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# Detection of Cracks on Mobile Screen Based on Computer Vision

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**Abstract**—In this study, a computer vision-based identification system is established for the detection of cracks on mobile screen. By using a CCD (Charge Coupled Device) industrial camera, images of mobiles' screen on the industrial assembly line are obtained. For each mobile, the CCD industrial camera is revolved from several different viewing angles during detection of the mobile to avoid that cracks cannot be detected from specific viewing angles. Then the obtained RGB model images are converted into HSI color format. According to the obtained hue and saturation values, this system could accurately and effectively identify both large and tiny cracks on mobile screen, which demonstrates the validity of the machine system. This system could help modern industry for fast and effective cracks detection on mobile screen.

## 1. Introduction

Nowadays, smart mobile phone has become an essential device in our daily life, which serves the functions of communication, entertainment, study and so on. For the smart mobile phone, the screen plays an important role as displaying, human-phone interaction and some other fundamental functions. Right now, the screens are usually made of fused silica or sapphire, which makes the screen equip with high hardness. As for fused silica and sapphire, though hard they are, they are also fragile [1], so these materials could probably get damaged especially during the process of packaging. Therefore, some tiny cracks may exist on the mobile screen. What's worse, the screen may be even broken completely. These disadvantages would influence the imaging quality and the experience of users. As a result, the screen with cracks should be defined as defectives. So, it is important to accurately recognize the tiny cracks or the broken screens and filter them out.

Traditional ways like recognition with human vision is not able to identify minute rifts easily, and it would raise the labor cost. Besides, considering the high speed and large amount during mobile phone production, human vision is unreliable to a large extent due to the human eye fatigue in a long time of work. As a consequence, the accuracy of detection and recognition rate would gradually decrease, which indicates the unreliability of the human vision. The weaknesses above show that the traditional methods are not suitable for the case we have mentioned. Therefore, a new method with high precise and high speed is necessary for mobile phone screen defect detecting. Among many new methods, machine vision has been already successfully employed in many situations of defects recognition with high accuracy, high automation and fast speed [2-5]. S. Liang and his coworkers [6] used an extraction and classification algorithm to detect concrete crack based on machine vision, which could effectively and accurately extract crack images and classify various kinds of cracks. D. Wang and his colleagues [7] proposed a machine vision-based monitoring method for detecting the fatigue cracks



in U-rib-to-deck weld seams, and it proved that their methodology was of great promise. S. Lan et al. [8] presented a method of defect recognition of ceramic crack aided by computer and made the classification of cracks more reliable and efficient.

Aiming at the problem caused by the disadvantages of human and according to the success made by machine vision, a computer vision-based identification system is established for the identification of cracks on mobile screen in this study. By using a CCD (Charge Coupled Device) industrial camera, the images of mobiles' screen on the industrial assembly line are obtained. In order to avoid the cracks not detected from specific viewing angles, the CCD industrial camera is designed to be revolved from several different viewing angles during the detection of the mobile. Then, the obtained RGB model images are transformed into HSI color format. On the basis of the obtained hue and saturation values, the characteristic of cracks' region on screen could be identified. This system can help modern industries to quickly and effectively detect cracks on mobile screen.

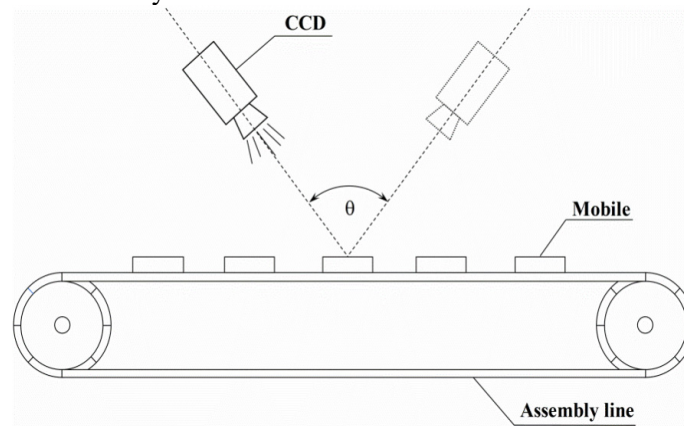


Figure 1. The diagram of machine vision cracks detection system for mobile.

## 2. Experimental Setup

Fig. 1 shows the defection setup of the machine vision system in the production line. CCD has been famous in all kinds of fields for its high signal-to-noise ratio (SNR), small pixel sizes, low light levels and other strengths [9]. Therefore, the CCD (2048×1536 pixels, frame rate of 12 fps) was chosen to be the key component of our detection system.

After obtaining the original images of cracks by the CCD industrial camera, they are decomposed through which the RGB parameters are obtained. In order to reduce the effect of poor illumination situation in the production lines, the obtained images based on RGB model are converted into HSI format. The RGB to HSI model is calculated by the equations as follows [10],

$$\theta = \arccos \left[ \frac{(R-G)+(R-B)}{2\sqrt{(R-G)^2+(R-G)(G-B)}} \right] \quad (1)$$

$$H = \begin{cases} \theta, & G \geq B \\ 2\pi - \theta, & G < B \end{cases} \quad (2)$$

$$S = 1 - \frac{3\min(R,G,B)}{R+G+B} \quad (3)$$

$$I = \frac{R+G+B}{3} \quad (4)$$

As the intensity is related to the illumination, and this is exactly the factor which is supposed to be mutative, only the hue and saturation are mainly concerned. As a result of the difference between cracks and perfect areas, we set thresholds for both hue and saturation.

According to the thresholds, the image segmentation from the hue and saturation diagram is carried out. If the screen is perfect, the hue values of the obtained images should range between the thresholds which had already been set. Otherwise, the cracks area would have hue values beyond the threshold

during the process of detection. Finally, the same pixel areas are connected according to the region with cracks being presented. After that, the division is completed and the results are exhibited.

We had carried out several experiments, and we found a fact that due to the existence of the crack in the screen, air gap clearance would be formed. Once the light irradiated on the cracks, it would be reflected and scattered randomly as a result of the different refringence between air and the components of the screen. From specific viewing angles, the cracks probably could not be detected. To solve this potential problem, the CCD industrial camera needed to be revolved from several different viewing angles.

### 3. Results And Discussions

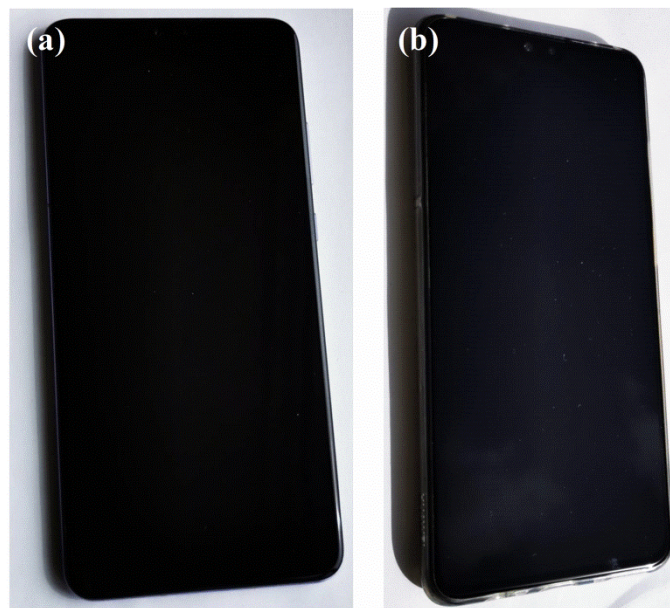


Figure 2. The images of undamaged mobile screen in different view angles.



Figure 3. The detection of large crack by the machine vision system



Fig. 2 shows the images of a certain type of undamaged mobile screen in two different view angles. It is found that the mobile screen looks in perfect condition from both two different viewing angles. However, if there were cracks, they could probably not be detected in specific viewing angles, which are shown in the pictures below. Therefore, all the mobiles in our experiments had to be detected from a series of different viewing angles by the CCD industrial camera. These two images were selected from the series of images from different viewing angles.

Fig. 3 exhibits the procedure of mobile screen with large crack by the machine vision detection system. A big crack existed at the central of the screen, which was nearly perfect if it was detected in the orthophoria view angle, as presented in Fig 3(a). Therefore, this big crack might not able to be recognized if the CCD industrial camera took picture from only one angle. Once the CCD industrial camera was revolved from a different viewing angle in Fig. 3(b<sub>1</sub>), the mobile crack emerged. Therefore, it is obvious to explain the main reason that the CCD industrial camera needed to change its position from time to time. Fig 3(b<sub>2</sub>) distributes the detection result of the mobile crack marked by the red lines. It is demonstrated that the machine vision detection system is effective for large mobile cracks recognition.

In order to further verify the validity of the machine vision system for the tiny cracks detection, more experiments were carried out. Fig. 4 displays the identification of mobile screen with tiny crack by the machine vision detection system. In this case, a small fissure existed at the bottom of the screen. Similar to the situation of large crack, the tiny crack was undetectable from a certain angle, as shown in Fig. 4(a). After rotating the CCD industrial camera by a specific angle, the tiny crack turned to be observable in Fig. 4(b<sub>1</sub>). Using the same method, the tiny crack was marked by the red line successfully as well. It is further demonstrated the validity of the machine system that this system is effective for both large cracks and tiny cracks.

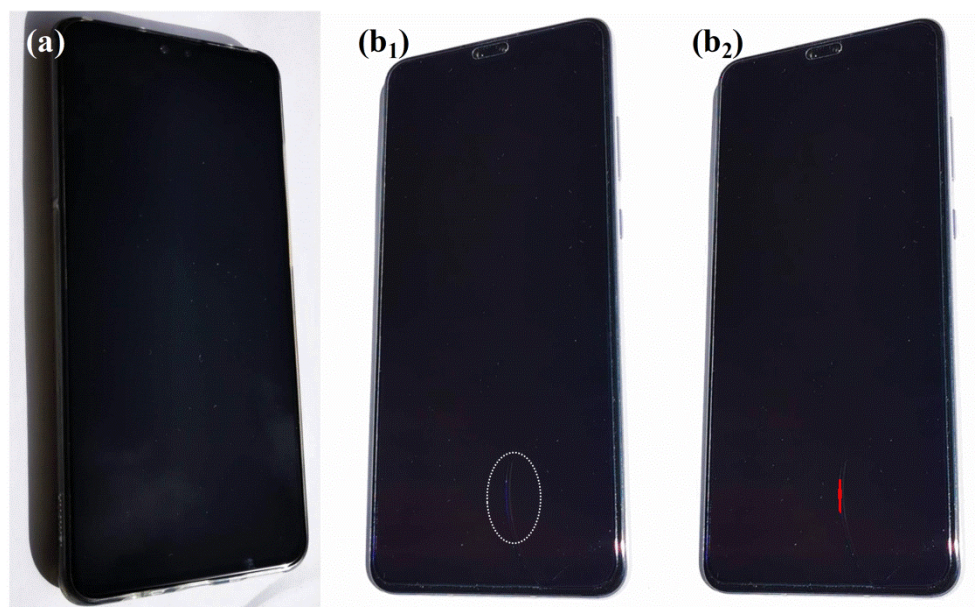


Figure 4. The detection of tiny crack by the machine vision system

#### 4. Conclusion

In conclusion, we establish a recognition system based on computer vision to identify the cracks on mobile screen. The CCD industrial camera is used to obtain a series of images on the production line in real-time. In order to avoid the inability to detect cracks from specific viewing angles, the CCD industrial camera is revolved from several different viewing angles during detection of the mobile. Then, the obtained images are converted into HSI color format to reduce the effect of environmental

brightness. The characteristic of cracks could be identified according to the corresponding threshold of the hue and saturation. This machine vision could greatly improve the production efficiency and the degree of automation for cracks detection of mobile screen.

### Acknowledgment

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