Light Field

ライトフィールドとは？光の進行を表現・情報化する仕組みについて ｜アドバンスドテクノロジーX株式会社

The defect detection method for automobile surfaces based on a lighting system with light fields

SPIE.

**The defects detection method for automobile surfaces based on a lighting system with light fields**

*Han Yu*, Wei Yin, Mingyu Li and Juntong Chen*
*Nanjing University of Science and Technology, Nanjing, Jiangsu Province 210094, China*
**yuhan@njust.edu.cn*

**INTRODUCTION**

During the process of automobile manufacturing and transportation, it is inevitable to cause automobile surface defects, such as scratches, sunken, blots, and so on. This will seriously affect auto sales and lead to huge economic disputes between transportation companies and consumers [1].

**Fig. 1** Automobile transportation and existing detection methods. **(a)** Cross-border transportation; **(b)** Manual inspection; **(c)** Computer vision inspection

In order to find automobile surface defects in time and take corresponding remedial measures, the automotive industry often uses the traditional inspection method i.e., manual detection. However, considering it takes 5-10 minutes to inspect each vehicle, a long and intensive manual inspection will reduce the accuracy and efficiency of defect detection [2].

**Disadvantages of current manual inspection:**

1. **The criteria for human vision are not quantified.**
2. **Manual inspection can only be completed by experienced workers.**
3. **A long and intensive manual inspection will reduce the accuracy and efficiency of defect detection.**

In this work, we designed a defect detection method for automobile surface based on a lighting system with light fields. Four groups of illumination in different directions were used to obtain high-quality defect images as input data of the YOLO V5 network for image defect detection and classification. In order to detect the defects of complex, and highly reflective areas of vehicles, such as metal wheel hubs and front bumpers, a multi-exposure fusion algorithm was used to obtain the fused images without overexposure so as to realize a more robust defect detection of automobile surface.

**METHODS**

Based on the intensity analysis as show in Fig.2(a), our defect detection subsystem consists of four pairs of lighting sources equally surrounding the camera. we adopted an upgraded the multi-exposure fusion (MEF) algorithm [3] to achieve high-quality image as input data of the YOLO V5 network [4] for image defect detection and classification.

**Fig. 2** Principle and procedure of defect detection system for automobile surface. **(a)** Analysis light intensity of different reflective surfaces; **(b)** Defect detection subsystem; **(c)** Synchronous interval scanning between adjacent subsystems; **(d)** The procedure of defect detection algorithm; **(e)** Defect detection system of the whole automobile surface.

Four groups of selected and detected results are fused as labels and outputs respectively. The recall of defect detection is determined by comparing the overlapping rate with threshold.

**Fig. 3** Evaluation of detection accuracy. **(a)** Manually marking defects in four images as a label; **(b)** Label fusion; **(c)** Detection results in four images as output; **(d)** Output fusion; **(e)** Recall calculation method.

**RESULTS**

To verify the actual performance of the proposed defect detection method, the subsystem is set up including four white LED lighting source and a camera(The Imaging Source_DFK 33UX226) with the resolution of 4000 × 3000.

We carry out defect detection for the black, brown, and white doors of the automobile, as well as the front windshield and wheel hub respectively. It can be seen from Fig.4 of the test results that our system can detect defects in various parts of the car surface and classify the detected defects into different types.

**Fig. 4** Defect detection results of different automobile areas.

**CONCLUSIONS**

In this work, we have designed a defect detection system of automobile surfaces based on a lighting system with light fields. Compared with the traditional detection method, our system can complete the collection and defect detection for the whole automobile surface rapidly and achieve more objective and reliable detection.

**REFERENCES**


[1]. L. Armesto, J. Tornero et al, "Inspection system based on artificial vision for paint defects detection on cars bodies", IEEE International Conference on Robotics and Automation, 1–4(2011).
[2]. J. Molina, J.E. Solanes et al, "On the detection of defects on specular car body surfaces", Robotics and Computer-Integrated Manufacturing 48, 263–278(2017).
[3]. H. Li, Kede Ma, H. Yong, L. Zhang, "Fast Multi-Scale Structural Patch Decomposition for Multi-Exposure Image Fusion", IEEE Transactions on Image Processing 29, 5805-5816 (2020).
[4]. J. Redmon, A. Farhadi, "Yolov3: An incremental improvement", Computer Vision and Pattern Recognition, 1804.02767(2018).


*Tracking No. PA22-PA110-43*

https://patents.google.com/patent/CN116839486A/zh

以设定的感兴趣区域ROI及待测构件关键特征为输入， 获取零部件初始图像后自动确定目标照度分布， 并反算多角度LED分区光源照明参数， 以实现自适应照明效果， 进而实现自动化、 高精度零部件视觉检测。

https://www.mdpi.com/2075-4701/13/5/861
V202にているドームで、最適照明配置シミュレーション

Defect Detection Method for Large-Curvature and Highly Reflective Surfaces Based on Polarization Imaging and Improved YOLOv11

https://github.com/Xavierman/Fusion-of-multi-light-source-illuminated-images-for-defect-inspection
https://ris.utwente.nl/ws/portalfiles/portal/278719723/10.1016_j.ymssp.2022.109109.pdf
In the extracted ROIs, defective regions are manually defined/labeled by human inspectors (viewing five multi-light source illuminated images) and then uniformly divided into a number of image patches
(200 × 200) as illustrated in Fig. 5(b). In addition, we include 3,600 and 900 image patches without defects (Normal) to the training
and testing datasets, respectively.
汎化性能のために、ROIをパッチに分割。

**绿色LED照明**：在检测金属、 玻璃和塑料表面缺陷时， 绿色LED照明能提供更高的对比度， 使缺陷更易被识别。

https://www.nature.com/articles/s41597-025-04454-6
**A dataset for surface defect detection on complex structured parts based on photometric stereo**

https://www.mdpi.com/2076-3417/14/6/2591
For this purpose, we analysed the variability in quantitative parameters (area and orientation) of damage obtained at different degrees of illumination for two different light sources: LED and conventional incandescent lamps. We calculated each image’s average illuminance and quantitative parameters of recognised defects. Each set of parameters represents the results of defect recognition for a particular illuminance level of a given light source. The proposed approach allows the results obtained using different light sources and illumination levels to be compared and the optimal source type/illuminance level to be figured out.