Edge detection for Local Navigation System for Vision Impaired People Using Mobile Devices

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Abstract- A major problem faced by blind and vision impaired people is path finding in indoor and outdoor environments. Navigation for vision-impaired people is very arduous because they must use a device such as white canes to avoid obstacles in their way. Many navigation systems have been developed for vision impaired people, based on ultra sound sensors, Global Positioning System, White Cane and wearable devices using image processing. Some of navigation systems like GPS are not suitable in the indoor environments due to poor accuracy. This overall research project aims to build a comprehensive real-time navigation system using arrange sensors in a hand held devices. The Authors’ research focuses on methods for real time local navigation based on edge detection techniques using mobile devices. This research paper proposes approaches for experimental data captured and the issues relating to image quality. This experiment aims to identify issues in image quality including low light conditions, low quality images due to movement of the capture device and static and moving obstacles in front of the user in both indoor and outdoor environments. From this information, image-processing techniques will be identified to assist in object and path edge detection necessary to create a guidance system for those with low vision.

Keywords - indoor navigation, image processing, edge detection, vision impairment, path finding, way finding

1. Introduction

According to world health organization latest records, 285 million people are visually impaired worldwide and 39 million are blind and 246 million have low vision [1]. Vision is the most important role in our life. Vision-impaired people facade to many difficulties in their day today life knowing where they are going and what are the obstacles in front of them while they are walking.

Many researchers have conducted research on helping vision-impaired people in way finding, navigation and map orientation [2-5]. Most of these use external sensors and additional infrastructure deployed in the environment such as Wi-Fi, RFID tags or markers. However, limited number of systems have been developed on mobile device based - path finding [1] using image processing for vision impaired people to find their destination, but they use additional infrastructure such as color tags and barcodes to identify the environment. GPS is very useful outdoors but quite ineffective indoors because walls in buildings block GPS transmissions and require additional devices for signal transmission and this will significantly encounter additional cost of apparatus and maintenance [4].

This work focuses on methods for real time local navigation (indoor and outdoor) based on edge detection techniques using hand held devices (mobile phone). This article discusses proposed method to analyze the issues relating to image quality. In our proposed system uses a smart phone placed on vision-impaired person’s chest height and hip level belt mounted that take real time images.

This research paper focuses on the challenges that have to be face in path finding using edge detection techniques in image processing [2], [10]. Those are:

- Low-light illumination (at night and different weather conditions during the day)
- Heavy shadow conditions.
- Low quality images due to movement of the capture device and static and moving obstacles in front of the user.

Under these conditions it’s difficult to detect edges of sidewalks, corridors, path edges, stairways, pedestrian crossing and obstacles.

In section 2 will discuss the brief review of related works of various path detection systems. In section 3 we talk about our proposed methods and limitation of our implementation platform and we present the conclusion and future works in section 4.

2. Related works

Jose et al [2] have discussed an algorithm for vision impaired people, focused on local navigation: detection of path borders and obstacles in front of the user by using a biologically inspired algorithm for optical flow based on multi-scale key point annotation and matching, using wearable cameras and computers. Canny edge detection algorithm, Zero crossing algorithm and Hough transformation were used in this experiment. There are some restrictions on the user; the user should learn to control his head and not to waver much with their body while walking and swaying the white cane in front of them. And they assumed that they have done this work under sufficient ambient
illuminations. Therefore this can be failed under low light or night.

Mohanjeri et al. [3] presented a system with two cameras placed on blind person’s glasses. Comparing the real-time images taken from the two cameras identifies obstacles. This work is based on probability of equivalent points and verified with binary method, standardize and normalized cross-correlation. This system is highly sensitive for the height of the cameras and distance between them.

Ran et al. [4] discussed an indoor/outdoor blind navigation system (Drishiti system) for blind and vision-impaired people. Ultrasound positioning is used in this system to provide the measurement of indoor environment and the working range of this system depends on the coverage of the wireless network and considered average height of the users.

Coughlan et al. [5] offered a cell phone-based way finding system for the visually impaired people. The specially designed signs in the environment such as labeling locations (offices and restrooms) were used. But tag installation in rooms, building and landmarks is very high cost and this kind of systems could not be used for a wide range. Deville et al. [6] presented a real time alerting system, based on the detection of visual salient parts in videos using color system and musical instrument sounds.

Castells el al. [7] proposed obstacle detection method using edge detection. This system detects obstacle and guide to avoid them. Canny edge detection algorithm and histogram methods were used with 5 frames per second capturing rate to detect and avoid obstacles on the sidewalks.

Jie et al. [8] presented a portable Electronic Travel Aid (ETA) system for sidewalk detection using image processing. Their capture rate is 2 frames per second and they have used HVS (Hue (H), saturation (S) and brightness (V)) color space, which is less sensitive to light or shadows, iterative threshold segmentation method to select threshold value, Kirsch edge detection algorithm and Hough transformation. Lu et al. [9] proposed an algorithm to detect and precisely localize curbs and stairs for autonomous navigation using Canny edge detection algorithm and weighted Hough transformation.

Bourbakis [10] researched a two-dimensional (2-D) vibration array for detecting dynamic changes in three-dimensional (3-D) space during navigation and provides these changes in real time to visually impaired users (in a form of vibration) to develop a 3-D sensing of the space and assist their navigation in their working and living environment. Bourbakis is used fuzzy-like reasoning segmentation (FRS) method for edge detection and spatiotemporal diffusion and kernel based motion detection for detection of moving objects in the image sequence. Bourbakis has considered one frame per second. Bourbakis have mentioned the FRS methods eliminate highlights and shadows to some degree.

Dunai et al. [11] discussed a Real time assistance prototype- a new navigation aid for vision-impaired people. The system consists of two stereo cameras and a portable computer for processing the environmental information. The aim of the system is to detect the static and dynamic objects from the surrounding environment and transform them into acoustical signals. Main tasks in this research are detect and avoid obstacles and to follow the route. Recently many vision systems [12-14] have been developed for vehicles for tracking road lanes and obstacles in the roads.

In our current literatures, authors are proposed methods for path finding and obstacle detection in the way of vision-impaired persons under sufficient lighting conditions and limitations on the user. Aim of this research is develop an enhanced real-time local navigation system for path finding in using edge detection techniques in image processing under various conditions, as mentioned previously.

3. Proposed Method

This research project aims to build a comprehensive real-time navigation system for vision-impaired people using arrange sensors (camera, accelerometer, gyroscope and magnetometer) in a hand held devices such as smart phones. The following research focuses on methods for real-time local navigation (indoor and outdoor) based on edge detection techniques using hand held devices (mobile phone).

In this experiment, the capture device is mounted in two different positions (chest and hip of a person) to determine an optimal position while the subject is performing different activities such as walking on sidewalks and stairways. Stability of capturing device and how it positions relatively to the ground level through out the activity are the key areas to measure in determining the optimal position. When capturing the images, the walking speed of user and oriented angles may affect to image quality (increase the noise of an image). Minimizing these problems and to determine the optimal solution, 3 frames per second are captured for further processing, as this is sufficient for the average walking space.

Under the low-light conditions (Figure 1) or poor weather conditions, when the number of photons entering the imaging system in camera is low, the image captured in the color filter array has a low signal-to-noise ratio. Then the camera produces quite noisy images and it should be removed for further processing. Figure 1 illustrates different methods of image enhancement and histogram equalization and is efficient. Situations like low-light condition, noise of image will be increased and fuzzy components become high in traditional enhancement methods and therefore the special histogram equalization [15] is used to enhance the features of the image and remove the noise level. The Discrete Singular Convolution Edge Detector (DSCED) is applied to obtain initial edges. The Canny edge detector is well-suited optimization edge detection method, which depends on the computational band with W and standard deviation (sigma) and it does not provide much freedom for frequency selection. DSCED [16] has additional parameter alpha, which depends on the frequency selection. Therefore the DSCED algorithm will be used
for our problem domain.

\textbf{Figure 1:} (a) original image, (b) gray scale image, (c) Histogram equalization (histeq), (d) Double-plateaus histogram (special histogram equilization)

As shown in Figure 2(a) next challenge is to overcome is the heavy shadow conditions. Figure 2(c) shows after applying the DSCED edge detectors and figure 2 (d) after removing shadows for enhanced image in shadow conditions. Due to the heavy shadows discontinuities of edges can be occurred and edge detection techniques produce false results in edge detecting. For the shadow removal, Simple Shadow Removal method [17] is used in order to gain good performance on a variety of out door images. To obtained shadow free image, the derivative of the image is taken and the shadow edges derivatives set to 0 and finally restores the image using 1D reintegration (Hamiltonian path based).

\textbf{Figure 2.} (a) original image , (b) gray scale image, (c)

DSCED (d) after removing shadows

In addition to the said lighting conditions, low quality in images due to movement of the capture device and static and moving obstacles in front of the user is a further issue that requires processing.

A linear motion in one direction blurred the image shown in figure 3 during exposure. The deblurred image is obtained by applying following equation.

\[
f(x,y) = A - mg'(x-ka,y) + \sum_{k=0}^{m} g'(x-ka,y)
\]

\[
0 \leq x, y \leq L \tag{1}
\]

\(k\) and \(m\) is an integer, \(k,m=0...K-1\) and \(A\) is a constant.

The distance of the capturing device travelled is determined using the readings of accelerometer and gyroscope. Once the deblurred image is obtained, DCSED edge detection technique is applied.

\textbf{Figure 3:} (a) original image, (b) gray scale image, (c) edge detection of (b), (d) wiener filter, (e) Lucy-Richardson filter, (f) filter by using equation 1

Path detection using edge detection relates with discontinuous line segments. Hough transformation is a powerful mathematical tool for connecting these vanishing points and boundary detection. To connect these discontinuous lines use equation (2)

\[
d = x \cos \theta + y \sin \theta \tag{2}
\]
The perpendicular distance from the line to the origin and $\theta$ , the angle between the line’s perpendicular and the horizontal axis.

4. Conclusion
The aim of this work is to develop a more efficient algorithm for real-time path finding using edge detection for vision impairment people. The vision-impaired persons can be guided to find their path avoiding obstacles and heading on correct direction in path under poor light conditions and low quality images. Proposed method is to improve the image features and quality and apply the edge detection technique. Special histogram algorithm for poor lighting conditions, shadow removal algorithm and special equation for blurring images are used in this system. The similar systems have been developed for object tracking and obstacle avoiding like humans in navigation system for vision impaired people and intelligent car systems. This paper proposed a method to get a high quality image form taken by hand held devices such as smart phones before applying edge detection algorithms. The major challenge to be faced in this work is the limited resources available in mobile devices. Due to the processing power and memory limitations in mobile devices and the high-expected overall throughput, the complexity of algorithm must be minimized and optimized.

Reference


