Detect of Railroad using Image Processing and Applying it on Syrian Railways

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Abstract - *Recently, the use of computer vision has increased in all fields. It helps in detecting objects, and faults in railway transport systems. It can also assist in monitoring that status of the railway using data obtained by cameras and smart sensors. Given the importance of rail transport in general, and in Syria in particular, efforts are being made to develop monitoring systems to allow monitoring the railway, especially after the Syrian railway network was sabotaged. In this research, a database was adopted to perform digital image processing operations, which consists of real video clips that were captured through a camera installed at the front of the locomotive for one of the railways in Syria, in order to discover, identify and monitor the two lines of the railway network. A series of digital image processing applications have been used on images clipped from a video file, and the rail line bends have been detected under various lighting conditions. The experimental results have been analyzed and it has been shown that the proposed method has accurate and effective results.*

Key Words: Computer Vision- Curve Detection- Image Processing- Railway Detection

1.INTRODUCTION

Monitoring the status of railways has a direct effect on the safety of the track. This task is usually provided in a manpower-based manner. However, there are some disadvantages in terms of cost and good results1. In recent years, technological progress has led to the development of manpower-based methods in this field. With the lower costs for computers and electronic devices and the development of software technologies, railway monitoring techniques provide more effective and reliable results. There are many studies in the field of railway computer vision monitoring2,3. image processing is a branch of computer science Informatics, concerned with performing operations on images with the aim of improving them according to specific criteria or extracting some information from them.

Rail transport is one of the commonly used modes of transport. Compared to other modes of transportation, rail traffic is very important. Multiple locomotives run continuously on one or two lines4. In spite of various and various research efforts in this field, there are still difficulties regarding images processing of complex scenes with changing lighting conditions, low contrast, blurry backgrounds5. Other difficulties exist when it comes to detect lines Rail-road using image processing and recognition systems6. Most research focused on studying two directions: the first direction depends on to distinguish the railway lines in order to monitor their conditions7. The second direction depends on the use of digital image processing techniques and computer vision in railway networks within smart systems8.

As in any digital image processing system, choosing the color space for processing constitutes is the most important stage. In this study, a new method based on image processing using Python and OpenCV environment is presented to detect railways. The proposed method consists of three main parts including preprocessing and feature extraction. At the start, traditional image processing methods were used, which are consisting of six successive stages: get the image (image acquisition) By a light sensor (for example, a camera, a laser sensor, etc.). pretreatment (pre- processing) Such as filtering the image from noise or converting it to a binary image cropping image (segmentation) To separate important information (eg any object in the image) from the background. Feature extraction (features extraction) or attributes.

Features rating Link it to the pattern you return to and identify patterns.

Understanding the picture (image understanding).

Then Canny Edge algorithm is used to detect and extract the edges of the railway. Finally, the Hough transform method is used in the processing stage of the extracted features. As a final result, the railroad tracks are obtained clearly and with great accuracy on the image. Taking into account the slope of each straight line and thus, the railways are revealed. The proposed image processing method in this research is very

fast, as it was found that the proposed method gives quick and successful results.

1.1 Previous studies:

Many studies exist to detect the two-line railways. Karakose and others proposed a way of seeing the railway to determine the lines and their bends1. In this study, a computer-based visual rail condition monitoring is proposed. By means of a camera placed on top of the train the rail that the train is on and the neighbor rail images are taken. Singha and others explore the possibilities of computer vision-based monitoring through drone imagery. The experimental results ensured that the proposed method provide high reliability and accuracy10. The discovery of the railway components was carried out as in11, 12.

The researchers here detected failures in real time on the railway surface by developing a contactless method based on image processing. The railway surface was detected by extracting a portion of the railway images. The faults of the detected rod surfaces were determined using the contrast enhancement method. This method only allows detecting the surface of the rail and identifying surface faults13.

Trinh and others suggested an integration and optimization method with multiple sensors for railway inspection14. In the proposed method, distance measuring devices were used to identify railway objects with multiple cameras. With this method, failures such as parts defects, alignment, surface failure and inclination were identified during rail inspection.

2. Materials and Methods:

2.1 Research importance:

Computer vision-based railway monitoring methods are possible using data obtained with the help of computers and the digital processing of the captured images. This research proposes to monitor the state of the railway visually by means of a camera placed on the top-front of the train. The track on which the train is running, and the pictures of the neighboring railways are captured. Edge and feature extraction are applied on the captured images to identify the rails.

The contribution of this research lies in restoring the safety of the traffic of the Syrian railway network, because of the global and local importance of rail transportation. This will help running freight and passenger trains to the maximum capacity over these railways. The video image processor is a combination of methods that are extracted to process the data provided by the imaging sensor which is a camera placed at the front-top of the train15.

The operator sets several railroad detection areas within the field of view for the camera. Then, real-time image processing algorithms are applied to these regions in order to extract the required information, such as the path of the two railway tracks and the curves of the track. The advantages of this method are that the camera is mounted to the front of the locomotive rather than to the road. In this way, detection defects caused by shadows, weather and reflections can be overcome.

2.2 Search objective:

Applying real-time image processing algorithms using Python and Open CV library to discover fails in the two railways a moving locomotive using camera fixed on the front-top of it.

This research comes from the requirements of the railway reality in the Syrian Railways General Corporation to achieve the safety of rail traffic. This is important to guarantee reliable rail transportation of shipping goods and fuel, especially the Syrian Railways General Corporation is carrying a massive reconstruction and rehabilitation of the railways, after the huge damage they suffered from because of the current conflict in country. Hence the importance of this research is to achieve optimal control of the railway with tracking bends, through the digital image processing using real time camera.

The novelty in this research lies in discovering the two railways in a clear way, with the focus on detecting bends during the movement of the train, in real time, by installing a tracking camera on the head of the train.

2.3 Search method:

The captured images of the railway are processed using Python and Open CV library. ..Each video frame is converted into a series of images. The images are sent through a set of filters and convert them into digital images (frames) In order to optimally determine the two railway lines with the bends of the lines through a set of stages, but at first a set of pre-treatment operations is carried out.

2.4 Initialization:

In order to reduce the human input and the number of parameters required, an initialization process is carried out for each train. After that the system will keep the configuration file and update it automatically. The only human intervention required during this process is to determine the gap between the rails and the left rail start position, as explained below, at which point a trigger is used.

2.5 Determining the starting position of the rails:

The starting location of the rails should be determined to create windows from the bottom to the top. This method assumes that the gap between the rails is fixed. To make it work in real time, the algorithm must become linear, and to do that, a sliding pair of windows has been created, so that the gap between windows is the same as the gap between bars and is read from the configuration file.

2.6 Image processing steps:

Images of the railway captured via the camera are processed According to the stages shown in Fig 2. The stages are explained in more details in the coming sections.

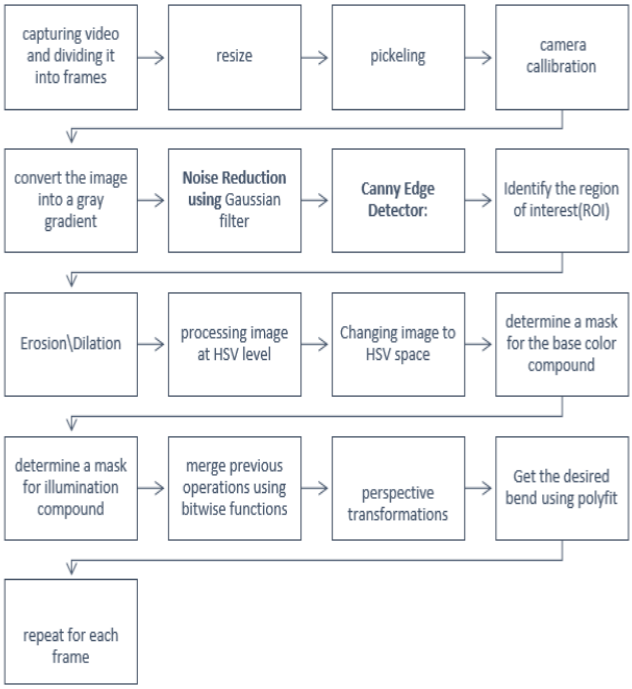

Fig -1: shows the workflow of processing the captured images using the camera fixed at the head of the locomotive

Figure 2 shows example of the captured image that is ready to be processed from Syrian Railways:

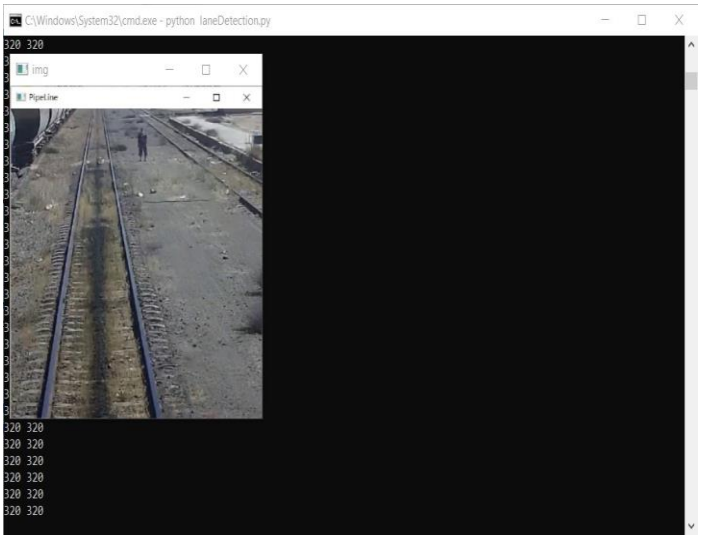

Fig -2: Basic image captured from the camera fixed on the front of Syrian locomotive

Frame Size Adjustment (Resize):

This modification is done using the. method cv2.resize() Where the image size can be determined manually or by scaling factor

Image stack: It is used to serialize and deserialize the structure of a Python object, so that any object can be stored in Python and saved to disk. The stack first renders the object as a string before writing it to the file, by converting it to a string of characters.

Distortion processing Caused by the camera: Some cameras cause significant image distortion. There are two main types of distortion, radial distortion and transverse distortion.

Processing the image in gray level: A set of operations were performed on the image, as shown in the following Figure 3. Video frames are converted from RGB to grayscale because processing a single channel image is faster than processing a three-channel color image, especially most of the significant information is in the luminance part of the image, not in the chrominance parts.

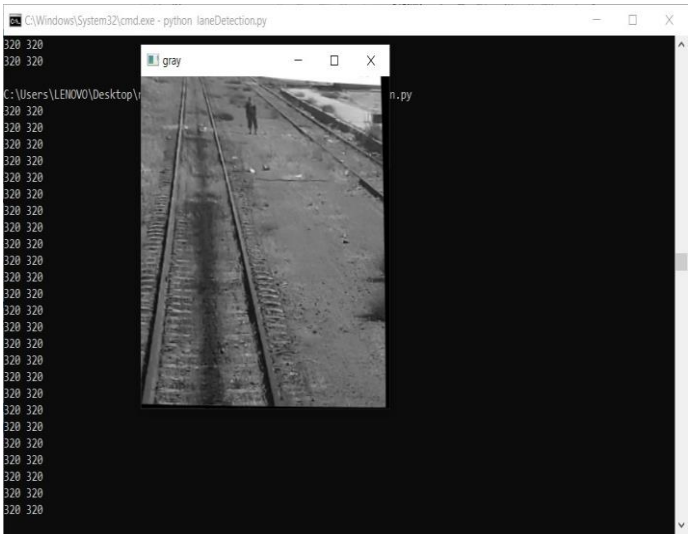

Fig -3: The railway image after converting to grayscale

Noise Reduction: Noise can create false edges, so before moving forward, it is necessary to perform image smoothing. The filter used here is Gaussian. Figure 4 shows the image after applying Gaussian filter.

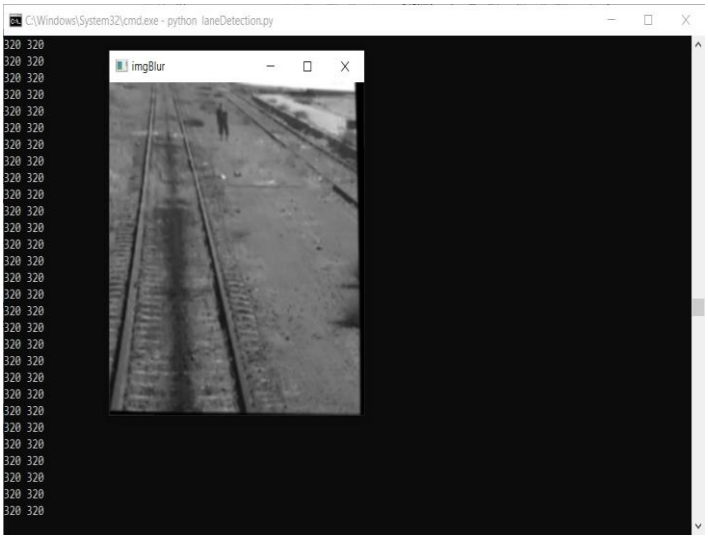

Fig -4: The railway image after applying Gaussian filter

Applying edge detection using Canny algorithm edge Detector:

Edge detection using Canny is a famous algorithm for defining edges. Figure 5 shows the image after applying Canny method for edge detection.

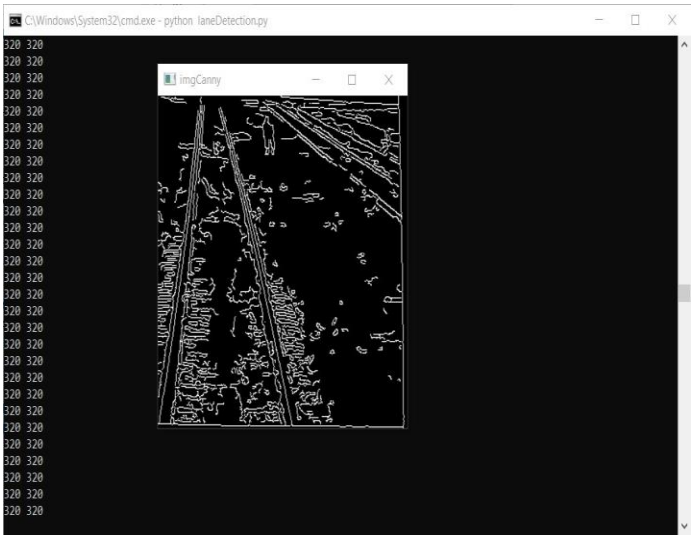

Fig -5: The railway image after applying Canny Edge Detector.

Determine the region of interest (ROI): This stage only take into consideration the area covered by the road corridor. A mask with the same dimensions of the railway image is created. A bitwise AND operation is performed Between each pixel of the image and the mask. finally hides the image without the two train lines and shows the region of interest traced by the polygonal contour of the mask. Here the mask is used as a triangle, as shown in Figure 6.

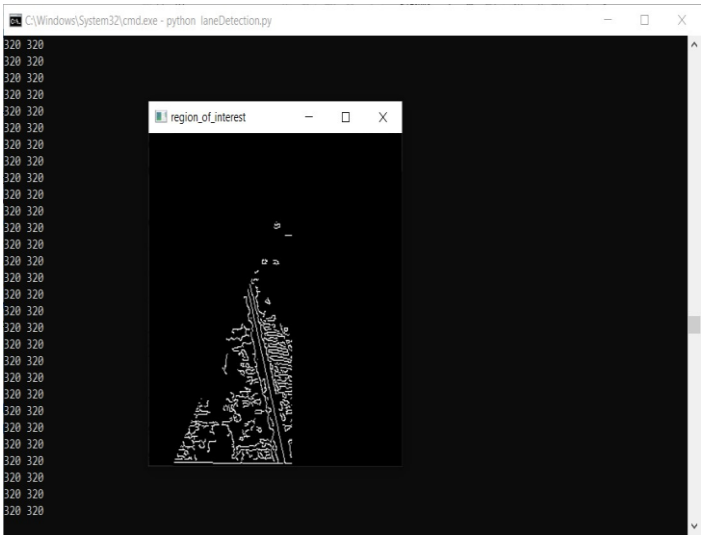

Fig -6: The railway image after extracting a region of interest

Erosion process: This process is used to smooth the front surface limits. Fig 7 shows the image after applying Erosion process.

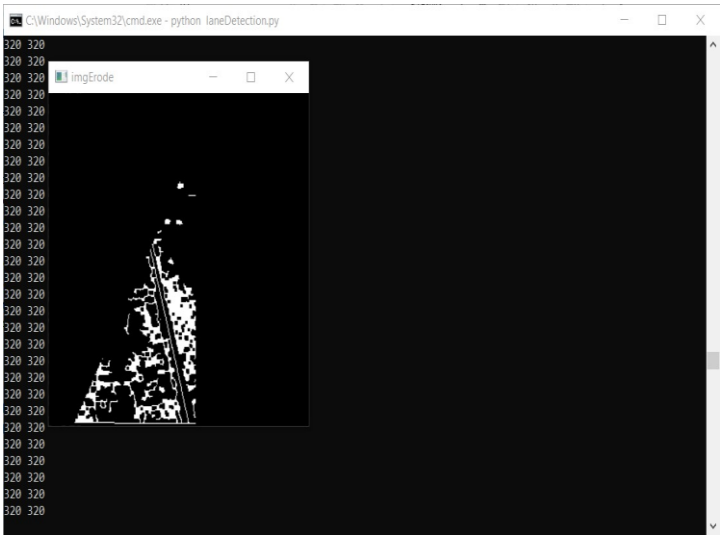

Fig -7: The railway image after applying erosion operation

Stretching Dilation process: It is the opposite process corrosion area. Usually after applying the erosion process to remove the noise of the white area in the picture, the body area is decreased. For that erosion process is followed by a stretching process to increase the area and restore its eroded parts. As a result of converting the color image to gray level and then applying the Canny algorithm and determining the region of interest, unfilled voids in the railway lines have appeared. For that the use of erosion and expansion filters are essential to get a more accurate result, as shown in Figure 8.

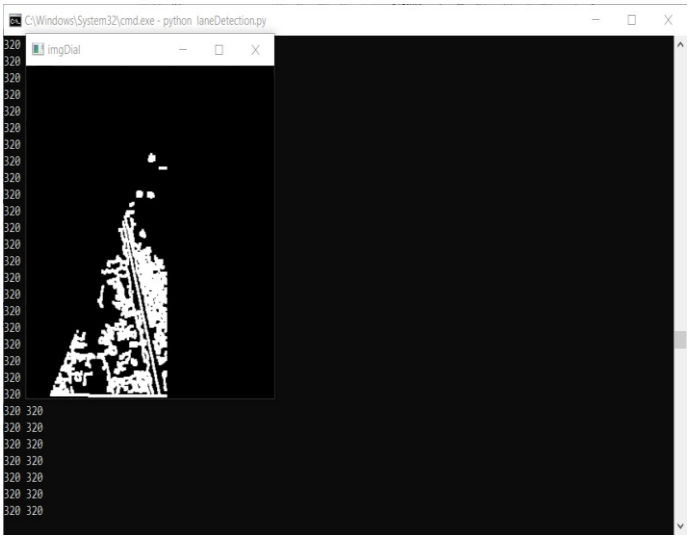

Fig -8: The railway image after applying dilation operation.

Convert the image to color space HSV (hue, saturation, value): There are many available methods to convert a grey image to color spaces. In this paper, the image is converted to gray for processing, then converted to HSV color space (hue, saturation, value).

Bit-level operations (Bitwise operation): It includes operations NOT, XOR, OR, AND. These operations are very useful when determining which part of the image is not rectangular and here the images were combined using the instruction Bitwise OR.

Perspective adjustment: perspective transformation standardization scaling: It is the process of determining the size of the image dimensions, through the function cv2.resize.

Obtaining the required curvature: here the basic image is used with a curvature point from the left and a curvature point from the right according to the following function polyfit

Figure 9: The final result.

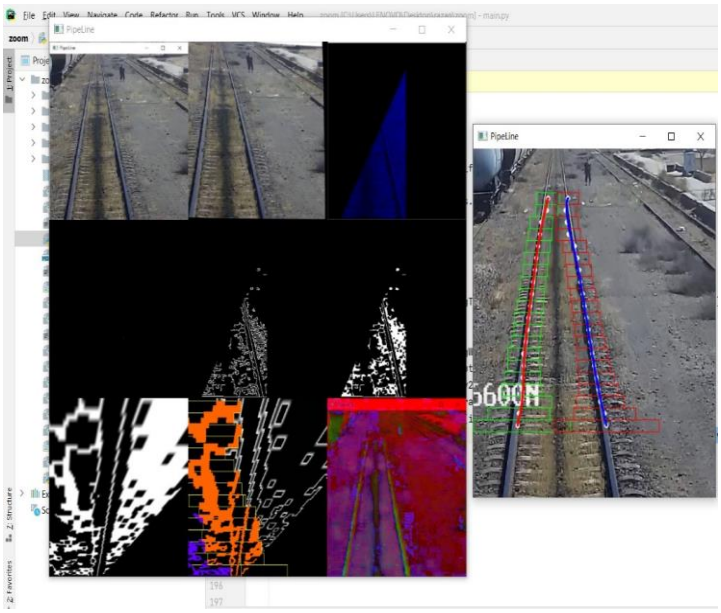

Fig -9: The final result.

Discuss the results:

Using the stages described above, on images captured using the camera at the front of the moving locomotive in real time shows that the proposed image processing method can detect two railroad tracks with great accuracy. The stages and steps that are performed, and the results of the image processing show that the image obtained in this way is characterized by great clarity and high accuracy ,in addition to the speed of image processing in this paper compared to other methods mentioned in the previous studies.

Through the experimental results in this research to monitor and identify the two railway tracks, the two railway tracks were detected and the railway surface was monitored. Compared with similar studies, it's been found that no method has been developed to detect railway components and monitor railway surface failures and the condition of the railway line in real time and during the movement of the locomotive.

The method proposed in this research has been compared with some related previous studies as shown table 1.

Table-1: Comparison of the proposed image processing method with other studies.

Image size(pixel)	standard deviation(ms)	processing time(ms)	
480×360	2.1	125	Suggested method for searching
640*480	2.3	1064.6	Ref[11]

512*832	4.1	247	Ref[12]
320*240	2.5	120	Ref[13]
220*220	1.7	100	Ref[14]

From the previous table, the components of the railway, the surface of the railway and its direction on the railway were revealed. The dimensions and processing time of the image were given to discover the railway track. Looking at the processing time and image dimensions for the references mentioned in table 1, it's been found that the proposed method is successful and achieved a high speed of image processing and high image accuracy and clarity.

3. CONCLUSIONS

This paper considers monitoring the conditions of Syrian railways in real time using camera mounted at the front of a moving locomotive. This study proposes a new method of image processing to detect the two railway lines, which they are the most important components of the railway. In the proposed method for discovering railway components, edge extraction was performed on images captured from a camera mounted at the front of a moving locomotive. The straight lines in the picture were classified and the image was processed using Python after the video was cut into frames according to gray-level image processing techniques, and then HSV the two stages are complementary to each other, and an adjustment process has been made to the image size to obtain the final version of the image.

The benefit of the proposed research method, is it can be applied to a video clip and not only a static image. In addition to the possibility of discovering curves and thus discovering the entire rails of the railway and identifying them clearly and accurately along the train track even with the presence of curves. The other important point of this research is that there is no need to consider the conditions of environment brightness and its impact on image processing. The results show that the proposed method exceeds other methods in terms of speed of processing and accuracy. The proposed method is an effective alternative for railways.

Future prospects and suggestions:

This research relied on image processing techniques to detect railways. Techniques such as AI and deep learning techniques can be used to process the image from a moving video in real time to improve the results further and detect obstacles and malfunctions possible acquisition of the two railway lines.

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Authors' declaration

- All the Figures and Tables in the manuscript are mine ours.
- Ethical Clearance: The project was approved by University of Aleppo.

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