Design of Crack Detection and Measurement Using 2D Laser and Camera on Moving Vehicles

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ABSTRACT

Detecting cracks and measuring displacements is an important issue in road management. However, most of the existing studies have difficulty in accuracy of measurement for practical applications that require timely processing. In this paper, we propose a sensor fusion system for road crack detection and measurement on a moving ground vehicle. It is designed to detect various cracks using camera images and to measure the width and depth of cracks by mapping 2D line information synchronized to the camera image. This method can be used with a road monitoring system that requires higher level of accuracy and timely processing.

KEYWORDS

Sensor Fusion System, 2D Line Laser, Clustering, Crack Detection, Crack Measurement

1 INTRODUCTION

Cracks are a potential risk to the road safety. Due to the characteristic of cracks becoming wider, detecting cracks and measuring displacements on road is essential for road management. The level of road risk can be evaluated for accurate diagnosis by tracking the length, width, depth and severity of a crack [1].

In this paper, we propose a sensor fusion system that combines a camera and a 2D line laser to achieve more accurate detection and measurement of road surface cracks on a moving ground vehicle.

The camera image data is effective in accurately detecting various cracks by applying it to object detection technology based on rich color-based surface information. However, the camera image based approach inevitably has difficulty in limitation of measurement because there is no depth information. On the other hand, 2D line data based detection approach may cause the distortion of crack length or low visibility due to a change in the speed of a moving ground vehicle. Compared to the camera, conversely, 2D line laser enables accurate measurement of the width and depth of cracks through the coordinates of the lines of the surface collected in real time. Thus, the limitations of the camera are made up for by the 2D line laser. Our proposed sensor fusion system is designed to detect various cracks and measure the length of cracks from a camera image and to measure the width and depth of cracks by mapping 2D line information synchronized to the camera image.

The rest of the paper is organized as follows. In Section 2, we present recent works in the detection and measurement of cracks. In Section 3, we design our sensor fusion system on moving ground vehicles. We conclude in Section 4.

2 RELATED WORKS

With the advancement in computer vision and artificial intelligence field, recent techniques have been proposed for the crack detection and measurement [1-2]. The most common method uses image-based crack detection techniques which are based on image processing or machine learning. In [2], the authors presented a crack detection and measurement using a single camera. They focus on the classifying the crack shape and measured the length and width of cracks. [3] also proposed a deep learning-based approach (fully convolutional network) to crack detection and analysis. They utilize morphological features to measure the width and length of the cracks.

However, the camera image based approach inevitably has difficulty in accuracy of measurement because there is no depth information. Some techniques have attempted to identify and quantify the cracks by considering the depths of cracks based on 3D information from various sensors such as LiDAR [4]. However, they require significant processing time than 2D techniques and thus are unsuitable for real-time monitoring systems that require timely processing [5].

3 SENSOR FUSION SYSTEM FOR CRACK DETECTION AND MEASUREMENT

In this paper, we present a sensor fusion system combines a camera with a 2D line laser to achieve more accurate detection and measurement of road surface cracks. It is designed so that two data can be mapped with time by fixing a 2D line to be displayed at the center of the camera's FOV as shown in Figure 1.

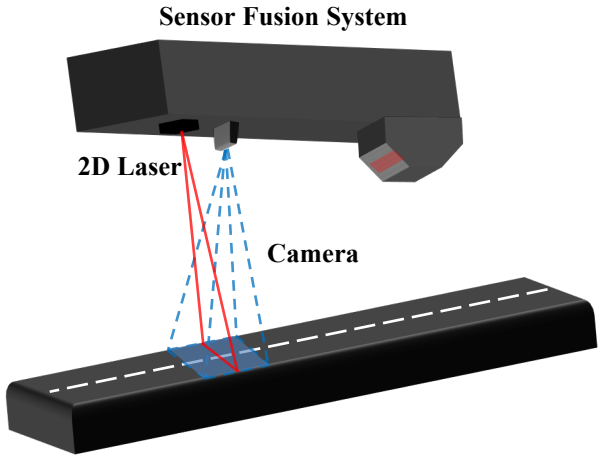

Figure 1: The overview of sensor fusion system

We use a 2D line laser which enables the vehicles to collect line data rather than a single point at high speed. The single-line data consists of a set of relative coordinates X and the depth coordinates Z of a crack from the road surface. Our system stores and manages these line data by formatting them as a pair with the time they were collected.

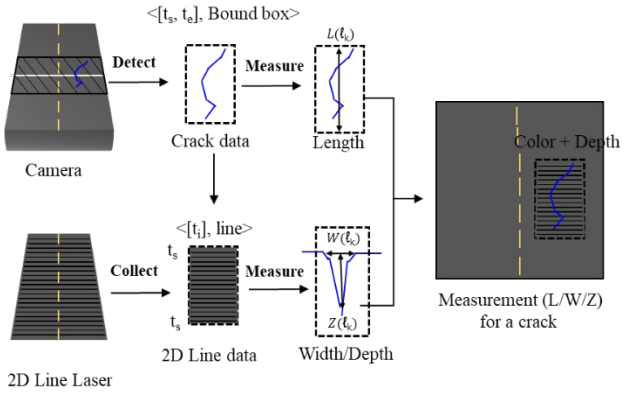

Figure 2: The crack detection and the measurement phase

Our system operates in two phases: the crack detection phase and the measurement phase as shown in Fig. 2. First, the cracks in the road are detected in the camera image using the object detection model. Whenever the detector detects a crack, the system can get bounding box information for that crack. The synchronization algorithm calculates the start time (Ts) at which the lower point of the bounding box passes through the center of the camera and the time at which the upper point of the bounding box passes through the center of the camera (Te). The crack color information can be mapped to depth line information synchronized through the start time and end time of the calculated crack data as shown in Algorithm 1.

Algorithm - Sensor Data Synchronization

```
while sensors fusion on do
    if detect the crack then
        make the bounding box
    end if
    if the bottom of the bounding box comes to the center then
        Ts ← currentTime
    end if
    if the top of the bounding box comes to the center then
        Te ← currentTime
    end if
    if Te > Ts then
        lines ← Get Line From 2DLaser (Ts, Te)
        Width, Height ← Measure(lines)
    end if
end while
```

4 CONCLUSIONS

In this paper, we proposed a methodology to detect and measure the road surface cracks on a moving ground vehicle. The system consists of a camera and a 2D sensor. The proposed method detects cracks through camera image data, and improves the accuracy of measurement using crack's width and depth information based on 2D line data.

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