

TACTILE NAVIGATION SYSTEM FOR NAVIGATION OF BLIND PERSONS

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Abstract – This article obtains by system for using in navigation systems for orientation of blind men in unknown terrain. This system named as "Tactile Navigation System" is a compensation instrument for blind persons. It is composed from three basic elements: camera, control unit and tactile activator. The tactile navigation system converts the image from the camera to the tactile information and transfers this information to the blind person. The blind person can recognize by vibration of the tactile activator placed on the antebrachium, if he comes on an impediment or if he can continue free go. He will detect individual impediments at short time than different compensation instruments. Blind stick wouldn't have a competitor in this device, but a helper. This system should make easy to blind person an orientation in terrain.

Keywords: Tactile systems, blind persons, navigation, camera, tactile activator

1. BASIC INFORMATION

The need of navigation of blind persons is still a challenge. The white stick accompanies them for centuries, even in the electronic age. This article is a small contribution in this branch. The aim of the projected device is to enable the orientation of blind persons in the space. The design and the individual components have undergone some changes during the development, as the technology of individual elements developed. But the basic idea has not changed. The described tactile navigation system includes a camera, a control unit, a tactile activator and a power supply.

2. OVERVIEW OF PRESENT SYSTEMS

For the better awareness in this issue, we will present some already developed and experimentally verified navigation systems for blind persons.

One of the used systems is the Tyflosonar [7], which represents a multi-functional electronic device. It uses ultrasound for the distance measurement. In addition to the obstacle detection it includes also a sound beacon and a sound indicator of light intensity. Additional functionalities are the obstacle distance measurement and the accumulator test. The blind person wears the device usually on the chest.

The navigation system Dinasys [8] is intended for orientation of visually handicapped persons in an unfamiliar environment of buildings, corridors, closed outside areas or

other closed rooms. This navigation system is not intended for orientation in streets or in open space. The navigation system consists of two components – a modified white stick and very strong permanent magnets. The magnets are put into or glued onto the ground to mark the proper path. The magnet can be placed under a carpet or embedded into soil up to 5 cm deep.

The other system is called by the authors Tongue Display Unit (TDU) [9]. The TDU has been designed at the University of Montreal. The system consists of a camera that scans the surroundings. The processed signal from the camera gets to a 12x12 matrix, which is located on an elastic foil. The foil is put on the tongue. The tactile cells of the tongue are stimulated by electrical impulses in individual points of the matrix. The letter T was tested in various positions. After a short practice, very good results in its recognition were achieved. The simultaneous brain examination has proved that while using the TDU, the picture processing centers of the brain are stimulated. It even holds true for persons that are blind from birth and that have never used the brain view centers.

An interesting solution of navigation of blind persons is described in [10]. The device is a vibration belt, which is equipped with eight vibration motors evenly placed at the belt's perimeter. The belt is connected with a GPS module with a preset address. The direction of the motion of the blind person is characterized by the vibration of the corresponding vibration motor.

The last non-invasive system is a blind persons' camera [11]. This camera has got no LCD but a Braille display, which is capable to display the picture in 3D-mode. It enables the user to sense a picture by means of the touch. This way can the blind persons perceive their surroundings by means of visual information by way of the touch.

Recently, with the advance of the neurosurgery and the optical surgery, invasive solutions start to be implemented, e.g. an implant of the artificial retina or a picture taken by a camera, which is after modulation transmitted into the brain view center. As the article is focused on non-invasive methods, further information of the invasive solutions can be found in [5], [12], [13].

3. MEANS OF THE INFORMATION GAIN ABOUT THE SURROUNDINGS

As mentioned above, the described tactile navigation system is intended for the navigation of blind persons in an unfamiliar or a partly familiar environment. A block diagram of the entire system is shown in Fig. 1.

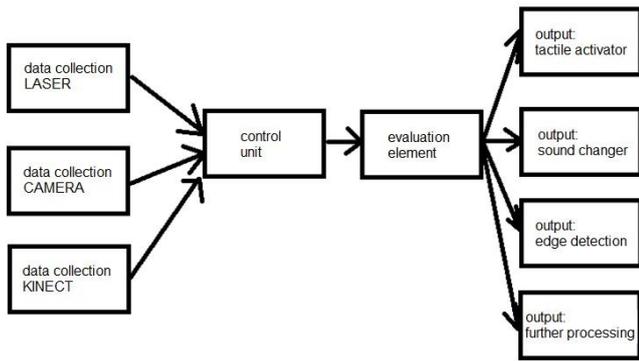


Fig. 1. Block diagram of the navigation system.

The tactile navigation system enables to collect information from various sources, not only from a camera or from a laser distance measuring system, but also from other supportive systems, e.g. the Kinect. The control unit and the evaluation element process individual signals, convert them into requested form and transmit them to other components of the system, which mediate the information to the blind person by diverse ways. The system described in this article passes the information on via a tactile activator, which by means of vibrations of motors transfers this information through skin receptors at the forearm [1] - [3]. Another way of use is a sound changer that should by means of speech synthesis speak the transmitted information, and so warn the blind person acoustically about the situation in front of it or in its surroundings. An alternative is use of acoustic signal with variable frequency. The designed tactile system is controlled by a microprocessor; it has to work with minimal energy in real time, so there are high demands on the simplicity of the recognition system.

A camera CMUcam3 was used to record the environment [14]. The camera is placed on the head of the blind person and it records the area in the direction of the head's turn, so the space of the view and the likely walk is scanned. According to the configuration of the processor, the camera can make a video record or individual snapshots by preset instructions that depend mainly on the recording and processing speed.

Individual pictures are passed on the control unit, which by means of SW detects edges and converts the resulting picture into information that can be transmitted to the blind person. The edge detection can be carried out by means of various software tools and methods; we have used the Hough Transformation. A closer description is in the part about the picture processing. To get the information about the obstacle distance, we need to use either two cameras or a rangefinder.

Other system that complexly solves the gaining of information about the environment is the game console Kinect by Microsoft. It combines a RGB camera, deep sensor, broadscale microphones and a separate control processor. Kinect can follow the motion in 3D mode, react to instructions and orders and it can even recognize a change of emotions or voice timbre. Today, there are being performed tests of a tactile navigation system that uses the

sensor Kinect. The blind person will obtain exact information about the surroundings in that it can move safely.

4. PICTURE PROCESSING

As described above, individual pictures from the camera are transferred to the control unit that detects edges and that converts the resulting picture into information that can be passed on the blind person. A very important part of working with pictures and searching for specific objects is the pre-processing of the picture, further information can be found in [4] and [5].

The color picture loaded by the camera is initially converted into a gray-scale and then its contrast is modified. Afterwards the edges are highlighted by means of an edge algorithm. The method LoG has proved to be most convenient. Then the picture was processed by the Hough Transformation [6], by means of which the parametrical description of the picture was obtained. All mentioned algorithms were programmed in the MATLAB environment.

5. TACTILE ACTIVATOR

The tactile activator is a box (see Fig. 2) that consists of 9 miniature electro motors, their control units and the control unit of the entire tactile navigation system. The signals from the camera or from the control unit of the system are brought by cable into the tactile activator and then are converted into information for the blind person by means of control units and a multiplexor. The information is created by an electro motor. The shaft of the motor is equipped with an eccentric mechanism that creates vibrations by its irregular shape after the spin-off of the motor. The electro motors are set into a 3x3 matrix, that will be extended to 5x5 matrix of motors in the future, in order to ensure the highest possible accuracy of the system. To transmit the vibration to the blind person, the electro motor is equipped with a small plastic plate that is placed in the opening of the plastic deck of the tactile activator. The electro motor is embedded in a rubber wrap in order to distinguish the vibration of the motor and not to influence other parts of the activator (Fig. 2). Vibrating electro motors by the company Maxon [16] were used, specifically the motor 30200 EC 10 lat, 0,2 W.

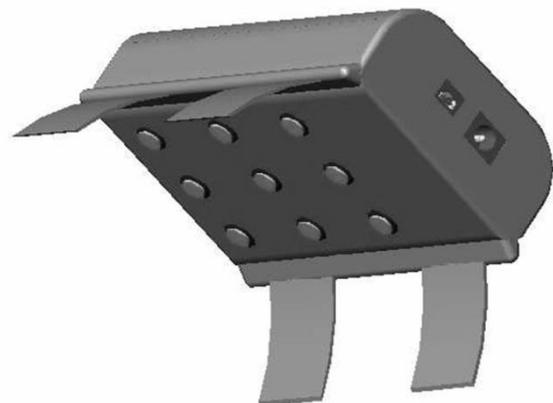


Fig. 2. Tactile activator.

The activator itself is placed on the forearm and it is fixed by two belts that ensure its right position and that prevent shifting or slipping from this position. The belts are wide enough to minimize the pressure onto the arm and to ensure that the wearing will not be unpleasant (Fig. 3).

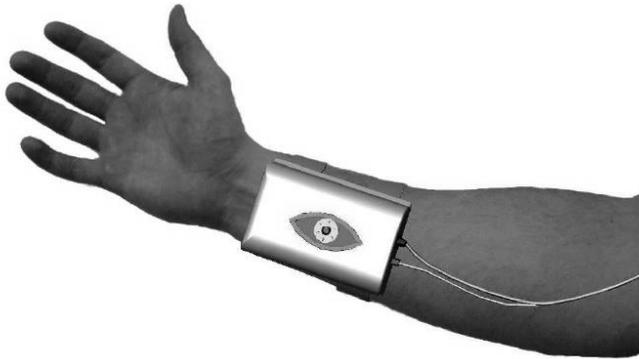


Fig. 3. Tactile activator – placing on the forearm.

By this prototype, the power supply of the entire system is realized by means of a battery that is placed in a bag at the waist. The entire system is designed to help with the orientation as much and to limit as little as possible. As the control unit the 1-Q-EC Amplifier DEC Module 24/2 was used [16]. The unit is connected with the tactile activator with a 17-pin connector.

6. THE RESULTS OF FUNCTIONALLITY OF THE TACTILE NAVIGATION SYSTEM

Fig. 4 and Fig. 5 demonstrate the behavior of the electro motors of the tactile activator while passaging through a door frame or through a narrowed space. The camera records the picture and converts it into data for the microprocessor. It calculates two vertical edges that don't adjoin with each other, because their distance is sufficient. The data processing matrix evaluates the distance as high and passes the information on the specified control units that get going the electro motors at the sides of the activator. If the blind person approaches the frames, the picture will not change, so the same electro motors will be working. The transmitted information would change only by deviation of the camera's direction. Red marked vibrating motors that warn the blind person about the door in front of it. Vibrating motors warn about an obstacle, non-vibrating motors guarantee a free pass. But the disadvantage of the 3x3 arrangement is clearly visible. With the 5x5 layout it would be possible better specify the position of the door frame.



Fig. 4. Experimental door frame.

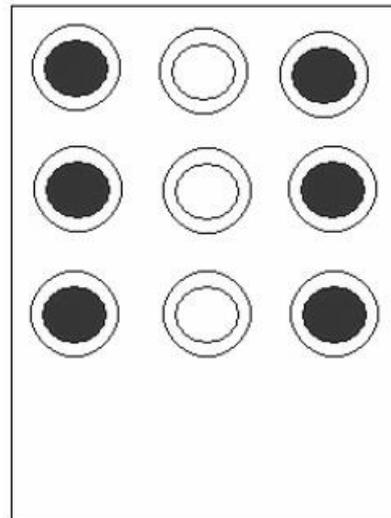


Fig. 5. Visualization of the active motors of the activator.

While passing stairs (Fig. 6), the system detects a group of horizontal edges. The stairs are announced by vibrations for a specific time of the first row, then of the second and finally of the third, see Fig. 7. This way the blind person can be warned about rising stairs. The electro motors continue working until the blind person is in the space in front of the stairs or until walking the stairs. As soon as the recorded space in front of the camera changes, the work of the electro motors changes correspondingly. While going down the stairs, there is a problem with the appropriate detection of the edges. After their detection the electro motors will work in a reversed order than by rising stairs.



Fig. 6. Experimental stairs.

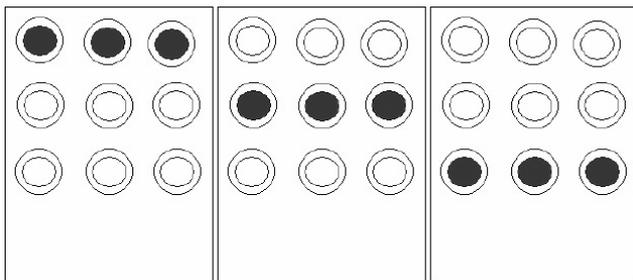


Fig. 7. Visualization of the motors warning about the stairs.

7. CONCLUSIONS

The article is a contribution to the issue of the orientation of blind persons in an unfamiliar environment. The emphasis is put on the attributes, capability and possibility of use of the system. The system is designed for blind persons in the first way, but by its extension and by usage of additional supporting systems it can be used in every branch. The aim of the project is to design a functional system and to put it into practice in order to contribute to a simplification of the workflows. We can be also point out new possibilities of game consoles like the Kintec that can be used in support systems for disabled people.

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