Path Generation and Map Construction for Mobile Robot Navigation

Honnaraju B, Murali S

***Abstract:** Vision based mobile robot navigation is one of the important because the robots can resolve lots of problems in which human life is dangerous, difficult and costly. A difficult problem is to make a vision-based robot navigate properly to the target by avoiding the obstacles. Path information is very essential for successful navigation of the robot. The main purpose of this paper is to present an approach for mobile robots to generate path and construct maps. This work is focused on providing the path information of an environment using a single 2-D camera. Whenever robot identifies the human in the corridor, it generates the information of the path information and constructs the map is achieved based on the human moment and the human position. On the robot the camera is mounted which acquires images in real time. Oath information is generated for mobile robot using acquired real time images and processing real time images.*

***Keywords :** Depth, floor, map, path, robot navigation.*

I. INTRODUCTION

Smart mobile robots must be able to recognize objects and recognize indoor environment where they like to independently navigate or operate. The path information is essential for the mobile robots to traverse or work in the indoor spaceA wide variety of robot vision technologies have been designed and built to determine obstacles and geometric information on free scene. Normally, information about path, obstacle and free space is typically described as a map. Map construction is the mechanism which incrementally integrates new sensing data from the mobile robot vision systems. Mobile robots sensing data is embedded incrementally in the local diagram. The generated map may contain much information, such as, fixed objects, moving objects, wall information, moving information etc. Generation of path information and construction of map are not easy tasks. It requires many important internal sub tasks. One of the important tasks of map construction is 3-D depth estimation. Stereo vision system and hardware sensors have been widely used for 3-D depth estimation. In the proposed work, mobile robot has fixed with a single 2-D camera for 3-D depth estimation. Estimating 3-D depth using a single 2-D image is a major problem in computer vision, and is also very essential in applications for robotics, aerospace, scene perception and 3-D reconstruction.

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S Murali, N Avinash[1] also proposed a method that applies the projective geometric perspective technique and gives the concept of measuring the distances between the object's edges, which are parallel to the image plane in the actual scene image. The strategy adapted to uncalibrated images without any comprehension of the camera's necessary parameters. A R Varkonyi, Attila L, Bencisk [2] have developed the new hybrid navigation system HYRON. The main aim of this system is to incorporate the benefits of hybrid systems combines the local and global methods. Further, a new optimal graph generation method is introduced. Vikram Raju, R Deepu, S Murali[3] identified a model that shows impressive development improvements and a powerful model for estimating the depth of an object in an image by using the image resolution data that can never be modified once an image is captured. H.J Ko, J.H. Kim [4] presented a method to construct the 3D global map in the room from the stereo cameras are connected to the ceiling for mobile robot navigation. Baris Fildan, Veysel Gazi, Shaohao Zhai, Na Cen and Engin Karata[5] established a distance-finding process, and then maintained the constraints on agents to keep distances from some other agents. This way robotic swarms are regulated. B Honnaraju, R Deepu, and S Murali [6] proposed a model showing positive improvements in technology and an efficient model for estimating the distance between humans and the camera from a single 2-D image by utilizing human height as guideline. The paper presents the use of Genetic algorithm [7] for path planning. A PID controller and an ultrasonic sensor have been utilized for the map generation.

The global map as initially less information, but it becomes more comprehensive by adding the camera sensor's local information. The detailed global map (information such as, static obstacle, door location, steps, etc.) is very useful for the purpose of global mobile robot navigation.

The intent of this paper is to present a human movement-based approach for path generation and map creation. The generated path and map is used further for path planning and navigation. In the proposed approach, information of 3-D depth is measured on the basis of reference of human height.

II. PROCEDURE FOR PAPER SUBMISSION

The method of generating the path is comprised of several phases. To begin with, the 2-D monocular camera associated with the robot acquires images. The image obtained is preprocessed to determine if the person is present within or outside the image.

Aggregate Channel Feature (ACF) people identification system has been used to recognize the human presence.

Once the human appearance is confirmed, the next step is to assess the distance between humans and camera based on the reference height of humans [6]. Following are the essential steps needed in the proposed methodology:

- Human identification using the People Identification Frameworks feature of ACF.
- Estimate distance dependent on reference human height.
- Save the value of the distance and location to the path information file.
- Generate path map from path information file.

The block diagram for the suggested approach is shown in figure 2.1 below.

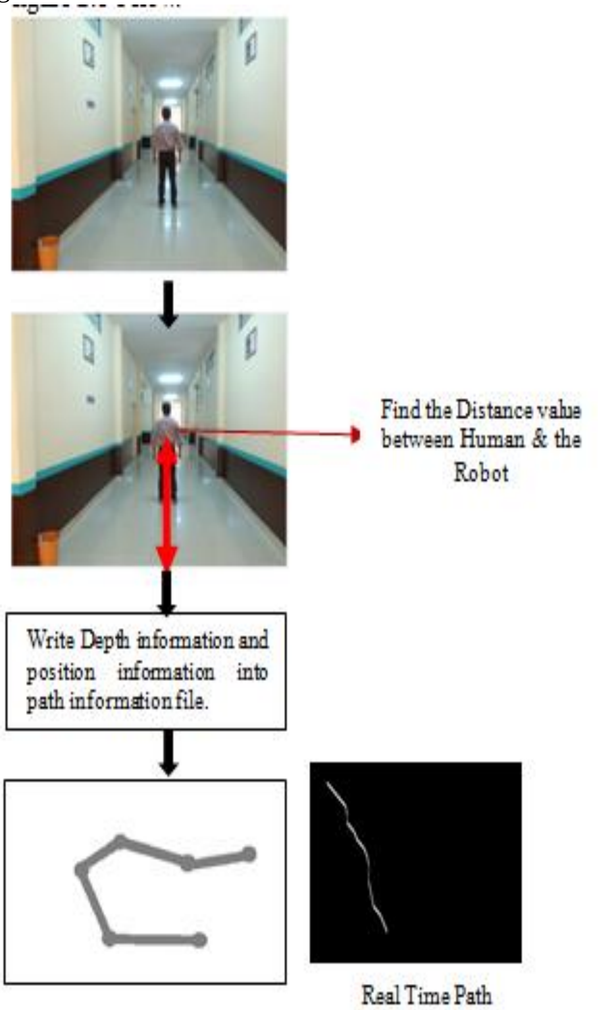
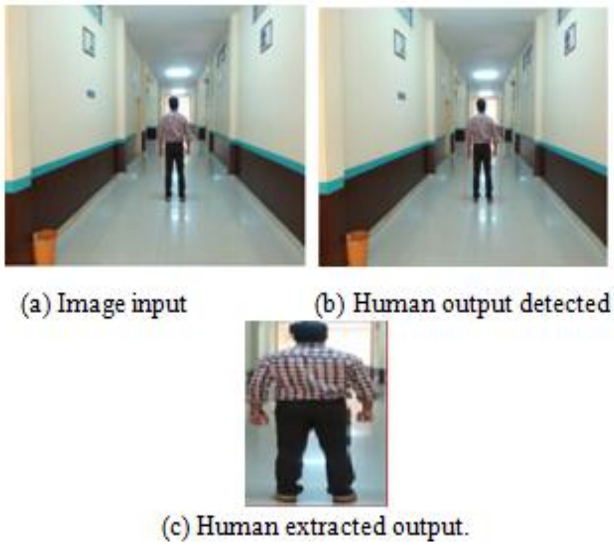


Fig 2.1: Proposed methodology block diagram.

A. Human Detection

Real – time human detection and tracking a huge, challenging and important field of computer vision research. Human detection challenges are illumination changes, camera motion, cluttered scene, uneven background, etc. This has a wide range of human recognition applications, computer human interaction, video monitoring, gender classification etc. Human identification is done in the proposed approach based on mechanism of face detection. Face detection may be taken as a special case of object type detection. In the identification of object type, the task is to find the sizes and positions of all objects within an image belonging to a given class. To identify faces an ACF people recognition system was being used. The detection of ACF people returns the human position (x, y co-ordinates), height, and width in the image. To improve the efficiency of the distance estimation process, only human area is being cropped, segmented and distance is measured using human position information. Human detection and human body extracted output is shown in the figure 2.2.



(a) Image input (b) Human output detected

(c) Human extracted output.

Fig 2.2: Output of the human detection and extraction output.

B. Estimation of distance information

When a human is identified, the next procedure is to estimate the depth information according to the steps below [6]:

- The human position finds in the segmented image.
- If the human's location is not in the image center, repositioning is done and distortion value (the distance between the human and the center of the image) is determined.
- It requires estimating the amount of zoom operations.
- Convert the number of zooms into the distance value to determine the information about the 3D depth.

Measurement of distortion value during the measured distance between the human and the robot is very much necessary. Distortion value is calculated by the point of view between the robot and the human being. When the human and robot are perpendicular to the viewing axis, the viewing angle is 0^0 and the distortion is 0. If distortion value is 0, then the path direction will be straight. In another human scenario the distance from the robot is horizontal, the distortion value is greater and the distance is greater. Sign of the distortion value indicates the direction of the human movement. If distortion between the robot and the human is positive, then the path direction is towards left direction else path direction is towards right direction.

The distortion value range with respect to angle of view (human and robot position) is illustrated in figure 2.3.

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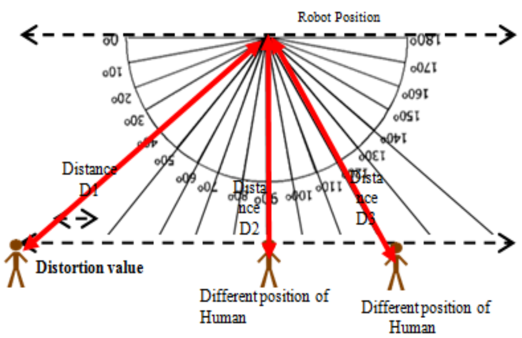


Fig. 2.3: Distortion and viewing angle.

Distance value extracted from the image based human height as a reference is shown in table 2.1. Direction of the path is calculated from the distortion value. Distortion value is the distance between human and image center position.

Table 2.1: Distance and path value calculation from the image sequences.

		
Distance: 10 feet Position: 242x330 Direction: Right	Distance:13 feet Position: 248x322 Direction: Right	Distance: 8 feet Position:250x100 Direction: Left
Image 1	Image 2	Image 3

Figure 2.4 shows the direction of the human movement, direction and distortion angle. Here the robot position is at the center. For this image distortion value is < 0 means the direction is right direction.

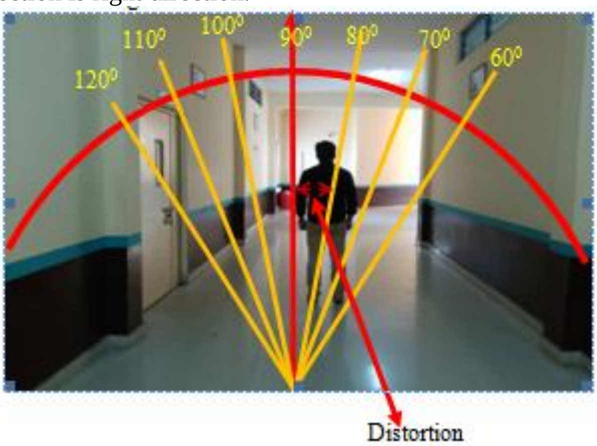


Fig 2.4: Human position in the plane of the image, viewing of the human angle and measuring the distortion.

C. *Store distance and position value*

Extracted distance, position and direction of human movement value are required for synthetic path creation. Distance value is in terms of number of zooms and distortion value is in terms of pixels. Position of human is reference to image coordinates. Distance value is determined based on number of zoom operation and the distortion value. Distance value is converted as the length of the path and the distortion value gives the direction of the path.

Path information is recorded in the database. The path information file consists of X coordinate, Y coordinate, distance value and the distortion value. In figure 2.5 the path information stored in the database is shown.

D. *Generate Path from Path Information*

As the robot moves, its motion is documented in the database as mentioned above and is used to construct synthetic scene map as shown in the block diagram above. Figure 2.6 demonstrates the output of the Path generation using the proposed method. Utilizes the created map to find the shortest path. The other robots, with no vision, can use generated map and path information. The synthetic map is transformed into a binary image where a path represents a white pixel. The image is scaled down into the range of 10 pixels per 1 foot of human walked in this proposed work. Synthetic map is continued in next image of size 640*480 size in case, the robot moves beyond the current map frame. Afterward, maps are stitched according to robotic motion in various images.

X	Y	Distance	Distortion
242	330	10	-10
248	322	13	-5
250	100	8	100
240	407	7	-100
242	330	10	-20
300	500	13	-200
266	350	8	-150
240	320	8	0
228	320	9	-6

Fig 2.5: Content of the Path Information file.

Consider the situation, where the current endpoint of the generated path is at the top end of the Map. So further map updating is not possible in the current map. Then the expansion of the map is required. The expansion of the map is achieved by stitching of empty map image in the required position. Figure 2.7 illustrates the process of empty map stitching.

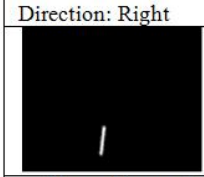
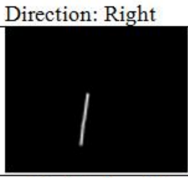
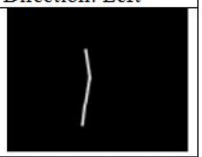
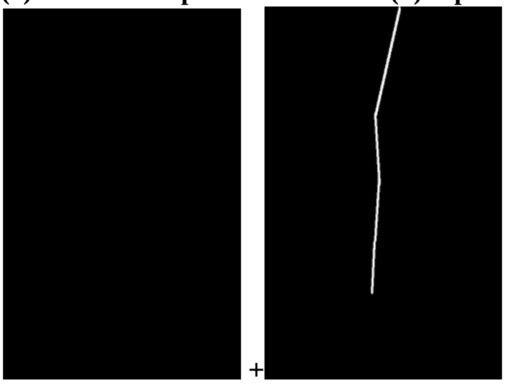
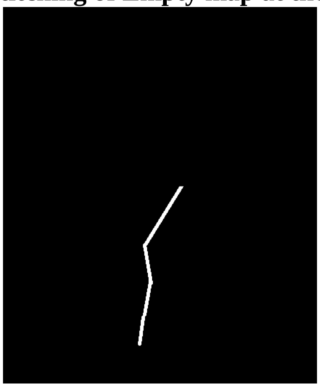
		
Distance: 10 feet Position: 242x330 Direction: Right	Distance:13 feet Position: 248x322 Direction: Right	Distance: 8 feet Position:250x100 Direction: Left
		
Map of Image 1	Updated Map from second image	Updated Map from third image

Fig 2.6: Distance, position and direction estimation from the input image. Map generation from the extracted path information which is stored in the path information file.

(a) Current Map **(b) Input Image**



(c) Stitching of Empty map at the top



(d) Empty map is stitched at top of the generated map.
Fig. 2.7: Stitching of empty map at required position of the generated map.

III. EXPERIMENT

The experiments were carried out in MATLAB environment. In our developed algorithm, the processing rate for one single frame is around 60ms, by this we are able to work at a frame rate of around 15 fps. The camera sensor used in the current work is set to record video sequence at 30fps and frame size of 640x480 (width x height). In our experiment, we have considered few assumptions. (1) The robot is able to travel at fixed speed 0.6 meters per Second. 5 minutes is needed to travel 3 meter distance. Total number of frames in 5 minutes video is 5*60*30 = 9000 frames. (2) Processing of all captured frames is not required because many of the frames have redundant information, so only few frames are enough for processing. (3) In this experiment, the robot will be stopped when robot travels predefined distance and it captures three images (left side image, right side image and front image) of the environment. (4) The path of the environment was created by filling the white pixels onto 640*480 image frame based on the human presence and the distance.

IV. CONCLUSION

New method for constructing the path and map for the mobile robot navigation was presented in this paper. We created a 2-D map for the unknown environment, using the proposed approach. The approach presented in this paper is considerably not complex and less expensive because 2D camera was used. The constructed map has the advantage compare with other existing methods that it can be produced with less time. The map generation is accomplished by determining the location of the human being from the captured picture frame and the exact position, orientation and human height. The human existence is determined by the process of detection of people based on ACF. The main limitation of the presented approach is dependent the human presence in the environment. If the human presence is not in the environment, path generation is not possible. To overcome this limitation, in future work an ultrasonic sensor will be used along with camera sensor.

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