Copper Sleeve Bad Spot Detection Based on Watershed Segmentation

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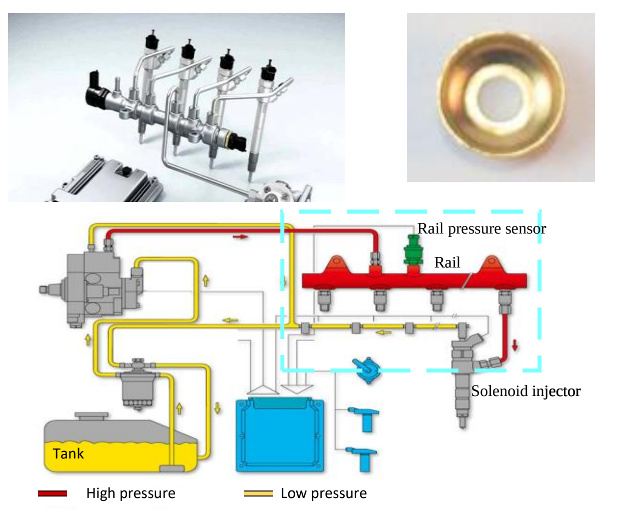
Introduction



High-pressure fuel line

The copper cap of the high-pressure fuel line in a car engine is one of the key factors affecting the safety and reliability of the engine's fuel system. Starting from the detection of surface defects in the copper cap, a copper sleeve defect detection algorithm based on watershed segmentation is proposed.

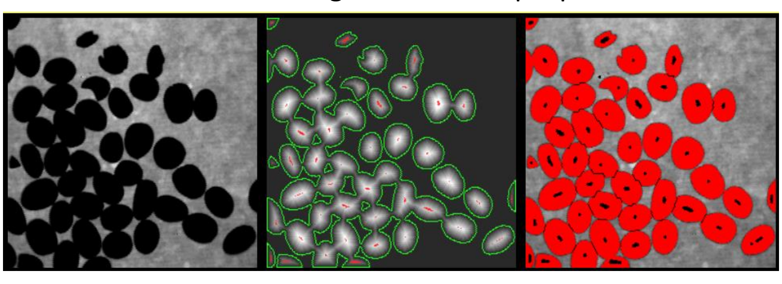


Figure 1. Coffee bean separation

Visual inspection process

- First, preprocess the collected characteristic images of the seals, then apply median filtering. Finally, locate the seals through the Hough transform and use edge tracking algorithms to detect defects in the seals.
- Use the watershed segmentation algorithm to segment the feature points data of the seal images, and use the watershed algorithm based on marked (mark) images to achieve better image segmentation effects, determining the areas of defects in the images.
- Through the Visual Studio software platform, establish the MFC experimental interaction interface of the detection system using the C++ programming language.

Watershed algorithm

The watershed diagram is shown in Figure 1. The watershed transformation maps the image matrix onto a topographic terrain, where each pixel value in the image corresponds to an altitude in the terrain map. The lowest areas of the terrain are called catchment basins. Water is poured into the catchment basins at a uniform rate, and as the water level rises, adjacent catchment basins overflow at the highest critical points. Dams are constructed at the overflow edges, forming what are known as watersheds.

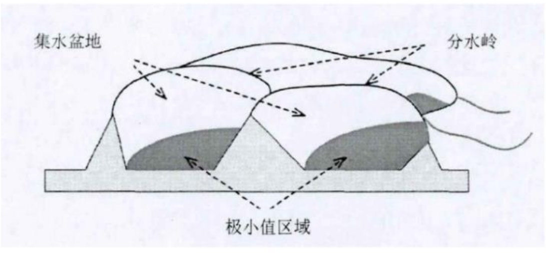
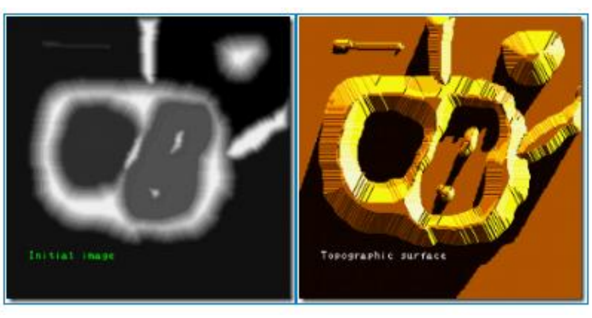


Figure2

Figure3



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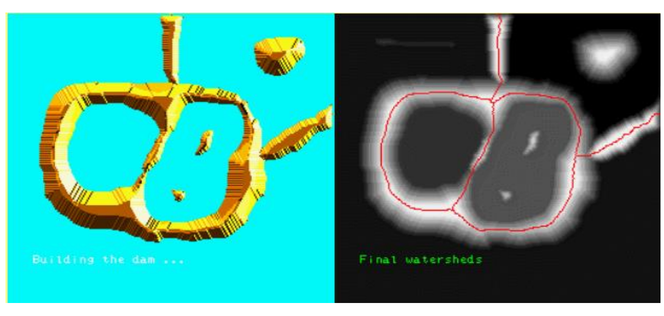


Figure4

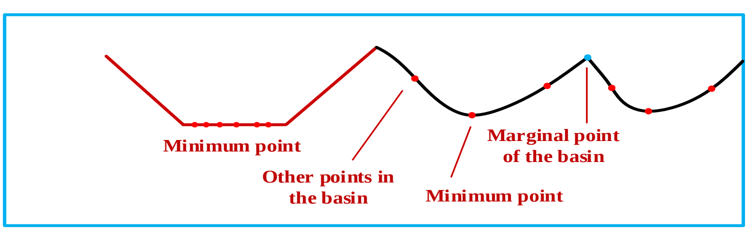


Figure5

1. A local minimum point, which corresponds to the lowest point in a basin.2. Other points within the basin, where a drop of water would converge to the local minimum point.3. Edge points of the basin, which are the points where the basin intersects with other basins, and where a drop of water would flow with equal probability into any of the basins. As shown in Figure 5.

Watershed transform

The minimum region of the image f(x,y) is represented by M1, M2…MR, and the catchment basin of the minimum region Mi is C(Mi). The minimum value of the gradient in the image f(x,y) is min, and the maximum value is max. If the set of coordinates (s, t) with g(s, t) < n is T[n], then:

$$T[n] = \{(s,t)|g(s,t)<n\} \qquad (1)$$

Where T[n] is the coordinate set of the points below the plane g(x,y)=n in g(x,y). The water level keeps rising from n=min+1 to n=max+1, and the corresponding topographic map is constantly flooded. Assuming that the minimum area Mi overflows in step n and the overflow depth is n, the horizontal plane area formed by the catchment basin C(Mi) is represented as Cn(Mi), where Cn(Mi) is the area of the catchment basin related to the minimum area Mi. Assuming Cn(Mi) is a binary image, the formula is:

$$Cn(Mi) = C(Mi) \cap T[n] \qquad (2)$$

If(x,y)∈C（Mi）and（x,y）∈T[n] ,then(x,y)point Cn(Mi) = 1,otherwise

$$Cn = 0 \qquad (3)$$

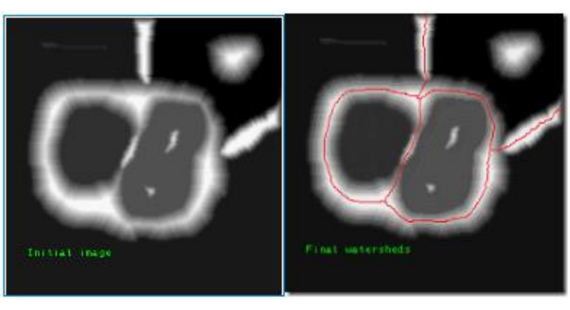


Figure 6. Watershed transformation diagram

Watershed segmentation

The phenomenon of "over-segmentation" exists with many small local minima points, which makes the segmentation result unsatisfactory and affects the actual recognition of the target. Using a watershed algorithm based on a marked (mark) image can effectively avoid "over-segmentation," as shown in Figure 7.

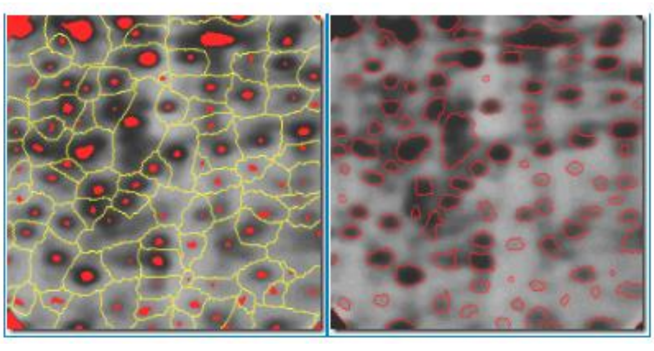
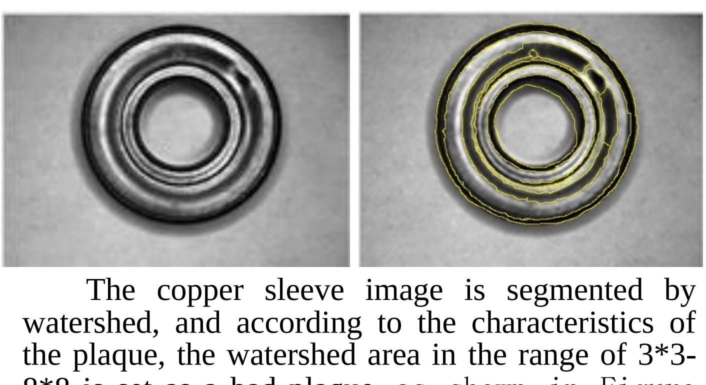


Figure7 Marker-based watershed segmentation

Figure 8. Bad class identification diagram



The copper sleeve image is segmented by watershed, and according to the characteristics of the plaque, the watershed area in the range of 3*3-8*8 is set as a bad plaque, as shown in Figure 8.

The bad spot result is shown in figure9 .


Figure 9. Bad spot segmentation results

Conclusions

This paper discusses in detail the design and implementation of a defect detection system for automobile engine high-pressure oil circuit seals based on watershed segmentation. In order to effectively improve the detection accuracy of seals, this paper combines the characteristics of seals with the shortcomings of traditional detection schemes, designs an optimized visual inspection system, and describes its hardware equipment and software algorithms in detail. One of the core technologies of this paper is the watershed algorithm, which uses image gradient information for regional segmentation. By simulating the process of water flooding the terrain, the minimum area in the image is divided into multiple basins, and watershed lines are established between the basins to achieve effective image segmentation. This system can not only improve the accuracy and efficiency of detection, but also adapt to the detection needs of different types of seals, providing strong support for the quality control of automobile engine oil circuit seals.

Acknowledgement

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