

Tiny Surface Defects on Small Ring Parts

Using Normal Maps



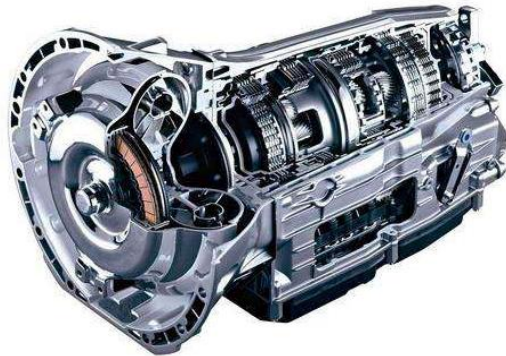
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誠樸雋偉 勵學敦行

CONTENTS

- 01 / **Introduction**
- 02 / **Overview**
- 03 / **Normal map reconstruction**
- 04 / **Defect detection**
- 05 / **Experiments**

1. Introduction



Detection of tiny surface defects
Ensure the quality of mechanical parts
The safety and performance of the car

1. Introduction



Laser, magnetic particle and ultrasonic
Machine learning based visual detection
Accurate and efficient high reliability

1. Introduction

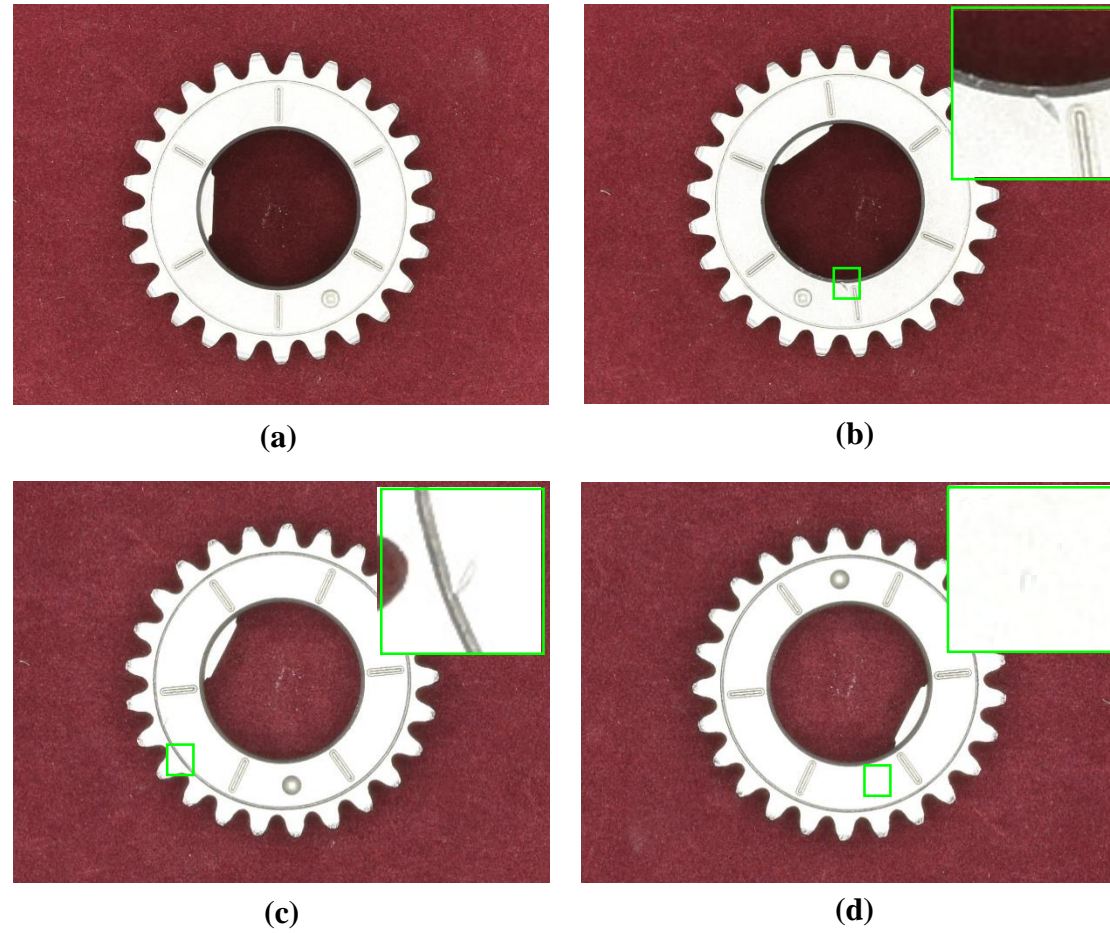


Fig. 1. Mechanical parts. (a) A normal part. (b-d) Parts with tiny surface defects. From the view of engineers, the scratch with over 0.5mm depth is considered as a defect).

2. Overview

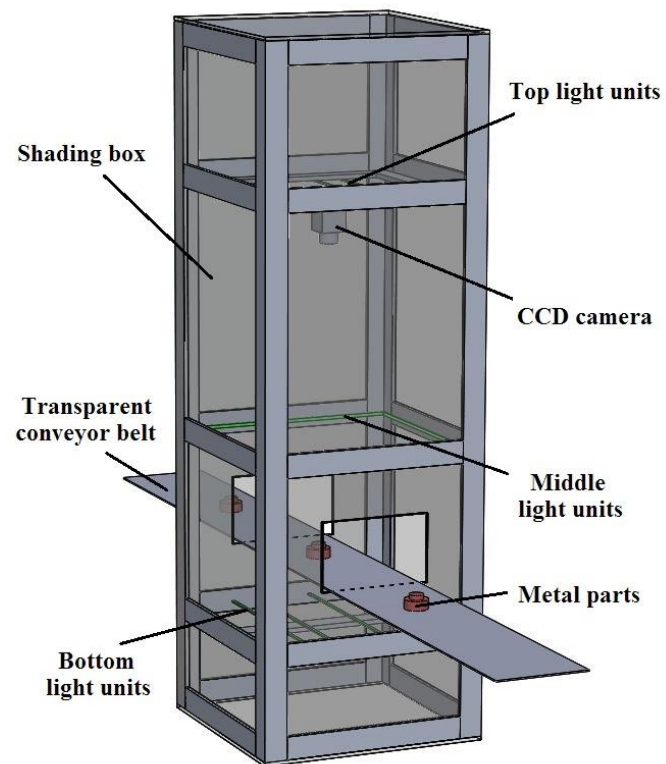


Fig. 2. Our image acquisition device. (The shading box is rendered with semi-transparency to explain the interior structure of the system.)

2. Overview

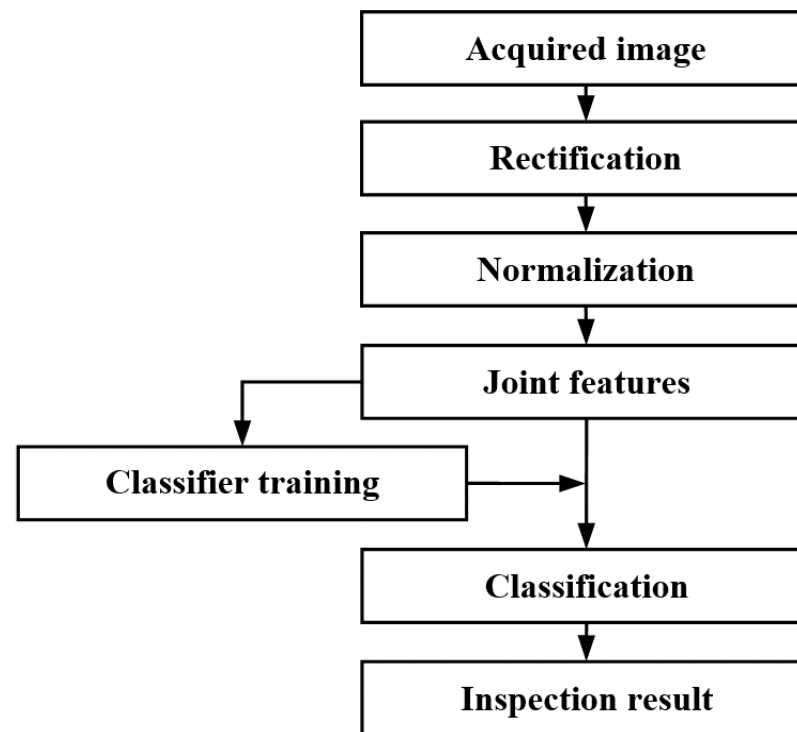


Fig. 3. Pipeline of the defect detection framework.

3. Normal map reconstruction



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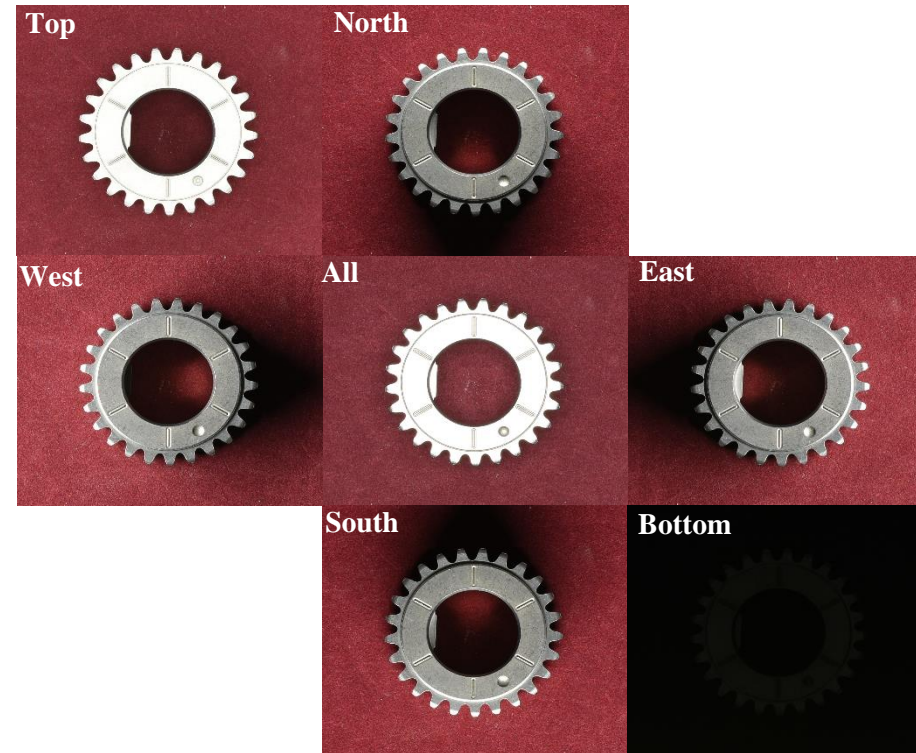


Fig. 4. Acquired images under the combined light units. (Top is meant to use only top light units. East is meant to use the eastern light units. All is meant to use top, middle and bottom light units)

3. Normal map reconstruction



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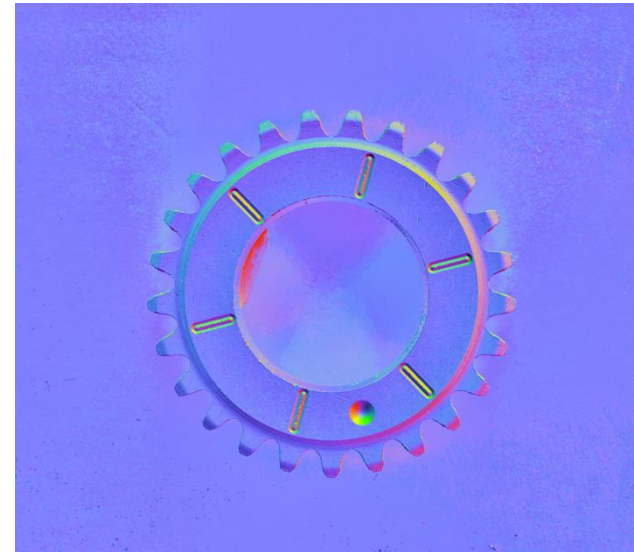


Fig. 5. The original image and its normal map (retain the details of metal parts without color jump)

4. Defect detection

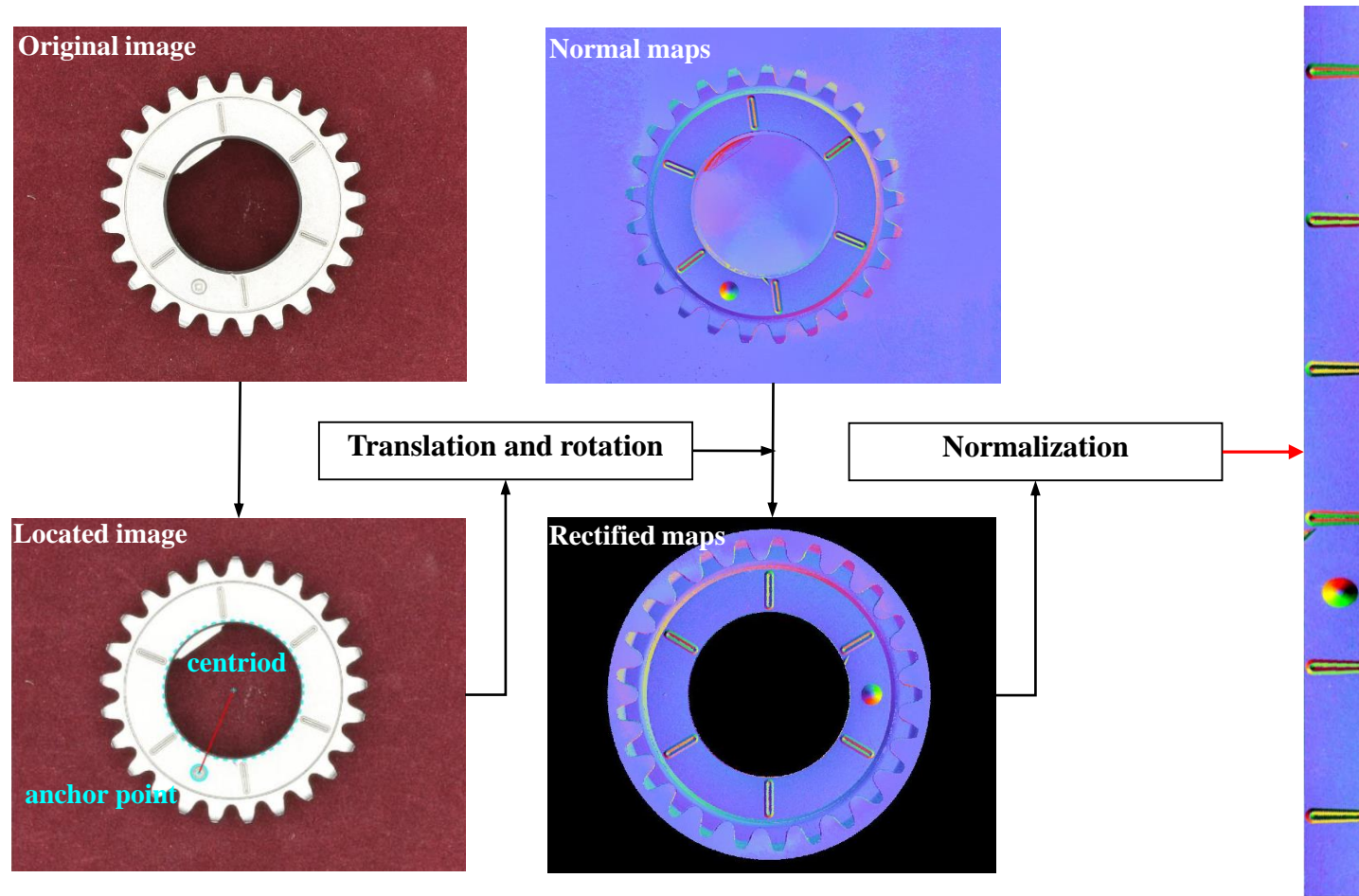


Fig. 6. Diagram of the normal information extraction.

4. Defect detection

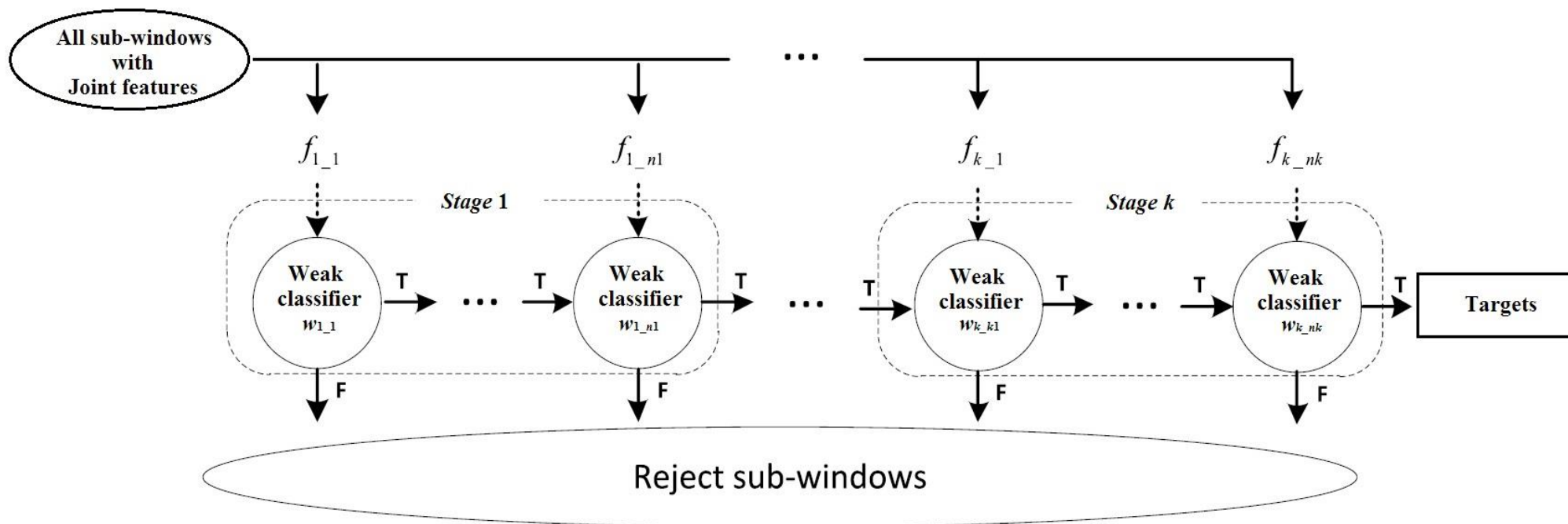


Fig. 7. Architecture of the cascaded detection process. (Joint features are LUV, gradient magnitude, LBP, and HOG.)

5. Experiments

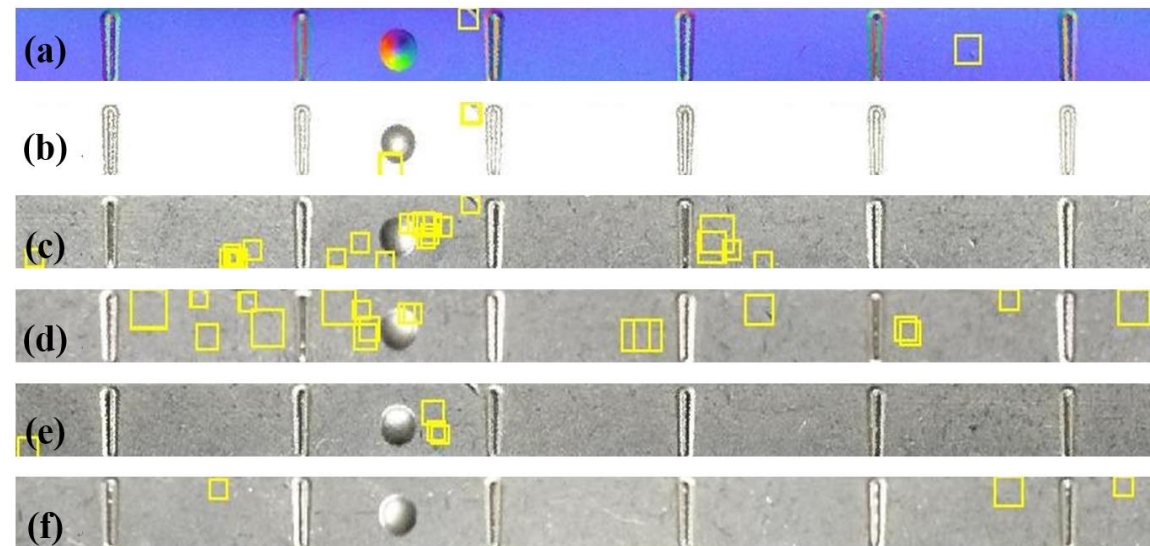


Fig. 8. Detection results of different images from combined light units. (a) Normal. (b) Top. (c) East. (d) West. (e) South. (f) North.



5. Experiments

Table 1. Detection results of different methods.

(HOG: the histogram of oriented gradients; GCCM: the gradient coded co-occurrence matrix; CNN: convolutional neural network)

| Methods | CDR/% | MDR/% | FDR/% | Speed/ms |
|---------------------------------|-------|-------|-------|----------|
| Cascade(Haar-like) | 81.20 | 9.80 | 23.93 | 11 |
| Cascade(HOG) | 92.31 | 7.69 | 12.82 | 17 |
| GCCM | 89.74 | 10.26 | 19.66 | 586 |
| CNN-based | 96.43 | 3.56 | 17.86 | 168 |
| Joint features+ Adaboost+SVM | 99.15 | 0.85 | 4.00 | 23 |

CDR: correct detection rate MDR: missing detection rate FDR: false detection rate

5. Experiments



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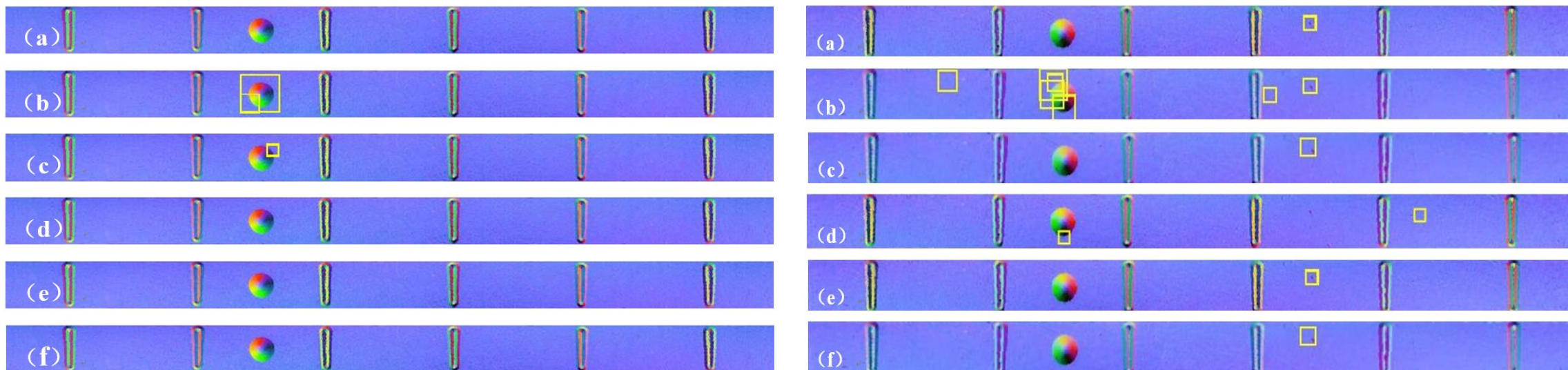


Fig. 9. Detection results of different methods. (a) Ground truth. (b) Cascaded detector with Haar-like. (c) Cascaded detector with HOG. (d) GCCM. (e) CNN-based. (f) Our method.

5. Experiments



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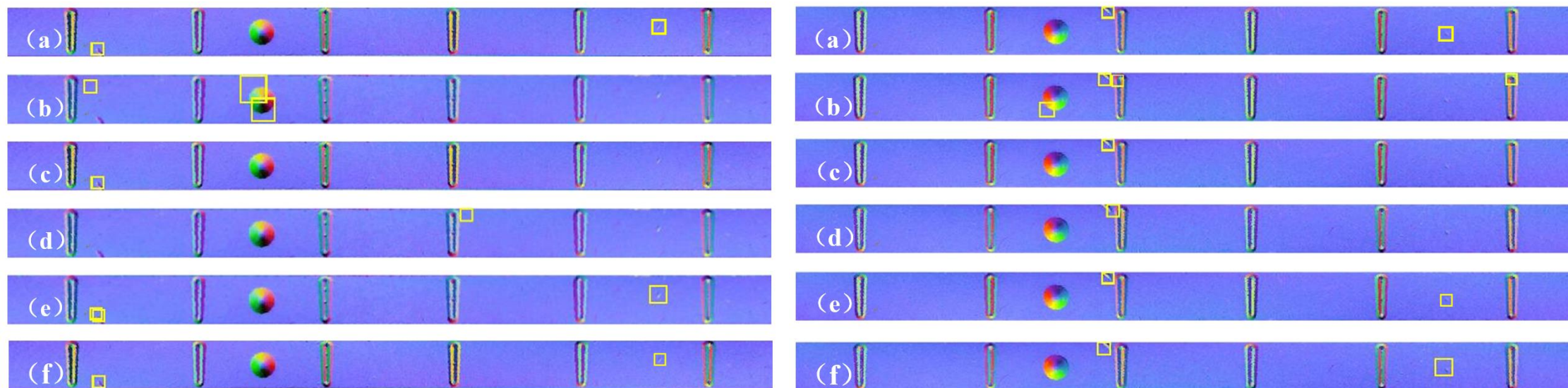


Fig. 10. Detection results of different methods. (a) Ground truth. (b) Cascaded detector with Haar-like. (c) Cascaded detector with HOG. (d) GCCM. (e) CNN-based. (f) Our method.

5. Experiments

There are three main reasons that make the visual detection framework have high inspection accuracy and speed.

- The cascaded detection approach is important to make the framework fast, which allows background regions to be quickly discarded while spending more computation on promising regions.
- Image normalization technology significantly speeds up the computation. About 90% of the background regions are filtered out by image normalization, and only 10% of the image regions need to be verified in the following module.
- The joint features are effective to capture the salient characteristics of the defects.

THANKS FOR YOUR TIME !



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