Aid system for visually impaired people at spatial orientation

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Abstract. The paper is devoted to the analysis of possibilities of infrared lasers and ultrasonic sensors of distance measurement in assisting visually impaired people.

1. Introduction
According to the world health organization worldwide, there are 37 million blind people and 124 million with low vision [1]. At the same time, according to UN projections, by 2020 the number of blind people worldwide could grow to 75 million people. According to some origins, the number of the counted blind and visually impaired in Russia is 218 thousand people, including wholly blind – 103 thousand. Modern technology allows visually impaired people and people with damage to the visual system to improve object recognition and orientation in space, which leads to improving their quality of life.

2. Statement of the problem
Visually impaired people are usually well oriented in space, but do not notice small obstacles in its path, such as curbs, steps up or down, small holes. To use the white cane they don’t have, but not noticed in time these obstacles can injure the person [2-6]. To date has developed and offers such tools to help visually impaired people, a cane as Mygo [7], cane SmartCane [8], LaserCane walking stick [9]. These canes or using laser sensors and then do not require contact with the surface, or they use ultrasonic sensors, but then at the end of the stick is a wheel or a sphere moving on a surface on which the moving people. Each stick is placed a pair of sensors: one to detect obstacles like a step up, and another to detect obstacles like a step-down. A significant drawback of all the proposed devices is the fact that they emphasize vision problems from its users. For people with weak eyesight is usually undesirable. Therefore, we consider the choice of sensors for the system to aid visually impaired people. These converters must be such that its dimensions could be integrated into a conventional walking stick. The outer diameter of this cane is typically 22-30 mm. An Additional requirement is that walking man did not need to touch the surface on which movement occurs, the end of the stick. The distance at which it detects the obstacle shall be not less than 1.5 – 2.0 m. Usually, depending on the used in the manufacture of materials, a cane may take weight from 0.1 to 0.4 kg but if you use canes made of titanium with adjustable length weight may be up to 0.8 kg. This fact also needs to be considered when choosing a sensor.

3. Experimental
For measuring small distances apply infrared (IR) laser and ultrasonic distance sensors. Infrared distance sensors contain an IR transmitter led and IR receiver photodetector. Infrared led emitting an infrared signal, and an infrared photo-detector detects the reflected signal. The amplitude of this
reflected signal is usually inversely proportional to the distance from the object to the infrared transceiver. The maximum distance is the threshold for determining the presence of the object. An example of such a sensor is the sensor range Sharp GP2Y0A02YK0F (figure 1) is an analog infrared sensor to determine the presence of an object at a distance of from 20 to 150 cm [9].

![Figure 1. Infrared sensor Sharp GP2Y0A02YK0F.](image)

The main disadvantage of this sensor is that the distance measurement is used triangulation method. For this reason, the measurement results depend on the angle of incidence of IR radiation on a controlled surface, which is unacceptable for the considered problem.

A significant drawback of optical, including laser, sensor is bad resistance to weather conditions. For example, contamination of the detector leads to the impossibility of detecting objects, while ultrasonic sensors with the same degree of contamination continue to work, but with less sensitivity.

The system to help people with impaired vision is currently developed. The main purpose of such systems is to provide information on the nature of the obstacles. As measurement sensors in such a system typically uses a pair of ultrasonic sensors. This seems the most reasonable, the more that existing ultrasonic sensors, such as used in Parking Systems (Parktronic), have small dimensions, allowing to place them inside a regular orthopedic cane. Ultrasonic sensors can have separate transmitters and receivers, and combined.

The first of these is the sensor HC-SR04 (figure 2). This ultrasonic sensor can measure the distance to obstacles in the range from 2 cm to 4 m. It is the most preferable in terms of price/quality, but its dimensions, components 40×20×15 mm, not allow you to place it inside the cane.

![Figure 2. Ultrasonic sensor HC-SR04.](image)

Parking sensors use a combined emitter and receiver. The most effective parking sensors at a distance from 25 cm to 1.8 meters are the sensors which correspond to a desired range of distances.

There are separate modules ultrasonic sensors (sonar), such as LV-MAXSONAR-EZ1 (figure 3), allowing to detect objects at distances up to 6.45 m. This sonar is one of the typical decisions on the basis of ultrasonic sensors MaxSonar-UT firms Maxbotix. Module output signals on the distance of the object present in three forms: analog signal, PWM and serial data R, and T. There is also a sealed design given module ultrasonic sensor LV-MAXSONAR-WRC1 (figure 3 b).
Examples of ultrasonic sensors are shown in Table 1, where added the most accessible sensor ParkMaster A [10]. The diameter of the sensors themselves is almost the same and ranges from 16.4 mm for the sensor used with the LV-MAXSONAR-EZ1 to 18.8 mm sensor ParkMaster A. The problem is, the Board size of the module LV-MAXSONAR-EZ1 is 19.9×22.1 mm, which eliminates the placement of the Board of the stick. As a way out of this situation, you can offer accommodation module LV-MAXSONAR-EZ1 in rubber cane tip diameter reaches 50 mm, and use this module to detect obstacles like a step or a curb. Sensor to detect the steps down it is advisable to place the handle of the cane and used as a sensor ParkMaster or A sensor selected from the module LV-MAXSONAR-EZ1.

Surface mount the sensor on the body of the cane implies the contact with the dust particles, water and maybe some reagents, which are applied to the road surface, resulting in a preferred use of the sensor is totally enclosed. Most of the sensors that are built in sealed design, protection of its internal structure correspond to the degree of IP67, which allows it to be completely closed against the ingress of dust and moisture. You should also use a sensor with a broad temperature range (-40°C to +70°C). Another option to consider is the beam width, which is usually contained in the technical documentation for the sensor or can be determined experimentally.

After assembly of the device, load the program memory of the microcontroller and layout of all elements in the cane, it was necessary to test the sample.

To do this, use normal laboratory conditions with obstacles of the type of steps down and steps up. The program was configured so that when approaching certain obstacles used the same algorithm like parking sensors on the cars that is, the closer the obstacle, the higher the pitch of the sound, and the farther away from obstacles so that it will be lower (figure 4).

The fundamental difference from the rest of the competing devices is to scan all the objects not only in the horizontal plane, but also below it, i.e. the presence of ledges, stairs leading down, and wells and hole.
4. Conclusion
The device showed good results when scanning a space in motion, in laboratory conditions. At the exit to the street, it was immediately revealed that one of obvious drawback is the device output. In a typical street environment due to noise sound with conventional piezoelectric sensors is not audible when using headphones. The user can also experience some discomfort because of people with impaired vision, a person receives compensation for a lack of vision in enhanced auditory senses, and a person cannot prevent them from functioning.

It can be concluded that the most effective would be to use not only one type of output signal (signaling of danger) but several at the same time. Additional information channel for a person can be a source of vibration in the handle of the cane. In this case, when using the vibration signal in the form of periodic bursts of pulses can be frequency of the vibration signal coding type of obstacle (step up or step down), and the frequency of the pulse train to be used for coding distance to the obstacle, i.e. the closer the obstacle, the higher the frequency of the pulse train. In order to be able to use the cane as a regular cane for walking, it is necessary to highlight the moments when it takes a fixed position in space. It can be implemented that including the system processing of the measuring information two-axis accelerometers. In the layout system aid visually impaired people was used 2 ultrasonic sensors HC-SR04, which provided the performance of the system if an obstacle is detected and the type of the step up, and step down.
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