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Railway track monitoring using drones

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Abstract. In recent times, the use of drones to monitor various types of transportation lines has attracted more attention. Unmanned aerial vehicles (UAVs) have a number of potential benefits over manual methods for inspecting transportation lines due to its permit scalable, quick, and affordable solutions to tasks that would otherwise be unsuitable for individuals who are subject to fatigue and measurement uncertainty. Therefore, the current study investigates the use of drones in image processing, early warning and situation assessment in the transportation sector. Due to their ability to capture aerial images in extremely high resolution at a low cost and while also covering large areas, drones are a very important source of visual data. The main goal of this work is to collect and analyse drone-shot images using MATLAB software in order to locate the line's fault and take the necessary corrective action to prevent accidents and save lives. The results of the current work concluded that the using of aerial image processing is very effective to increase and maximize the capacities of the transportation lines. Moreover, it gives more safety for the lines. UAV can survey and take pictures of the railway line for a distance of about 8.4 km in one hour, whereas a worker would need a full day to cover the same distance (a worker scans a distance of 7 km per day), so it saved time and effort.

Keywords. Image processing, transportation track, lines, Canny Edge Detection and monitoring.

1. Introduction

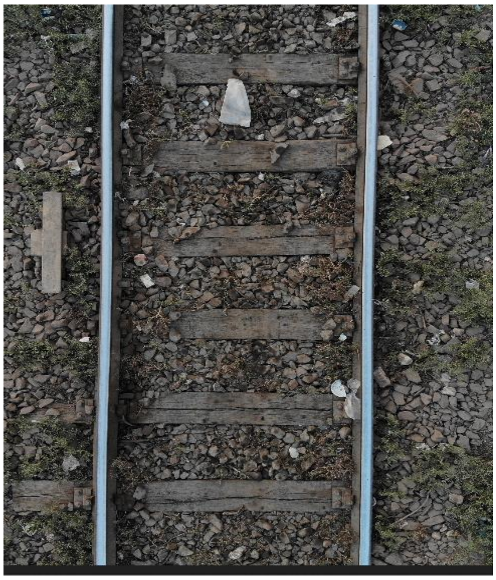
Railway track inspection consider one of the most important activities in railway operation and maintenance of a railway network[1] . One of the major technical challenges to ensuring the safety of the railway operation is the detection of railway intrusion objects[2]. The problems with operational security are surfacing more frequently now [3]. Railway system managers are working harder than ever to develop a precise and interactive system to detect current and possible destruction to railway transportation system. This entails gathering data of the highest caliber to stop accidents. Additionally, choices are made regarding the planning and prioritization of railway line maintenance, repair, and renewal. Recent years have seen an increase in the use of new methods for object diagnosis, such as Unmanned Aerial Vehicles (UAVs). C. Specht, W. Koc et al describe how to assess the railroad track geometry using satellite measurements [4]. As opposed to that, UAVs can be used to analyze bridges [5] and building exteriors [6]. UAVs have proven to be a very effective tool for completing these tasks because they can continuously monitor railway line segments. The major benefit of such a solution over conventional assessments using assessing vehicles is the removal of reduced train traffic, allowing trains to operate at their fullest capacity. UAVs can be outfitted with the best imaging hardware and a variety of sensors, enabling users to record data that is useful for both practical purposes and scientific research [7]. Because of the superior visual clarity and unique on-board flight adjustment systems, the measurement can be achieved with an precision of fractions of a millimeter to a single millimeter [8]. The UAV imaging system can detect and analyze a variety of railway infrastructure flaws [7], including rail burns, squat position, splits or head checking, and sleeper cracks. tracking misalignment. The article focuses on the image detection of defects in sleepers in particular because they effectively stop regular train traffic. Standard fault detection systems typically employ laser, magnetic, eddy current, or ultrasonic techniques to identify various rail infrastructure defects. [7]. The presented approach uses the image that have been taken from the UAV camera and analyzed by MATLAB software to detect the defects in timber sleepers. The damaged sleeper can be replaced with another one to overcome serious accidents in traffic services and a decrease train capacity, such as what happened before in the Cairo-Mansoura train accident at Toukh station before 2021.

2. Study Area

The presented research was carried out at Toukh station in order to detect the cracks on timber sleepers of railway track.
Toukh station is located on Cairo – Mansoura line near Banha city.

3. Experimental work

Professional UAVs equipped with Ultra 4K camera systems with UHD video capture capabilities, or Ultra High Clarification, with a pixel density of 4096 x 2160, at different image quality, and a variable viewing process, either horizontally or vertically down, based on the item being examined. With such spatial precision, it is possible to detect faults in the operating edge of the rail top flange, contours on the sleepers, fastener and rail connection implementation quality, and possible damage to the surface or structure of tunnels and bridges. [2]. This is an important function for inspecting a railway track and its associated infrastructure. Figure (1) depicts the results of an examination on these tracks performed by a pro Mavic air UAV equipped with 100 M-Pixels resolution optics and hovering over a height of 17 m above the railway tracks of the study area. Figures (1a–1d) display following widenings of the similar segment of the station along the tracks.



[a] [b]

[c] [d]

Figure 1. UAV imaging investigation of the station's track: a) an image of a track segment, and b), c), and d) subsequent enlargements of the image of this track segment.

4. Sleepers' Crack Fault Detection

The procedure for the recognition of crack faults in sleeper presented in the article, as shown in Figure 2, contains two main portions:

- plucking out the sleeper from the track, and
- defect detection in the sleeper using Canny Edge Detection Filter (CEDF).

4.1 Canny Edge Detection Filter (CEDF).

The Canny function is a new type of edge detection operator. It has decent edge detection performance and a wide range of applications. The Canny operator edge detection seeks the image gradient's partial maximum value. The gradient is calculated using the Gauss filter's derivative. The Canny operator detects powerful edge and poor edge using two thresholds. And only when the powerful edge is connected to the poor edge will the poor edge be included in the output value[9].

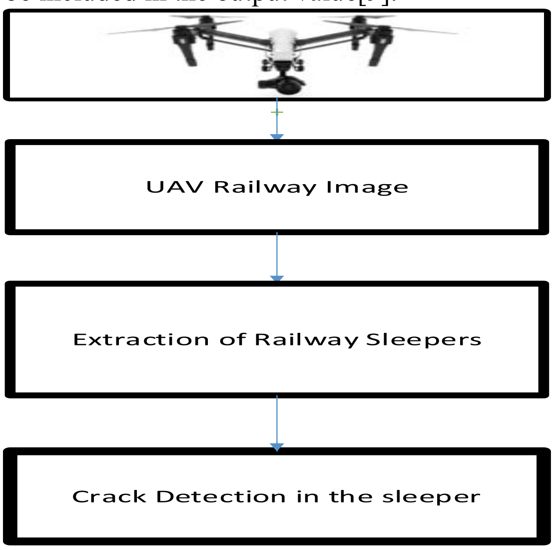


Figure 2. Structure of the described procedure for finding crack faults in sleepers.

5.Detection of failures in railway sleepers using MATLAB software.

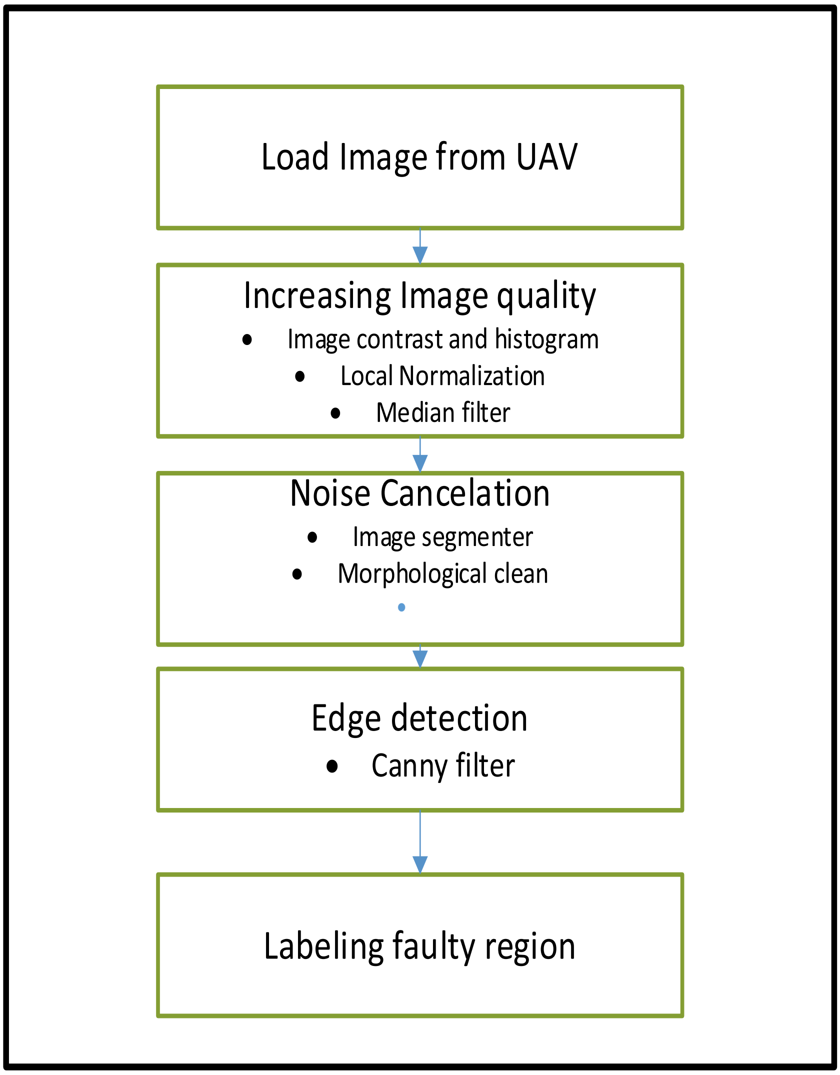


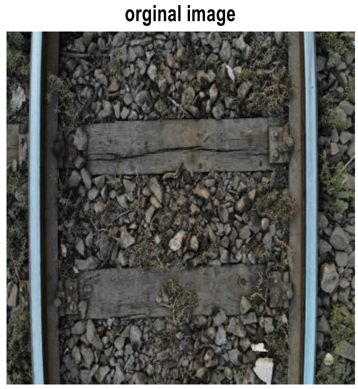
Figure 3. Image Processing Algorithm[10].

6.THE PROPOSED METHOD

The specifics of the proposed work's implementation are covered in this section. The proposed work employs the image's connected component method. study area of the railway track is captured. A camera on a UAV that is viewing the railway track can be utilized for getting images. The top view of the timber sleepers must be present in the railroad track image in order to detect cracks. The technique substitutes automatic inspection for manual inspection of the track section. A computer which has Intel(R) Core (TM) i7-9750H CPU 2.60GHz and 64-bit operating system features is used to perform the software analysis.

6.1 Steps of getting cracks in timber sleepers by MATLAB software

- importing the image into the MATLAB software.
- image enhancement is created to improve the image quality as shown in figures (4a-4d).



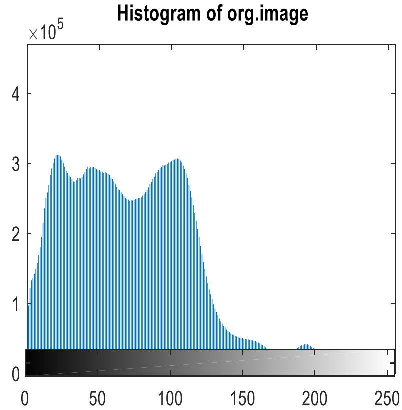
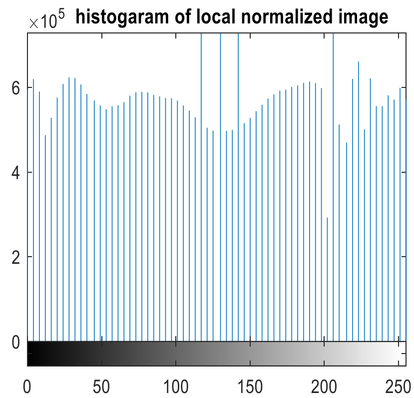
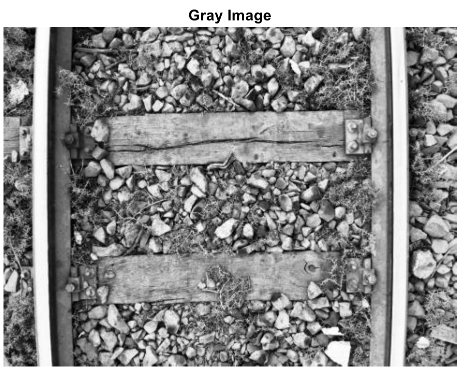


Figure 4. (a) original image (b) original image's histogram.



(c) Enhancement image (d) Enhancement image's histogram

- convert it to grayscale and binary (black and white) as shown in figure (5).



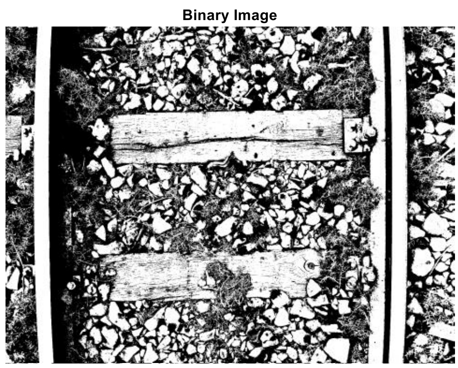


Figure 5. (a) Gray scale image (b) Black and white image

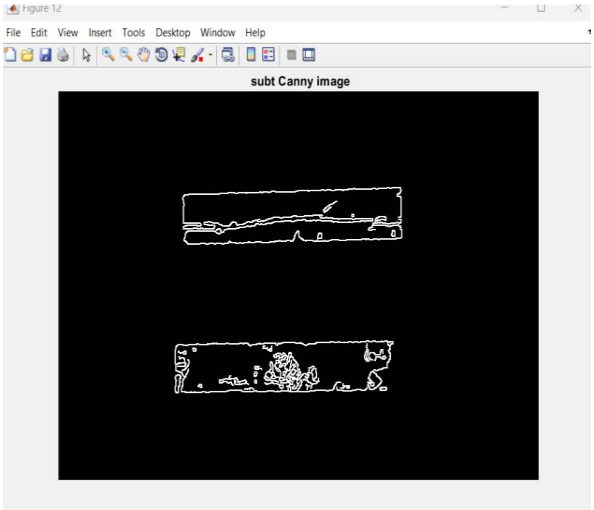
- apply image segmentation to extract the region of interest as shown in figure (6), and

Figure 6. Image segmentation of interest region (sleepers).

- Apply Morphological clean to cancel noise as shown in figure (7)

Figure 7. Image after Morphological clean.

- use a Canny filter to find sleeper cracks so that the sleepers can be changed as shown in figure (8)



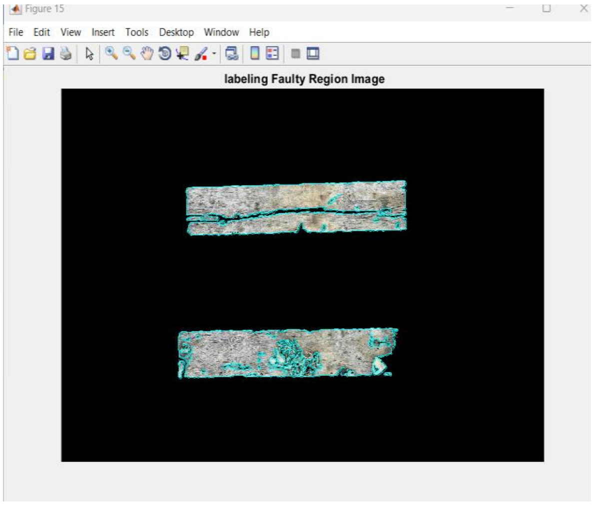


Figure 8. (a) Image detection using canny filter (b) Labeling the faulty regions image

6.CONCLUSION

The present work investigates the use of drones in image processing, early warning and situation assessment in the transportation sector. Due to their ability to capture aerial images in extremely high resolution at a low cost and while also covering large areas, drones are a very important source of visual data. It is concluded that:

- the UAV can be used to capture images along the track, which can then be fed into the suggested system to look for cracks. This will lessen the likelihood of any mistakes happening by making cracks easier to spot immediately.
- UAV can survey and take pictures of the railway line for a distance of about 8.4 km in one hour, whereas a worker would need a full day to cover the same distance (a worker scans a distance of 7 km per day), so it saved time and effort.
- The system's maximum efficiency can be guaranteed because it increases safety, reduce costs and speed up maintenance processes and it would be automatic and require less manual intervention[11].

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