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Tactile Guidance System for the Blind Based on Digital Image Processing

Tactile Guidance System for the Blind Based on Digital Image Processing

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Abstract. Science and technology are making earth-shaking changes in our daily lives, and as a special group, blind people should enjoy the fruits of technological progress. Since the traditional blind guiding device can only give rough information about the distance and orientation of the obstacle, the user obtains too little information, and there is still too much unknown fear during the traveling. The guiding effect is not great. Therefore, after considering the physical and psychological needs of the blind, this paper designs a system of tactile perception imaging instead of vision. The system collects obstacle information through the camera, performs digital image processing, and then displays it on the tactile imager through special encoding processing. Through the sense of touch, the blind person processes the tactile information into image information through the brain, thereby obtaining the size, shape and position information of the obstacle, and then forming a more concrete understanding of the obstacle, so that the blind can perfectly avoid the obstacle.

1. Research background and significance

1.1 Research background

The World Health Organization estimates that there are 40 to 45 million blind people in the world, and data shows that in 2010, the number of blind people in China was 8.248 million, accounting for 18% of the world's total blind. And about 450,000 new blind people will be added each year, that is, one blind person will appear every minute. Visual information accounts for a large proportion of the information we obtain on a daily basis, and blind people lose the ability to take the initiative to avoid obstacles in time because they lose their visual functions. Their normal life and safe travel are also inconvenient. In addition, the construction and use of blind roads have not received much attention. Uncivilized behaviors such as stacking items or temporary parking on blind roads often occur, which can easily bring danger to blind travel. In recent years, with the development of science and technology, research on guide blind technology at home and abroad has achieved some results, and electronic blind guide devices such as radio guide blind systems, blind electronic eyes, ultrasonic guide blind systems, and voice guides have appeared. However, these devices have some shortcomings: some functions are too singular and do not meet the actual needs; some are slightly cumbersome and are not suitable for daily carrying; some are too strong in character to be unacceptable to the blind. Therefore, there must be new developments and breakthroughs in guiding devices.

1.2 Research significance

Science and technology are making earth-shaking changes in our daily lives, and as a special group, blind people should enjoy the fruits of technological progress. Hearing and touch are the two main ways in which the blind person perceives the world. Considering that some scenes are not suitable for sound release and wearing headphones on the road, there is a certain risk, and the blind person has a more sensitive tactile perception. Therefore, this thesis replaces vision with tactile perceptual imaging, and uses digital image processing technology to design a blinding device that replaces tactile sensation. The image in front of the eye acts on the abdomen of the blind in a tactile form, thereby forming an awareness of the environment in the brain. Blind people do not dare to walk independently. They are mainly afraid of the surrounding unknown environment. This device can help the blind people to have a general "visual" perception of the environment, and the psychological barrier will be reduced, so that they can better avoid obstacles and walk independently.

2. Overall design

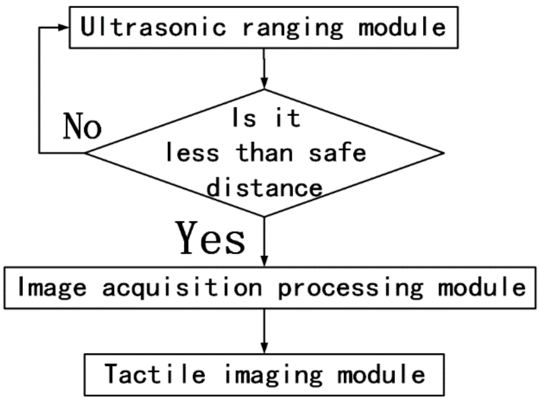

Figure 1. Overall system flow.

The entire device mainly includes three modules: ultrasonic ranging module, image acquisition processing module and tactile imaging module. The system flow is shown in Figure 1. The ranging module uses an ultrasonic sensor, and the image acquisition uses an ordinary camera, and the price is relatively low. The two modules are fixed to the waist by straps, and the ultrasonic ranging module adopts the ultrasonic echo positioning principle to calculate the distance between the sensor and the obstacle by measuring the echo time. When no obstacles are detected within the set safe distance range, the other modules do not respond. Once the obstacle distance is less than the safe distance, the image acquisition module is started immediately. After the image is acquired, the image processing is performed, and the main image information is extracted to form a pixel latticed image. The tactile imaging module is arranged by the array of vibrators, and corresponding to the lattice image after image processing, forming a one-to-one mapping relationship, so that the vibrator having the position of the specific image information vibrates to form a vibration of a specific position. In turn, imaging in the brain enables the blind to create a "visual cognition" of the environment through the sense of touch.

3. Detailed design

3.1 Functional design

3.1.1 Ultrasonic ranging. Considering that the two-dimensional image does not contain the environmental depth information, if the Kinect sensor is used to collect environmental information and is expensive, an ultrasonic ranging module is added to provide the distance information. Ultrasonic waves are not as susceptible to light as infrared light, are not susceptible to environmental interference, are capable of directional emission and acceptance, and have constant velocity in different media, so they are highly advantageous for detecting obstacle distances. Although the ultrasonic sensor cannot effectively detect the object close to the ultrasonic sensor, there is a detection dead zone. However, in the design of this paper, since the distance measuring module is only used to detect the safety distance, when the obstacle distance is less than the safety distance, the trigger signal is sent to the image. Acquisition processing module. Therefore, the distance measuring module is not required to detect an object that is close to the distance sensor, and the specific distance is measured, so it is most suitable to use ultrasonic waves for ranging.

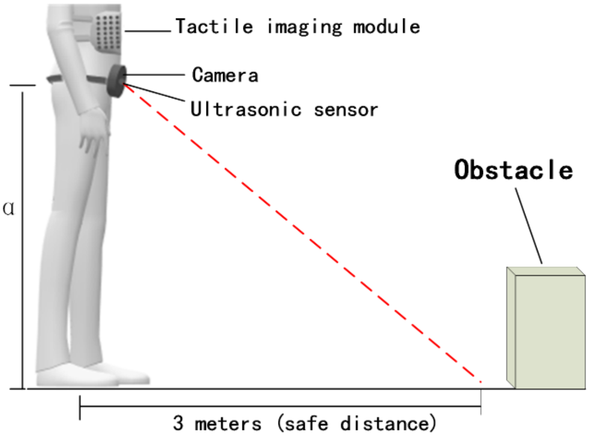

Figure 2. Schematic of ultrasonic ranging.

The initial set safety distance is 3 meters, assuming that the user's waist is at a height α from the ground. According to the Pythagorean theorem, the path traveled by the ultrasonic wave without obstacles is:

$$\beta=2\sqrt{3^2+\alpha^2}.$$

The echo time can be calculated from the sound velocity of the ultrasonic wave, and the distance of the obstacle is judged by the value of the judgment time. Since the distance is measured during walking, the measured time value is allowed to fluctuate within a certain range. In actual use, the value of a can be adjusted to suit the individual.

3.1.2 Image Acquisition Processing. Color images contain too much information. For high-resolution eyes, it can cope well with information-rich images. For blind people, the information acceptable to the senses of the senses should not be too complicated to sense the Informative images. Therefore, the image is processed into a binarized image for storage and utilization.

The image data is collected by the camera and transmitted to the image processing module for processing, including image graying, binarization, and filtering denoising.

In the first step, the image is grayed out. In this paper, the average value method is used to grayscale the color image, that is, the brightness values of the three components in the color image are averaged, and the obtained gray value is used as the brightness of the grayscale image.

$$Gray(i,j) = (R(i,j) + G(i,j) + B(i,j)) / 3,$$

R = G = B = Gray, which only stores one luminance information, reducing the amount of image data information and making it easier to store.

In the second step, the binarization process is performed, and the pixel whose gradation is greater than or equal to the threshold is determined as a specific object, and the gradation value is 255, and other pixels are excluded from the object region, and the gradation value is 0, indicating the background. Or other non-specific object areas. The binarization of the image facilitates further processing of the image, making the image simpler, and the amount of data is reduced, highlighting the contour of the object of interest. For the purpose of this article, the obstacles can be highlighted, so that the blind person can have a clearer understanding of the obstacle when using the device, and reduce the interference of the background information to the blind person to recognize the obstacle.

In the third step, after the above two steps, there will be some noise points on the image, which can be filtered by the filter to make the image smoother and further reduce the amount of information. The linear filter tends to blur the edge information of the image while filtering out the noise, while the nonlinear filter can preserve the edge information of the image while filtering out the noise. Therefore, nonlinear filtering is preferred. This article captures the obstacles on the blind road through the actual scene framing, and uses Matlab for image processing. The image before and after processing is compared as follows:

Figure 3. Captured raw image

Figure 4. Binarized image

Figure 5. Image after closed operation

A closed operation is a process in which an image is first expanded and then etched. It is used to fill small holes in an object, connect adjacent objects, and smooth its boundaries without significantly changing its area, which is for white points. The bwmorph function is used in the image processing process with Matlab. After processing, the obstacles are more prominent, and the surrounding environment and background are better weakened. The image opening and closing operation is essentially a process of mathematical filtering of nonlinear filtering.

3.1.3 Tactile Imager. After the acquired image is processed, the resolution is 320×320, and the designed tactile imager has a resolution of 16×16. In order to better match the two, the digital image is further compressed and encoded. According to the calculation, each vibration point on the imager should reflect the comprehensive information of 400 pixels. The design is as follows: set the value of each pixel toσ(σtakes 0 or 1), and calculate a certain vibration point corresponding to 400 pixels. The total value is

$$\gamma=\sum_{j=1}^{400}\sum_{i=1}^{400}\sigma(i, j).$$

Ifγ>=300, the vibration point is set to 1. Ifγ<=100, the vibration point is set to 0. When 10<γ<30, as long as there is a vibration point around the vibration point, the vibration point is taken as 1, otherwise it is 0. This not only allows the resolution to be matched, but also removes isolated information points without excessively removing the edge of the object information.

The above is still the image processing part, but it is only further processing after considering the tactile imager. After the processing is completed, the resolutions of the two are completely matched, and the image coding information is sent to the tactile imaging module, decoded and sent to the vibrator lattice, and the vibration image is established from the bottom up by the line refresh method.

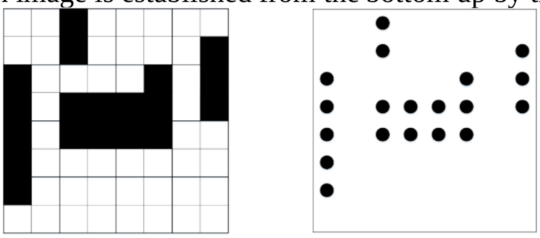

Figure 6. Pixel points remaining after special compression and encoding, as well as imaging vibration points on the tactile imager.

After wearing the device, the blind person can adapt to the basic information of the obstacle through the vibration information, and realize the tactile communication of the visual image.

3.2 Structural design

The guiding system consists of three components: an ultrasonic ranging probe, an image acquisition camera, and a tactile imager. Considering that the waist is relatively stable during the vertical walking process, the ultrasonic distance measuring probe is placed at the waist, which makes the distance detection more accurate. The image capturing camera is prevented from being at the waist, which is convenient for image stable collection and prevents image blurring, and the height is more suitable. The size ratio of the object in the image is more suitable. The upper body tactile sensitivity of the person is generally higher than that of the lower body, and because the abdomen area is large, it is convenient to place a certain area of the vibrator lattice, so the tactile imager is placed on the abdomen. The overall structure looks like the picture above.

4. Innovation

Traditional guide blind devices mostly use the prompt information to guide blindness. Voice prompts or tactile prompts are usually given, which is too simple and one-sided. For example, the device indicates that there are obstacles in front of the blind through tactile sensation, and can give rough information about the distance and distance through the difference in the tactile intensity, but for the blind, the information obtained is only a point with distance, and the other for the obstacle Information is not available, which makes the blind have an unknown fear of the road. This article is based on this as the starting point, to give the blind "second eye" as the starting point, design a touch-sensing instead of visual imaging guide blind system, the visual image acts on the blind skin in a tactile stimulation, after short-term adaptation In the future, the brain of the blind can easily process the tactile information into image information, and then form a more figurative understanding of the size, shape and position of the obstacle, so that the blind can reduce the fear of marching. At the same time, the road position of the barrier-free and feasible road can be clearly perceived on the tactile image. After a certain period of adaptation, the blind person can completely avoid the obstacle by wearing the device. Add some other features to the device, such as navigation, and some smart voice prompts, the blind person will be able to go to any destination by wearing this device.

5. Conclusion

This paper comprehensively designs a non-traditional guide blind system, which can no longer provide one-dimensional distance information of obstacles like traditional guide blind equipment, but provides the surrounding environment to the blind through the distance measuring device and the tactile imaging device. The three-dimensional information makes the blind people's understanding of the environment more three-dimensional, greatly facilitating the travel of the blind, and effectively improving the safety of blind people traveling alone. When you see the advanced nature of this system, you should also consider its shortcomings. Because you use an ordinary camera as an image collector, you can't solve the night travel problem. However, if you add an infrared camera application, you can add special processing to the captured image. The problem can also be solved. With the development of science and technology, people's lives are more and more convenient. Here I hope that more and more advanced technologies can be applied to help special people, so that everyone can bathe in the ocean of advanced technology.

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