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# Design and Development of Vision-Based Uneven Surface Detection Mechanism of Low Computational Complexity for Walk-Assisting Systems for Blind People

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***Abstract—*** *There are plenty of blind people who blind since birth or blinded by accident. Usually, they face a lot of problems while walking because most of the surfaces are uneven surfaces such as road bumps, and potholes. The goal of this study is to find a vision-based method for helping blind people to detect uneven surfaces. To identify uneven surfaces, color differences, and shadows of the uneven surfaces, techniques such as contour length, contour area, and nonzero pixel ratio of an image are being used. The image is initially captured and cropped to match the viewing angle of a human. An HSV filter is applied to the cropped image along with thresholding techniques for classifying the image components such as road, grass, or concrete. Further the HSV thresholds aid in obtaining more detailed information from the image. Subsequently, the image is divided into eight parts, and the nonzero pixel ratio, contour area, and contour lengths are computed for each part. The resulting data is stored in separate arrays, and maximum values are determined. If the maximum values from two arrays share the same indexes, it suggests the presence of potholes. To test the effectiveness of the proposed method, the test images of various surfaces were captured and test results. From the test results, we found that the proposed algorithm can identify things like potholes, and notify the user in advance. The findings of this study contribute to improving the mobility of visually impaired individuals by assisting them in navigating uneven surfaces more effectively.*

**Keywords— Uneven surface, HSV Filter, contour detection, Low computational complexity**

## I.INTRODUCTION

Uneven surfaces can be a big problem for blind people. Since they can't see, they depend on touch and other senses to know what's around them. When they walk, they have to be very careful because there might be things like tables, chairs, doors, and stairs in their way. As per the recorded studies and the data, identifying uneven surfaces, like potholes or bumps is the biggest problem for blind people while they are walking. people who as a result, trip or lose their balance, which can lead to injuries like bruises or broken bones. It's also scary for them because they can't see the walking surface, so they might feel anxious and avoid going to new places. To understand the surroundings, they use a stick called a "white cane"Click or tap here to enter text. But above their waist level, a stick can't be used. then they are more likely to collide. Furthermore, the white cane couldn't configure every uneven place in the ground.

In order to provide a solution, a vision-based uneven surface detection mechanism having low computational complexity has been proposed. The proposed system can assist visually impaired individuals in navigating challenging areas. The algorithm developed utilizes contour length, contour area, and nonzero pixel ratio to detect and classify uneven surfaces

The existing systems for assisting blind individuals include various technologies and approaches. One such system is the ultrasonic-based smart white cane, which uses ultrasonic sensors to detect obstacles and provide haptic feedback to the user. This cane allows users to scan their surroundings and navigate safely. Another system utilizes GPS trackers, which provide location information and guidance to blind individuals, helping them navigate unfamiliar environments. Computer vision-based navigation systems analyze images or videos captured by cameras to identify objects and provide real-time feedback to the user. Additionally, service dogs trained to assist blind individuals play a crucial role in their daily lives by providing guidance, support, and a sense of security. These dogs use their intelligence and senses to help navigate obstacles and ensure the safety of their handlers. Ongoing research focuses on enhancing the capabilities and accessibility of these existing systems, improving their accuracy, reliability, and usability to further enhance the independence and quality of life for blind individuals.

To test the effectiveness of the proposed mechanism, using the series of images of such surfaces, we extract threshold data differentiating even and uneven surfaces by HSV pixel values.

## II.METHODOLOGY

The proposed uneven surface detection mechanism has several stages to take the decision. First, capture the image and crop the image at the focusing angle, then apply the basic HSV filter to identify the image components such as road area, concrete area, and grass area. Then apply the secondary HSV filter to detect uneven surfaces. Then divide the cropped image into eight parts to enhance the result as shown in Figure i. The camera is placed at the head of the user as shown in Figure ii.

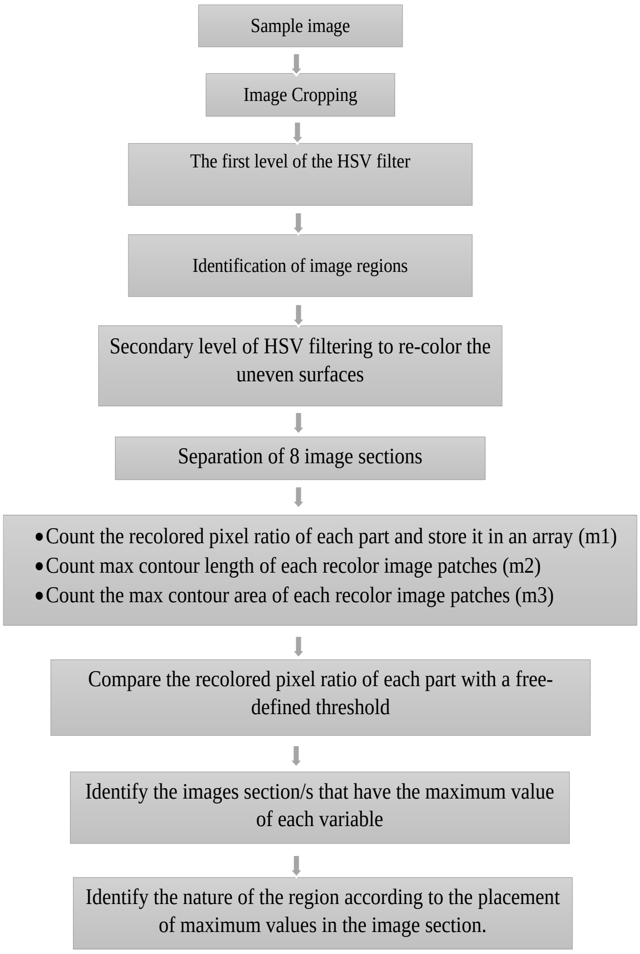


Figure 1: Block diagram

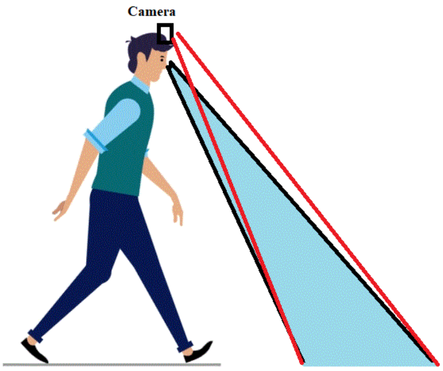


Figure 2: Camera setting for the system

### A. *image capturing:*

The first step of the proposed system is image capturing, which is done by the camera near the head of the user. The camera setting is fixed and It was assumed that the captured area is the surface the user will be in the next instant. The captured image of the camera is shown in Figure iii (a) and the captured images is called as 'sample image' hereafter. The image that applied at least one processing step is called as 'intermediate image' hereafter.

### B. *Crop the image*

The sample image as shown in Figure iii(a) covered a very large area with a wide angle but that much area does not need to identify uneven surfaces on the road. because it is required the nearest uneven surfaces according to the next step of the user. Therefore, the sample image should be cropped according to the viewing area as shown in Figure iii(b). It iminimizes the computational burden of the system

*(a)* *(b)*

Figure 3: (a) Sample image, (b) Cropped image of sample image

The sample image was a wide-angle image, therefor it is cropped beside the centre line of the sample image image. The camera set is fixed on the head of the blind person so the image centre is the center of the walking line.

### C. *First level of Image filtering:*

The lux level of the sourding such as morning, noon and evening are not constant as a result the RGB color rations are not effecty for color seperation based regin identification of the croped sample image of the specified application. The RGB colour ratio is changed with time. Therefor HSV colour filter is used to filter the croped sample image. The resultant image after applying first level HSV filter is shown in figure iv.

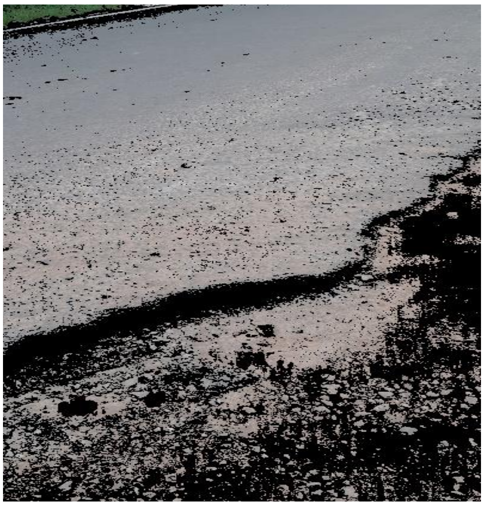

Figure 4 Basic filter added image

### D. *Identification of image regions*

The filtered cropped image may contain different types of surfaces/regions such as road areas, payments, grass, etc. The next step of the propsed mechanism is the separation of those regions.

It was done by comparing pre define HSV pixel ranges. The threshold of each ranges were estimated using a traning data set of varius images. The road area, pavement, and grass areas are used as main regions of the proposed system and the HSV pixel regions are seted acourdingly. The comparision process as shown in Figure vi. The algrothem is only prepared for three seet of regions such and concerte, grass and road area. It can be exted further regions by adjesting the threshlods.

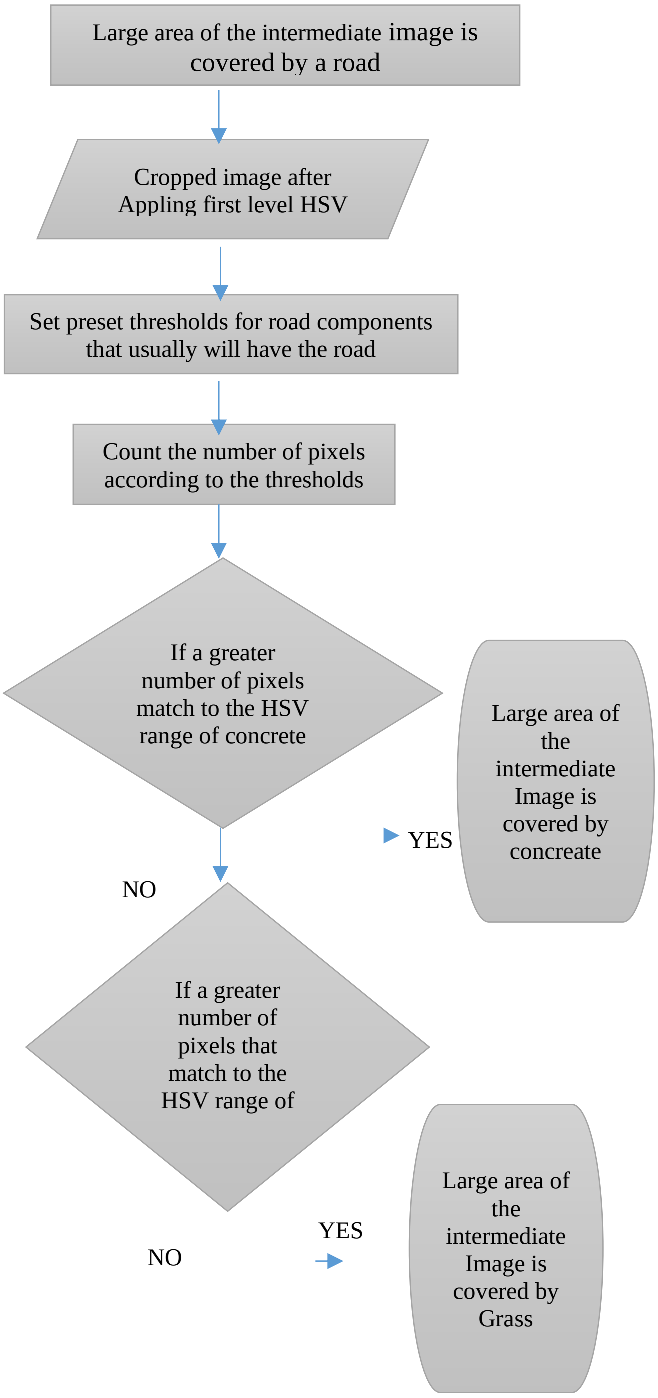


Figure 5: Image categorizing flow chart

*E. Secoundry level of filtering*

After identifying the image region, the second level of filtering is applied. In first stage filter only separate the image region using primary level of threshold ranges but secondary filter is added by narrow downing range abounding to the result in first level of filtering and recolor the regions which does not match to the selected identified rage. The resultant image after applying 2$^{nd}$ level of the filter is shown in figure vi (b). The threshold levels of both first level and second level were estimated trial and error method. The recolor regions by using black color are the regions that the pixel values more deviate from the selected pixel rage and It is the region that having uneven surfaces.

(a) (b)

Figure 6: (a) First level filter, (b) Secondary level filter

*F. Processed image divide into eight-part*

After adding secondary filter, uneven surface could be found but in this stage also some other areas contain Non zero pixel values there for the whole image was divided in to eight equal image sections as shown in figure vii, and analysis each image separately.

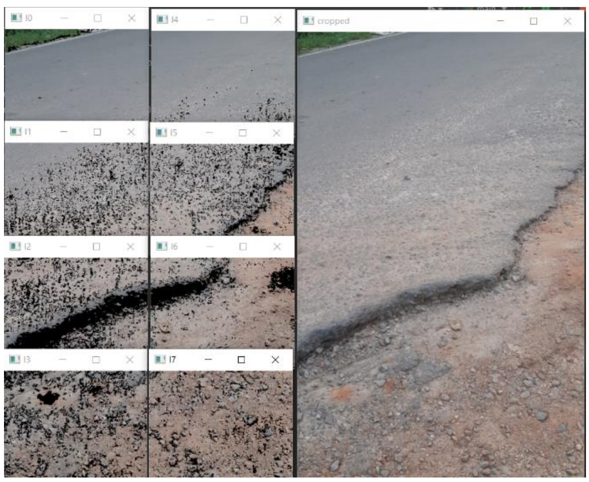

Figure 7 Cropped image with a small part of the image

### G. *Getting contour area and contour length*

Identification of the contours of each image section is the next step of the proposed method. Contours are continuous curves that represent the boundaries of objects or regions in an image. By analyzing the contours, we can identify the irregular shapes typically associated with uneven surfaces.

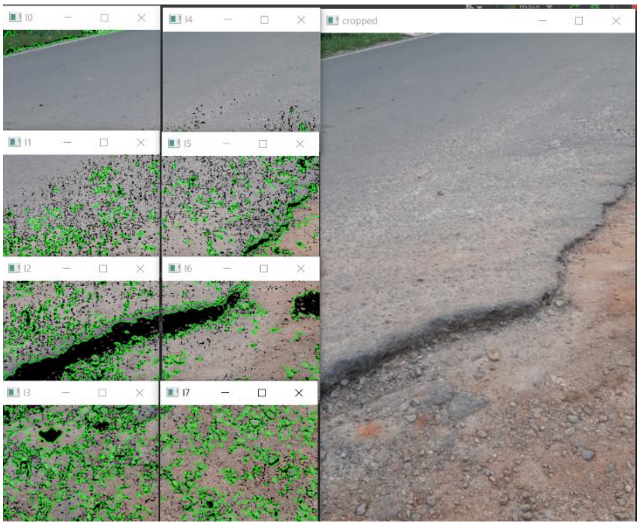

*Figure 8: Contour length and area counted image*

Figure viii: Contour length and area counted image

To determine length and area of each contour are evaluated. The length of the contour provides an indication of the overall size and extent of the uneven surface, while the area gives us insight into its magnitude. Based on predetermined criteria, such as minimum and maximum length and area thresholds, we classify contours as potential uneven surfaces.

### H. *Identifying uneven surfaces using contour area and contour length and Recolored pixel ratio*

To identify uneven surfaces For each of the eight parts, the nonzero pixel ratio is calculated by counting the number of recolored black pixels and dividing it by the total number of pixels in that section. This ratio provides an indication of the density of potential uneven surfaces or irregularities in that specific area.

Simultaneously, the contour area and contour lengths are computed for each part using the OpenCV library. These measurements help determine the size and extent of the detected contours, which are indicative of potential uneven surfaces. The calculated nonzero pixel ratios, contour areas, and contour lengths for each part are then stored in separate arrays. By finding the maximum values in each array, we can identify the most significant values across the image.

Next, specific thresholds are set for each part. These thresholds define the minimum required values for the nonzero pixel ratio, indicating the minimum density of potential uneven surfaces needed to classify an area as having uneven surfaces. If the maximum nonzero pixel ratio and contour length indexes coincide, it indicates that the section with the highest density of potential potholes also has the most significant contour. This alignment suggests the presence of actual uneven surfaces in that particular section.

If the any of two indexes are the same as shown in Table 1 the image part potential to be an uneven surface therefore whole image can be the uneven image.

*Table 1: Example data set of all variable*

| | A | B | C | D | E | F | G | H |
|---|---|---|---|---|---|---|---|---|
| Recolor pixel ratio | X | | | | | | | |
| Max contour area | | X | | | | | | |
| Max contour length | X | | | | | | | |

By considering the identified sections with matching maximum indexes across the arrays, we can conclude whether the image contains uneven surfaces based on the predefined thresholds. If the conditions are met, it suggests the presence of potholes in the road surface. This methodology allows for the systematic evaluation of different sections of the image, considering nonzero pixel ratios, contour areas, and contour lengths. By setting appropriate thresholds and analyzing the maximum values, we can reliably identify potential uneven surfaces and prioritize maintenance actions for safer road conditions.

## III. RESULTS AND DISCUSSION

The aim of this study was to develop an algorithm for detecting uneven surfaces to provide guidance for blind individuals navigating outdoor environments. The algorithm utilized contour length, contour area, and nonzero pixel ratio analysis techniques to identify potential uneven surfaces in captured images. To test the effectiveness of the proposed system varies test images of uneven surface in the walking arears such as roads, payments grass arears, concrete walking paths were captured. Around 30 images of each surface were selected for the test as shown in table 2.

*Table 2: HSV value* of captured test images

| Grass | | | Concrete | | | Road | | | Off road | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
|  | | |  | | |  | | |  | | | |
| H | S | V | H | S | V | H | S | V | H | S | V | |
| 80 | 120 | 70 | 6 | 14 | 182 | 114 | 9 | 139 | 4 | 48 | 138 | |
| 80 | 122 | 72 | 0 | 12 | 183 | 113 | 7 | 153 | 6 | 52 | 143 | |
| 88 | 126 | 77 | 5 | 14 | 168 | 110 | 5 | 143 | 7 | 59 | 139 | |
| 58 | 99 | 41 | 3 | 15 | 191 | 114 | 8 | 150 | 9 | 59 | 154 | |
| 57 | 98 | 40 | 6 | 13 | 189 | 109 | 14 | 148 | 8 | 54 | 147 | |
| 45 | 91 | 26 | 11 | 11 | 183 | 105 | 14 | 144 | 9 | 62 | 140 | |
| 52 | 99 | 29 | 6 | 14 | 179 | 114 | 9 | 148 | 7 | 61 | 150 | |
| 148 | 183 | 126 | 3 | 16 | 172 | 107 | 12 | 154 | 9 | 56 | 136 | |
| 54 | 94 | 41 | 0 | 8 | 192 | 109 | 14 | 147 | 8 | 50 | 139 | |
| 49 | 78 | 32 | 0 | 12 | 198 | 0 | 0 | 156 | 8 | 58 | 137 | |
| 66 | 104 | 57 | 11 | 10 | 197 | 105 | 14 | 141 | 7 | 53 | 129 | |
| 41 | 82 | 26 | 6 | 6 | 206 | 107 | 12 | 152 | 8 | 59 | 117 | |
| 108 | 147 | 102 | 0 | 7 | 206 | 114 | 8 | 153 | 7 | 57 | 138 | |
| 38 | 72 | 21 | 6 | 7 | 185 | 109 | 14 | 147 | 8 | 59 | 134 | |
| 117 | 154 | 111 | 3 | 14 | 203 | 103 | 12 | 149 | 9 | 57 | 156 | |
| 41 | 82 | 26 | 0 | 8 | 200 | 103 | 16 | 143 | 7 | 58 | 145 | |
| 51 | 90 | 37 | 6 | 13 | 191 | 103 | 16 | 143 | 7 | 55 | 148 | |
| 64 | 108 | 47 | 9 | 13 | 203 | 111 | 18 | 142 | 7 | 49 | 135 | |
| 38 | 72 | 21 | 0 | 6 | 172 | 0 | 0 | 139 | 6 | 48 | 117 | MIN |
| 148 | 183 | 126 | 11 | 16 | 206 | 114 | 18 | 156 | 9 | 62 | 156 | MAX |

The images were captured using a camera positioned on the head of the user. The images were processed and divided into smaller sections to allow for detailed analysis. The recolored pixel ratio, Max contour area and Max contour length are counted in each part of image named as A, B, C, D, E, F, G, H. The analysis focused on extracting features related to uneven surfaces, such as the presence of significant contours and the density of potential uneven surface pixels. The contour length and contour area measurements provided information about the shape and size of detected contours, while the nonzero pixel ratio indicated the concentration of potential uneven surfaces within each section

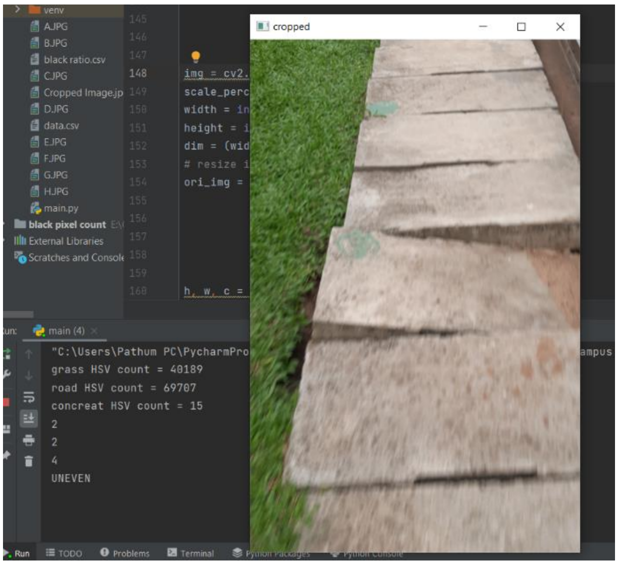


Figure 9: Decision taking example 01

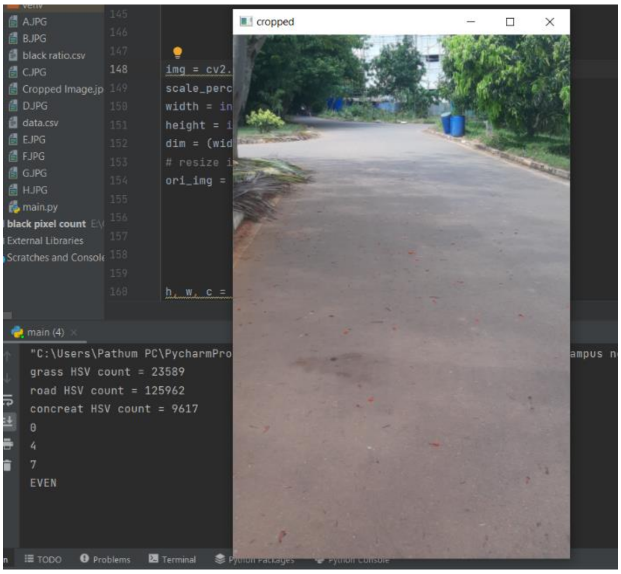


Figure 10: Decision taking example 02

By comparing the extracted features with predefined thresholds, the algorithm determined the likelihood of a section containing an uneven surface. If the contour length and contour area exceeded certain thresholds and the nonzero pixel ratio was above a specified value, it was classified as a potentially uneven surface location

Table 3: Decision taking data set bay manual and using algorithm for each sub-part

| IMG name | Original IMG sample | ropped IMG sample | Original IMG zero pixel | Processed IMG zero pixel | Even or un even by manual | Even uneven by algorithm |
|---|---|---|---|---|---|---|
| A |  |  | 310 | 942 | EVEN | EVEN |
| B | |  | 312 | 1025 | EVEN | EVEN |
| C | |  | 310 | 8654 | UNEVE N | UNEVEN |
| D | |  | 312 | 7524 | EVEN | UNEVEN |
| E | |  | 620 | 972 | EVEN | EVEN |
| F | |  | 624 | 2070 | EVEN | EVEN |
| G | |  | 620 | 7782 | UNEVE N | UNEVEN |
| H | |  | 624 | 2547 | EVEN | EVEN |

The algorithm was then tested on a dataset of real-world images captured in different environmental conditions, including varying lighting conditions, pavement types, and uneven surfaces sizes. The performance of the algorithm was evaluated based on its ability to accurately detect uneven surfaces and provide reliable guidance for blind individuals.

The results showed promising performance, with the algorithm successfully identifying the majority of uneven surfaces in the test dataset. However, it also exhibited some limitations in certain scenarios, such as low-light conditions or the presence of complex textures that could interfere with contour detection. In the algorithm development, keeping the computation burden lower than existing approaches were targeted.

Further improvements could be made by refining the threshold values, considering additional features, and exploring machine-learning approaches to enhance the algorithm's accuracy and robustness. Additionally.

Overall, this algorithm represents a promising step towards assisting blind individuals in navigating outdoor environments by alerting them to potentially uneven surfaces. However, further research and development are necessary to optimize its performance and ensure its practical applicability in real-world scenarios.

## IV. CONCLUSIONS

In this study, an algorithm for uneven surface detection was developed to provide guidance for blind individuals. The algorithm analyzes images by dividing them into sections and calculating contour length, contour area, and nonzero pixel ratio. Threshold values are set for each section, and if the maximum values of these parameters exceed the thresholds, it indicates the presence of an uneven surface.

Results from testing the algorithm showed promising performance in detecting uneven surfaces in the tested dataset. However, further refinement of the algorithm is necessary, including optimizing threshold values and exploring machine-learning techniques for improved accuracy and robustness. Future directions for research include refining the algorithm, incorporating machine learning approaches, developing real-time implementation, conducting field testing and gathering user feedback, and integrating the algorithm with assistive technologies. These efforts aim to enhance the algorithm's effectiveness and usability, ultimately improving the mobility and safety of blind individuals in urban environments.

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