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Detection of Static Obstacles for Railways

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Abstract
In the current railway systems, it has become a necessity to have safety measures in order to avoid accidents. One of the major causes that can lead to serious accidents is the existence of obstacles on the railway tracks. This paper presents an intelligent system which is based on image processing. Video surveillance is used to take snapshots at regular intervals which are compared for change detection. The obstacle is detected based on the analysis performed on the output of this comparison. This system is expected to enhance the efficiency and accuracy of the Safety management system for railways to a great extent.

1. INTRODUCTION

Detecting static objects in video sequences has several applications in surveillance systems such as the detection of boulders on railway tracks in public safety systems and has attracted the attention of vast research in the field of video surveillance. Proposed techniques aiming to detect static objects are achieved by the means of background subtraction succeeded by some kind of tracking. Background subtraction is a technique for segmentation of foreground regions in video sequences taken from a static camera. It basically detects the static objects by taking the difference between the current frame and the background model. In order to achieve good segmentation results, the background model must be regularly updated in accordance to the varying lightning conditions and some stationary changes in the scene.

2. LITERATURE SURVEY

2.1 Background subtraction

Background subtraction techniques are a commonly used class of techniques used for identification of objects of interest in a scene for applications such as surveillance [3]. It is a frequently used method for detecting static and moving objects in videos from static cameras. The difference between the current frame and the reference frame, often called the background image or background model is performed to detect static objects. The background must be a clear presentation of the scene with no objects that might prove to be an unwanted obstacle and must go through regular updating so as to adapt the varying luminance conditions and geometry settings. A comparison between the observed image and an estimation of the image that contains no object of the image is performed. The position where a significant difference between the observed and the estimated image is encountered is an indication of object of interest or an obstacle present. Background subtraction thus comes into existence from a simple technique of subtracting the observed image from the estimated image and performing threshold operation the result to detect objects of interest.

Naïve description of the approach [4]: Detecting the static obstacle as the difference between the current frame and the selected background model:

$$|\text{frame}_i - \text{background}_i| > Th \qquad (1)$$

Where Th is recalculated threshold value.

The background subtraction method uses subtraction or the difference of current image and background image in order to detect static objects, with simple algorithm but sensitive to changes in external environment and with poor non-interference ability [4]. In a simple static camera condition we combine dynamic background modeling with threshold selection method based on background subtraction and update background on basis of exact detection of objects. [5]

Any static obstacle detection system based on the subtraction of background images needs to handle a number of critical situations such as:

- Presence of noise in image
- Changes due to lighting conditions in the scene
- Movement of non-static objects like leaves on the tree
- Changes in light conditions (e.g. rainfall),

abrupt change from daylight to dusky light in the evening

2.1.1 Types of Background subtraction Techniques

The following are the techniques used for background image subtraction:

i. W4
ii. LOTS
iii. Heikkila and Olli
iv. Halevy
v. Cutler.

Brief description of the two techniques is as follows:

a. Heikkila and Olli:

Any pixel [2] in image is marked as foreground in the object sensitive region if

$$|I_t - B_t| > T \quad (2)$$

Where I_t is the current frame, B_t is the background frame and T is the pre-calculated threshold value. If the pixel is marked as foreground in last M frames, then the pixel represents the detected static object.

The background is updated as follows:

$$B_{t+1} = \alpha I_t + (1-\alpha) B_t \quad (3)$$

Where α is kept minimal in order to avoid artificial tails forming behind moving objects.

Following Background corrections are applied:

- If a pixel is marked as foreground in last N frames, in object insensitive region then it is updated as $B_{t+1}=I_t$. This correction compensates for sudden illumination changes.
- If a pixel changes state from foreground to background frequently in object insensitive region then it is updated as the above case. This correction compensates for fluctuating illumination, such as swinging branches.

b. W^4:

In this technique [1], a pixel is marked as foreground if

$$|M-I_t| > D \text{ or } |N-I_t| > D \quad (4)$$

Where M, N, D represents observable minimum, maximum and largest inter-frame absolute difference in the background scene. These parameters are estimated initially and then periodically updated for object insensitive region in the image. The resulting foreground image is eroded to eliminate 1-pixel thick noise and small regions are rejected.

2.2 Existing System

In the existing technique for detecting the obstacles at landslide prone areas, CCTV cameras have been used for video surveillance. The main objective of video monitoring is to identify the suspicious obstacle such as stones and prevent the losses by land sliding. The main disadvantage of the CCTV system is that it involves high manual interaction. It becomes very tedious for a person to watch a static scene a monitor for more than 20 minutes. It is difficult to maintain the heavy amount of raw data captured since a large storage space is required. Also the raw data when transmitted requires a higher bandwidth.

One of the systems implemented by 'Konkan Railways' is the 'Anti-Collision Device Network' (ACD) [6] is an on-board collision prevention system. This system consists of mobile ACDs for locomotives and guard vans, track-side ACD's for stations, level-crossing ACD's, loco-shed ACD's, sensor-based ACD's and ACD repeaters. Mobile ACDs take inputs from GPS satellite system for position updates and network with track-side ACDs located within a radius of three kms using UHF radio modems to activate brakes with the help of on-board Loco ACD(s) through their Automatic Braking Units (ABUs), whenever a collision-like situation is perceived. ACD Network is likely to prevent head-on and rear-end collisions, collisions at high speed near stations. In addition, collision with road-vehicles at level crossings. However some of the limitations of this system are as follows:

- This system uses radio based communication. Thus adverse weather conditions and failure in communication may result in malfunctioning of the system.
- Collision at level crossing is possible if the train and the level crossings are not fitted with ACD's.
- Availability of GPS data is cumbersome in shadow zones.

3. PROPOSED SYSTEM

In this paper we present a system that uses image processing techniques for autonomous surveillance. Obstacles present on railway tracks can be detected by acquiring snapshots of the regions at predetermined regular intervals. Significant changes in the snapshots represent the supposed obstacles. The system is capable of sending alerts to the concerned authorities in order to take further actions.

The system works in the following three important phases:

1) Snapshot acquisition and storage:

This system uses CCTV cameras positioned at most of the accident prone areas. Initially a background snapshot is acquired which ideally contains of no such accident causing objects. Furthermore the CCTV cameras take snapshots at predetermined regular intervals of time such as every 15 seconds. Relevant background snapshots and current frame snapshots are stored in reliable database for easy retrieval.

2) Image processing:

The input snapshots (background snapshot and current frame snapshots) are then subjected to various image processing techniques. It is first converted to a gray scale image in order to reduce the execution time. Gray scale is a range of monochromatic shades from black to white. Therefore, a gray scale image contains only shades of gray and no color.

After converting image to gray scale, it will further pass through processes for detecting gradual variations of the lighting conditions in the image, small movements of objects such as tree branches, birds, animals and bushes blowing in the wind and sudden changes in environmental conditions, (e.g. sudden raining), etc. by regularly updating the reference image using the Heikkila and Olli background updating technique.

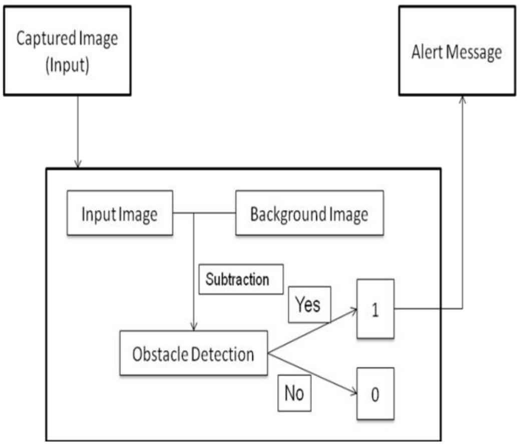

Figure1. System Architecture

Background subtraction technique is performed on the processed input snapshots. However, certain pixel region is selected as object sensitive region which is subjected to the subtraction technique. In case, if there is difference between two images then the system will return 1 else it will return 0. The instant at which output is 1, the next M snapshots are acquired within minimal time interval. If the output persists to be 1 in all snapshots obstacle is considered to be detected.

3) Alert Message Generation:

The instant at which the system returns output as 1, the GSM system is activated. The SMS is sent to the concerned authorities in order to take further action. The SMS includes the location, camera number, time stamp of the detected obstacle.

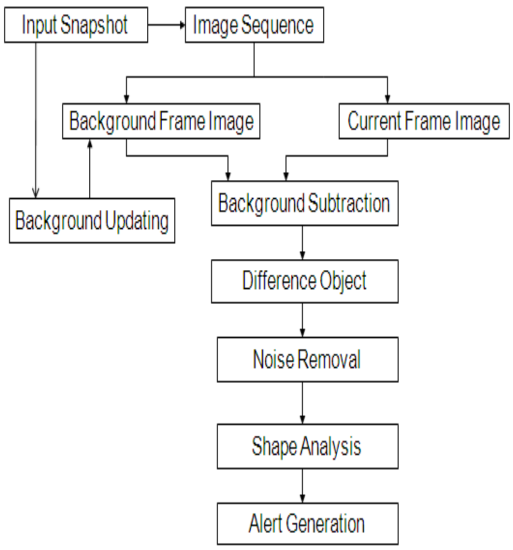

Figure2. Flow diagram of the system

3.1 Algorithms

- Gray Scale Conversion:
  The input image is first converted to a gray scale image. All gray scale algorithms utilize the same basic three-step process:
  a. Get the red, green, and blue values of a pixel
  b. Use math functions to turn those numbers into a single gray value
  c. Replace the original red, green, and blue values with the new gray value

```
For Each Pixel in
Image
{
Red = Pixel.Red
Green = Pixel.Green
Blue = Pixel.Blue
Gray = (Red + Green + Blue) / 3
Pixel.Red = Gray Pixel.Green = Gray
Pixel.Blue = Gray
}
```

- Background Subtraction:
  The processed input images are subtracted using the following algorithm.
  Background subtraction Algorithm:

  Dk (l, m) = 1 if Fk (l, m)-Bk (l, m) > T
  = 0 Otherwise

  Fk (l, m): Current Frame
  Bk (l, m): Background Image
  Dk (l, m): Difference Image
  T : Set threshold

4. Experimental Results

In the proposed method experiments are performed using MATLAB. The fig .3 represents the snapshot captured by the CCTV cameras. The fig .4 is image obtained after grayscale conversion using MATLAB. [7]

Figure 3.Original image

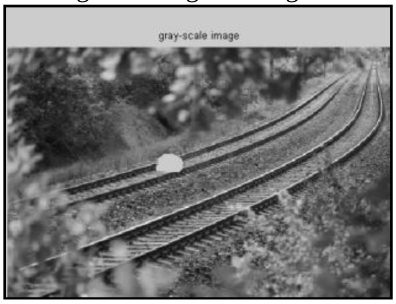

Figure 4 .Gray scale image


Figure 5 .Background image


Figure 6 .Current Frame image

Background subtraction technique is performed on fig .5 representing the background image and fig .6 representing the current image. The difference image obtained from above technique is represented by fig .7.


Figure 7.Difference Image

5. CONCLUSION

In this paper, we have presented a robust system to effectively detect obstacles on railway tracks that might prove fatal if not detected. The approach proposed is an autonomous system that uses image processing techniques. Changes in the inter frame images are identified and analyzed for presence of a static object. The proposed system integrates well with the GSM network so that alerts are sent in a timely manner. The experimental results reflect that the system is efficient, accurate and flexible in terms of operation and under different environmental conditions. Also system is more cost efficient than the existing system.

6. FUTURE SCOPE

This system can be further enhanced for detection of moving objects such as animals sitting along railway tracks that might not prove as a static obstacle.

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