, y) = \frac{d - c}{b - a} \times [f(x, y) - a] + c \]  

If the initial image grayscale is in the range from \( a \) to \( b \), and max\( f \) represents an extreme, and the final range is not in these two ranges, so if you want to adjust the grayscale value, just:

\[
g(x, y) = \begin{cases} 
  c, 0 \leq f(x, y) \leq a \\
  \frac{d - c}{b - a} \times [f(x, y) - a] + c, a \leq f(x, y) \leq b \\
  d, b \leq f(x, y) \leq \text{max}\ f
\end{cases}
\]  

2.2. System outline design

(1) Analysis of overall structure

The overall structure design of the system adopts the current popular MVC design pattern. MVC is a very smart design framework. The biggest advantage of MVC is the separation of data processing and view layer. In the past, some program designs often mixed the input and output of program data and data analysis and processing, but these three aspects of the program in the MVC framework exist independently, which also avoids the complexity of data interaction. In the interaction process, the control layer does not directly process the user's request, but uses certain means to select the response handler for processing at the model layer, and the model layer does not directly output and return the response. It is transferred to the view layer to return.

(2) System module analysis

The system modules are divided into four modules: concrete crack pretreatment module, concrete crack edge treatment module, concrete crack detection module, and concrete crack characteristic information calculation module. The concrete crack preprocessing module is divided into three modules: image smoothing, median filtering, and gradient sharpening; the edge processing module of concrete cracks is divided into four modules: Log algorithm, Sobel algorithm, Prewitt algorithm and canny algorithm; concrete crack characteristic information calculation module It is divided into two modules: concrete crack length calculation and concrete crack spacing calculation.

2.3. System detailed design

(1) Concrete crack pretreatment module

The preprocessing of the concrete crack image is mainly to eliminate image noise and reduce unnecessary interference for subsequent image processing.

(2) Edge processing module

An edge is also called a boundary, and it is generally a collection of pixels with sharp changes in local pixels. An image can be seen and intuitively felt by people, because the surrounding image is very different from it, which is the "edge". The root cause of this difference is that the difference between the pixel value of the surrounding pixels and the pixel value of the "edge" point is greater than most of any other two adjacent pixels.

(3) Monitoring module
The purpose of concrete crack image detection is to obtain the contour features of concrete cracks in preparation for the subsequent image feature analysis.

The extraction of cracks first needs to binarize the image of concrete cracks. After the image is binarized, the value of the concrete crack is "1" and the others are "0". The concrete crack detection is to scan each pixel of the image, and output the part of "1", and the part of "0" will be masked.

(4) Calculation module of concrete crack characteristic information

The calculation of the characteristics of concrete cracks includes the calculation of the length of concrete cracks and the calculation of the distance between concrete cracks. The length of the concrete crack is calculated according to the number of consecutive "1"s in the binary image, and the width is calculated according to the horizontal ruler method.

3. Experimental research on concrete management monitoring system based on particle swarm algorithm

3.1. Subjects
In order to make this experiment more scientific and effective, this experiment mainly measures the width of concrete cracks, obtains the machine vision measurement values of the concrete crack width under different shooting distance conditions, and compares the actual value of the concrete crack width with the machine vision measurement value. The absolute error and relative error of the measurement results are obtained, which verifies the accuracy and practicability of the system established in this paper.

3.2. Research methods
(1) Comparative method
This article sets up three different control groups for comparative analysis to judge the feasibility of the subject of this article.

(2) Observation method
In this research, we observe and record the data taken by the monitoring system, and organize and analyze the recorded data. These data not only provide theoretical support for the topic selection of this article, but also provide data for the final research results of this article.

(3) Mathematical Statistics
Use relevant software to make statistics and analysis on the research results of this article.

4. Experimental analysis of concrete management monitoring system based on particle swarm algorithm

4.1. Analysis of machine vision measurement value of crack width
In order to make this experiment more scientific and effective, this experiment analyzes the crack width of concrete by machine measurement, and the data obtained is shown in Table 1.

|       | Group1  | Group2  | Group3  |
|-------|---------|---------|---------|
| 700mm | 1.9486  | 4.0609  | 6.2223  |
| 800mm | 1.9078  | 4.04446 | 6.2321  |
| 900mm | 1.9496  | 4.0784  | 6.2064  |
| 1000mm| 2.0197  | 4.0794  | 6.2120  |
| 1100mm| 1.9136  | 4.0760  | 6.1850  |
Figure 1. Analysis of machine vision measurement value of crack width

It can be seen from Figure 1 that the actual value of the crack width in group 1 is 2mm, the actual value in group 2 is 4mm, and the actual value in group 3 is 6mm. The deviation of the three groups of measured data from the actual value is within the error range, which fully reflects the feasibility of the system studied in this paper.

4.2. Absolute error analysis of cracks

Use the crack width comparison ruler to measure the actual value W1 of the crack width, and use the crack monitoring software system to obtain the machine vision measurement value W2 of the crack width. According to W1 and W2, calculate the absolute error Eabs of the crack width. The absolute error is calculated according to formula (6). The calculation results are shown in Table 2.

$$E_{\text{abs}} = | W_1 - W_2 |$$  \hspace{1cm} (6)

Table 2. Exact error of crack width

| Measurements | Group1  | Group2  | Group3  |
|--------------|--------|--------|--------|
| 700mm        | 0.051  | 0.061  | 0.222  |
| 800mm        | 0.092  | 0.044  | 0.232  |
| 900mm        | 0.053  | 0.073  | 0.206  |
| 1000mm       | 0.020  | 0.079  | 0.212  |
| 1100mm       | 0.086  | 0.076  | 0.185  |

Figure 2. Exact error of crack width

It can be seen from Figure 2 that the maximum absolute error of the crack width measured by the particle swarm algorithm-based concrete management monitoring system measured by the machine...
vision measurement value W2 and the crack width actual value W1 measured by the crack width comparison ruler is 0.232mm, which is less than 0.3mm, and the maximum relative error It is 4.59%, which satisfies the system design requirements and proves the rationality and effectiveness of the system.

5. Conclusion
This paper establishes a concrete management monitoring system based on particle swarm algorithm. The system is based on image processing, and performs crack image processing through crack image reading, crack image preprocessing, crack image segmentation, and crack characteristic parameter extraction, etc. Target crack information. However, when the quality of the collected images is good, the concrete monitoring software system established in this paper can obtain better experimental results. However, due to the impact of environmental factors in actual projects, the quality of concrete crack images is often poor, and the system needs to be improved, to adapt to more complex situations.

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