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Real-Time Indoor Floor Detection for Mobile Robots using Iterative Approach

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Abstract:- This paper introduces an iterative technique to segmentation of indoor floor from a single 2-D camera connected to a mobile robot. The segmentation of the floor is an essential function for efficient mobile robot navigation, unlike previous approaches which rely on geometric indications, edges etc. Mobile robot mounted with the 2-D camera can capture floors images over long indoor sequences. Both floor and non-floor regions are all of a similar color when the conditions of illumination vary over a single image. The texture of the floor varies over a single image, and features may be lost as lighting changes. As mobile robot rotates, lot of information may be lost in the presence of small obstacles. Some floor areas are very shining under the artificial light condition. The radiant floor gives the wrong segmentation output. In the proposed approach does not require multiple images. The floor patterns are dynamically selected in the proposed research, and segmentation is performed based on the chosen designs. Camera calibration is not required in the proposed approach for floor segmentation. Also, edge cues and geometric cues are not necessary. The extensive experiment is conducted on a broad set of real indoor corridor floor image set.

Keywords: segmentation, pattern, floor, structuring element, standard deviation.

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1. Introduction

Floor segmentation is essential for indoor mobile robot navigation. By identifying which pixels belong to the floor, a mobile robot would be able to avoid obstacles and determine the geometry of the scene. It would be useful to build a map of the indoor corridor environment or to guide the robot as an area for which a map has been created. Another factor for floor segmentation includes programs such as measuring the size of the available free space in a room corridor, hall, etc. One of the challenges for indoor corridor floor segmentation is the reflections that are common on the floor. Thought on the floor which arises from the ceiling lights, light entering in from windows, door frames, or walls, often making it more challenging for a human observer to differentiate floor area.

A substantial amount of work has concentrated on the issue of identifying obstacles and avoiding them. The primary aim of these techniques is to detect the free space around the mobile robot instantly, instead of just the precise wall-floor boundary.

This paper introduces a new approach for mobile robot applications to indoor segment floors from a single image. The method does not use homography, optical flow, or stereo details, in contrast to existing techniques. One critical feature of the proposed solution is how it treats specular reflections properly. Indoor scenes it isn't unusual to include large quantities of light reflecting off the floor, especially when the overhead lights are bright, the sun shines through a window and the floor is extremely bright. Such reflections may contradict homography-based approaches, as they cause ground plane pixels to disrupt ground plane constraints.

2. Related Work

J Adorno et al. [1] have used an approach for floor detection. The method is based on the assumption of ground location; the floor detection chooses the super-pixels that correspond to the floor position. Deepu, R et al.[2] suggested a method of floor segmentation based on floor patterns. Clicking on the floor area will pick floor patterns. The user selects the amount of indoor environment floor patterns. Selected floor patterns are considered to structure elements of the structure. Floor segmentation is achieved by comparing the individual structuring element to the image of the input. Sourabh Bhowmick and Abhishek Pant[3] suggested approach to floor segmentation for mobile robot navigation. The proposed floor segmentation method senses both floor and shadows from a scene, irrespective of the change in illumination. In YCbCr color space and floor junction masking, a conventional breadth first-search based on region-growing technique was used to detect floor pixels from the scene using histogram-based features. Suryansh Kumar et al.[4] made use of presence and geometric signs in the formalism of the Recursive Bayes Filter. The filter allows for accurate segmentation even when the position of the floor varies, and it also ensures a precise distinction between floor and non-floor areas. Kim et al.[5, 6] and Zhou et al.[7] applied planar homographies to vectors of optical flows. The suggested approach only calculates a sparse floor representation by classifying sparse feature points, while the other two methods allow a pixel-wise decision to result in a dense floor representation.

3. Methodology

Figure 1 depicts the block diagram for the proposed floor segmentation method. Floor recognition is an important feature in the navigation of mobile robots. By moving within the free space and knowing where the floor is, mobile robot will avoid obstacles.

We suggested an iterative method for detecting floors in an indoor environment that does not involve edges of lines in this paper. For mobile robot navigation, complete floor information is not necessary at a single instant. Depends on robot characteristic, floor information extraction is essential. Example, if the mobile robot can travel 5 meters per min. Then 5 to 6 meters of floor information is sufficient for a mobile robot to complete the current movement. So, step by step floor information extraction is needed for mobile robot navigation. In the proposed approach, floor detection is achieved step by step based on the mobile robot characteristics (speed, height and camera resolution). When the mobile robot acquires an image of an indoor floor area, the acquired image may contain a large area of the floor. But, complete information on the floor is not necessary for mobile robot to complete the current movement. To extract required floor information, the only lower part of the image is processed to detect the floor. Once the image is captured, the bottom 35% of the image is selected to detect the floor. Processing of the lower part of the image is reducing the computation time.

In order to perform the floor segmentation, floor patterns are selected randomly. Randomly selected floor patterns are considered as structuring elements. Selected 'N' structuring elements are used iteratively to segment the input image. Every floor structuring element selected is matched with image block wise and outputs are fused.

$$C = \sum_{s=-a}^{a}\sum_{t=-b}^{b}(h(s,t) == f(x+s, y+t)) \qquad (1)$$

Where f is the image input, C is the count for comparison and h is the randomly selected structuring element (floor pattern). Here, every pixel of the input image is compared with the values of the structuring elements. Based on the comparison C count value is calculated. When the C value exceeds the specified threshold value, then selected regions will be considered as floor area. If in the case of C value is less than the predefined threshold, the selected area is not floor area.

Below figure 2 illustrates the block diagram of the fusion of segmented output.

Selection of structuring element (selection of floor patterns)

For efficient floor segmentation, floor pattern selection is significant. Floor pattern selection is performed randomly. Only below 35% of the image is considered for floor pattern selection. Floor pattern selection consists of the following steps:

1. Generate 2 random numbers. Selected random numbers must be within the specified floor area (below 35% of the input image). These random numbers represent X and Y coordinates of the image.
2. Records the structuring element (floor pattern) based on the above 2 points and perform the segmentation using the above approach.
3. Generate the next random numbers. New random numbers should not be the previous random

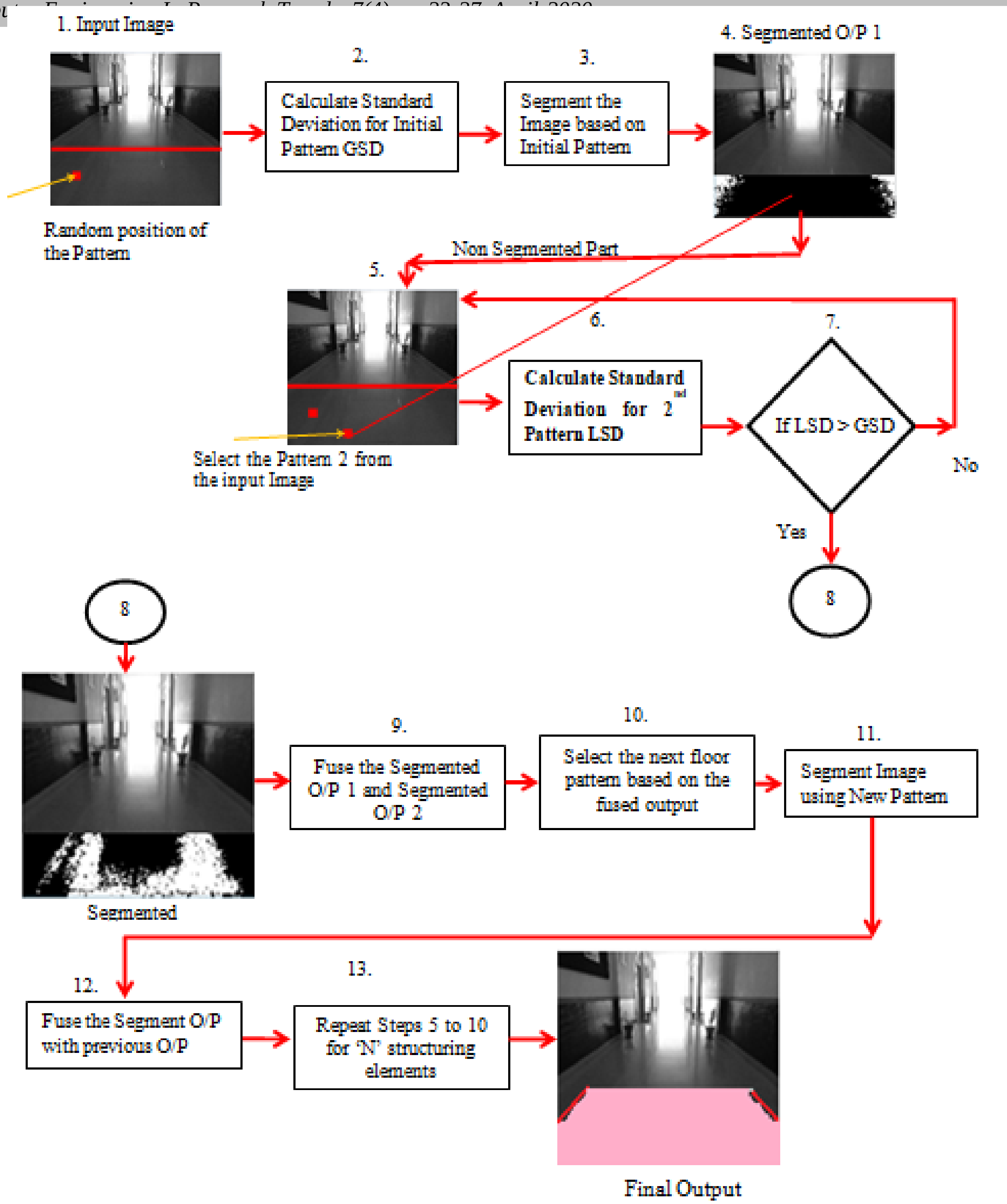


Figure 1: Block diagram for the proposed approach to floor segmentation.

numbers and should not be the segmented regions. This process iterates for 'N' number of times.

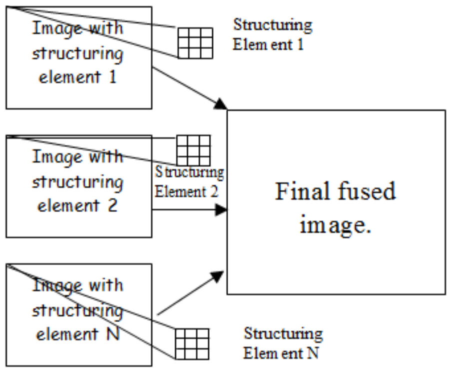


Figure 2: Block diagram for segmentation image fusion.

There is one central hypothesis considered in this work.

- During the selection of the floor patterns, there may be a chance of selecting already selected floor patterns. If in case of generated random numbers are of the segmented regions. Then a new random number will be made for floor pattern selection.
- When the generated random number selects the un-segmented region, the un-segmented region may be a wall area or floor area. To discriminate wall area and floor area pattern, we use one of the basic image properties.
- Standard Deviation is the basic image property is used for the discrimination process.

$$\sigma = \frac{1}{mn}\sqrt{\sum_{i=1}^{m}\sum_{j=1}^{n}\left[f(i,j)-M\right]^{2}}$$

--------------- (2)

Where M is the mean of the selected image region, m and n are rows and column size.

Figure 1 illustrates the complete floor pattern selection and floor segmentation process.

This process is repeated for 'N' number of floor patterns. Output of each pattern is fused into a single segmented image. The selection of 'N' depends on the user requirement. More number of floor pattern increases the segmentation efficiency.

4. Results and Discussion

Following important things are considered in our experiment:

1. Size of the mobile robot is 10x15 cm.
2. A robot can travel 5 meters/min.
3. Only 5 meters of floor area extraction is enough for navigation.
4. The camera, which is connected to the robot can capture 30 frames per second.
5. A total number of frames per min is 30*60.
6. But only 2 or 3 frames are required for floor segmentation.

The images that are used to test the proposed approach were captured by the camera attached to a mobile robot. We have captured images of our institute indoor floor images. During the initial experiment, we have tested our proposed approach on images available in the internet. Figure 3 shows the output of the floor segmentation on floor image available on the internet.

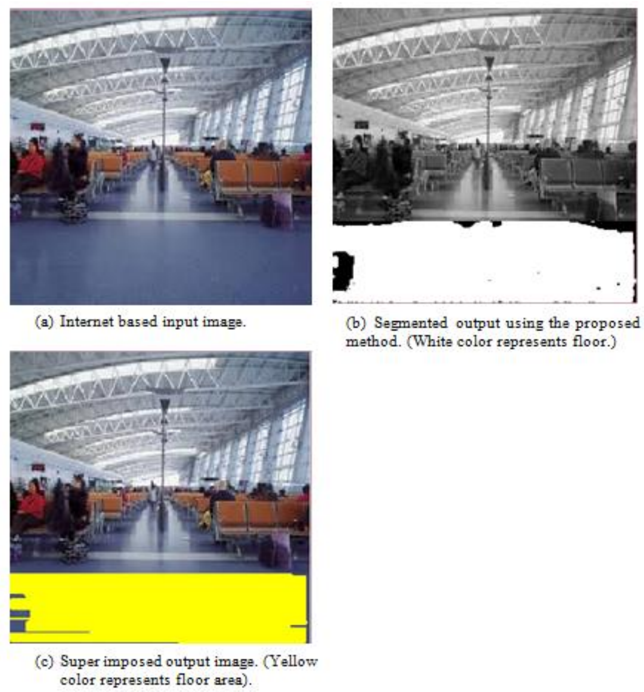
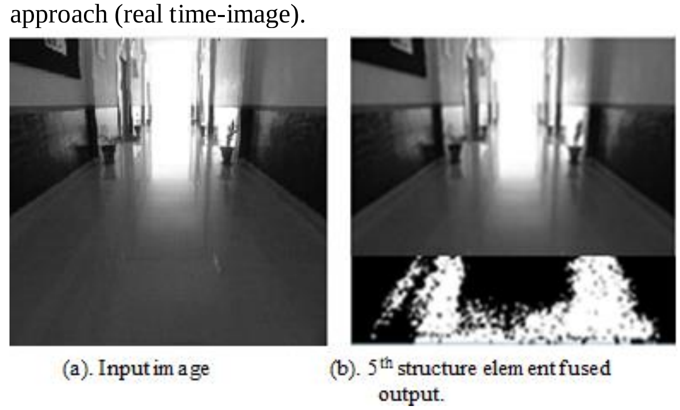


Figure 3: Sample output of the floor detection on image available on internet.

Figure 4 shows the output of the proposed floor segmentation approach (real time-image).



(c). Super imposed output

Figure 4: Output of the floor segmentation on real-time image.

5. Conclusion and Future Scope

This paper introduces a method for capable of detecting corridor floor space. Significant activity in robot navigation is floor segmentation. Floor segmentation is carried out according to the floor pattern (structuring element). Floor patterns are randomly selected based on basic image property standard deviation. Just 35 per cent of the input image is processed within the proposed approach and it reduces the time for computation. Since the robot just moves 5 meters/min. The number of floor pattern selection depends on the user requirement. If the number of structuring elements is more, we get excellent performance. In future, we propose to work on different image property and image features to improve the performance of segmentation.

6. Acknowledgement

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