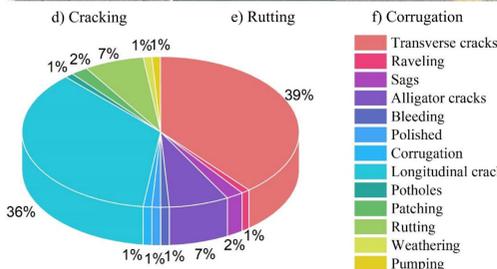


## Background



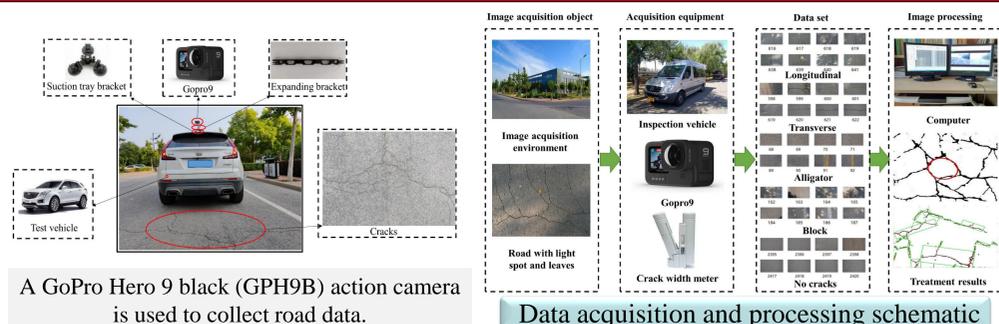
The total road mileage in China reached approximately **5.19 million** kilometres by the end of 2020 according to the Ministry of Transportation of China.

The most typical distresses of the pavement include sags, raveling, potholes, cracking, rutting, and corrugation.

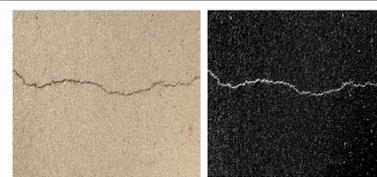
According to a recent pavement disease survey of a national highway in China, cracks account for **82%** of road pavement diseases. Pavement deformations, such as rutting and sag, accounted for 11%, and the remaining other diseases accounted for 7%.

Pavement needs to be maintained from the moment its service life begins. The maintenance strategy is mainly based on pavement quality indexes, such as the road damage rate (DR).

## Data acquisition and processing

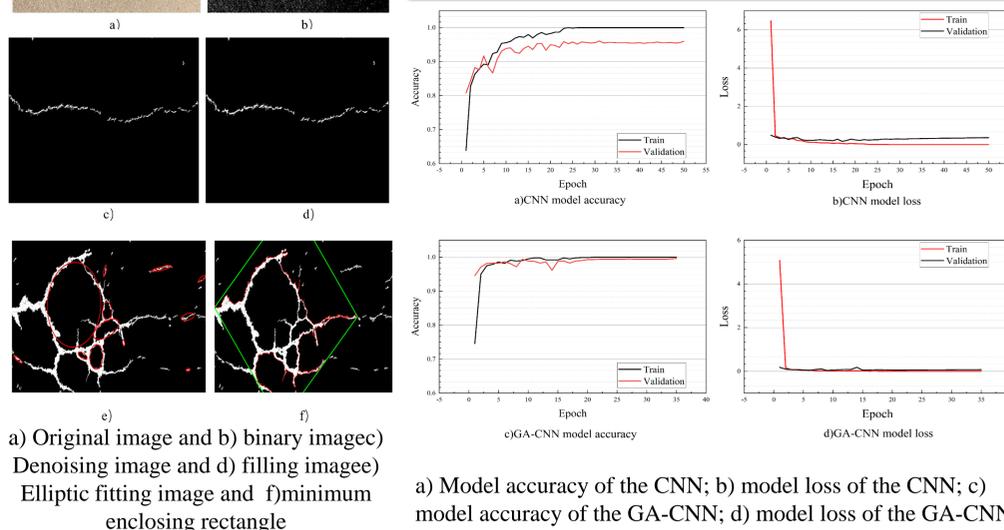


## Cracks feature extraction and Model evaluation

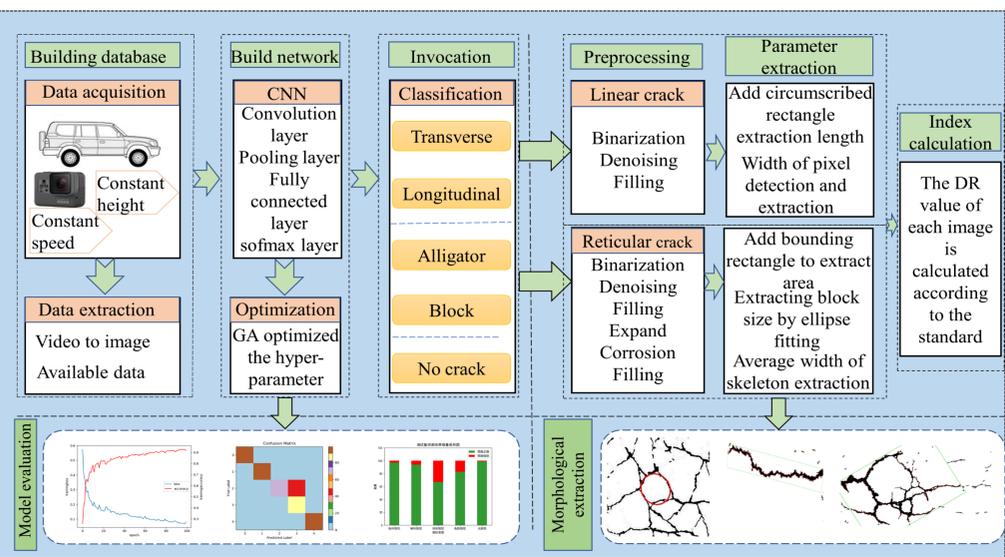


The crack features are extracted through operations such as image binarization, denoising, filling, circumscribed rectangle and fitting ellipse.

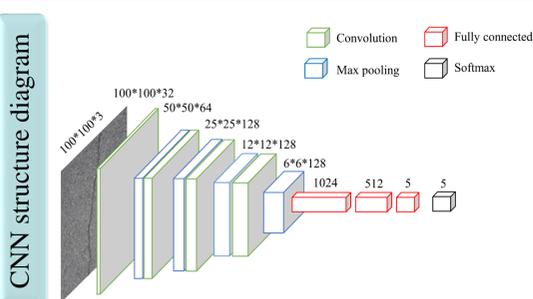
### GA-CNN optimization effect comparison



## Methodology



## GA-CNN



1) The network consists of four convolution layers, four maximum pooling layers, three fully connected layers, and one softmax layer. The activation function uses the RELU function.

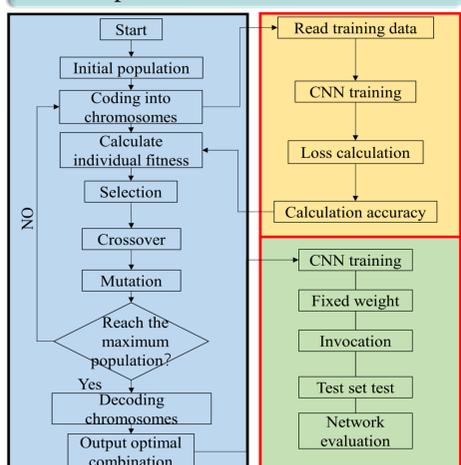
2) To prevent overfitting, the dropout function is added to make the neural network stop neurons with a certain probability in the forward propagation process. The softmax layer is used to output the classification results.

Table 1 Genetic algorithm parameter table

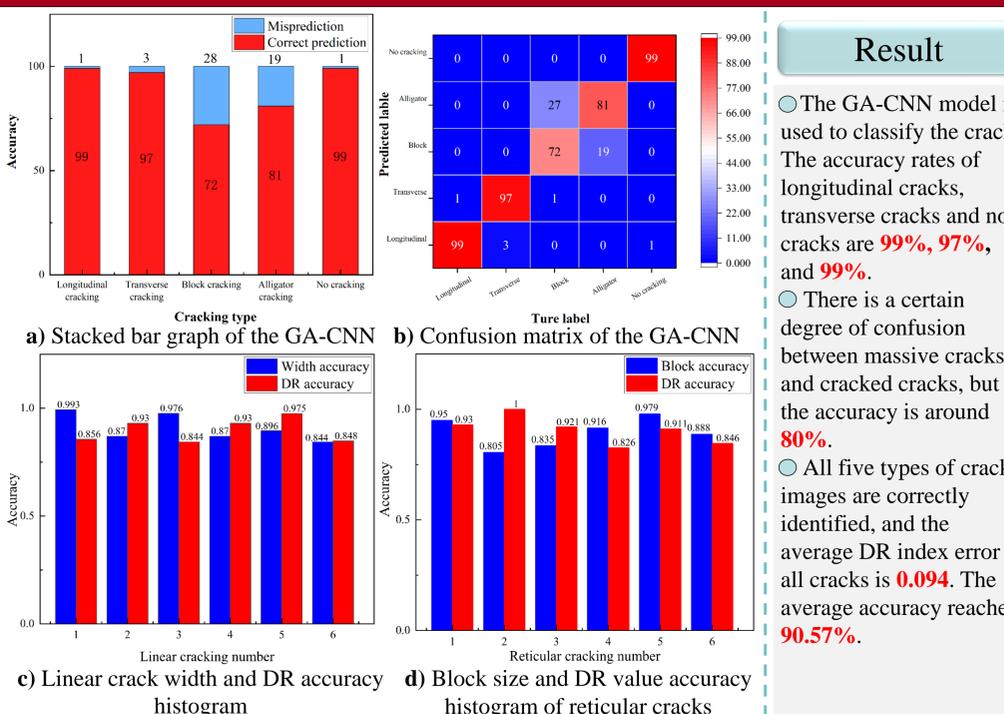
Parameter	Number of populations	Maximum number of iterations	Population inheritance rate	Mutation rate
Size	10	15	0.25	0.05

- Determine the CNN network structure.
- Set the basic parameters of the genetic algorithm.
- Initialization is started, and random hyperparameters combinations are made according to the selection rules within the set hyperparameters range.
- Selection, crossover, and mutation operations are performed to determine whether the maximum population number iteration is terminated.
- After obtaining the optimal hyperparameters combination, this hyperparameters combination is used to train the CNN network, the weights between neurons are fixed.

GA optimization CNN flow chart



## Results and conclusions



### Result

The GA-CNN model is used to classify the cracks. The accuracy rates of longitudinal cracks, transverse cracks and no cracks are **99%**, **97%**, and **99%**.

There is a certain degree of confusion between massive cracks and cracked cracks, but the accuracy is around **80%**.

All five types of crack images are correctly identified, and the average DR index error of all cracks is **0.094**. The average accuracy reached **90.57%**.

### Conclusions

- The genetic algorithm is used to optimize the hyperparameters of the convolutional neural network. The accuracy of the optimized GA-CNN is 89.54%. The maximum width of verification set reaches 99.6%. The accuracy rate of the model for linear crack and crack-free image detection is more than **98%**.
- The highest detection accuracy of the block is **97.9%**, and the average detection accuracy is 89.54%. The maximum width of linear cracks is detected, and the highest detection accuracy is 99.3% while the average accuracy is **90.82%**.
- Using the influence area of cracks to calculate the pavement DR, the average accuracy rate can reach **90.57%**. The calculated DR index can directly guide the pavement maintenance decision.