Magnetic Navigation System for Visually Impaired People

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ABSTRACT

This article is focused on the navigation of the visually impaired, for their easier orientation in unknown areas. The technical navigation system, whose hardware is integrated into the standard stick for the blind, is based on the principle of a digital analysis of a signal from the magnetometer. The analyzed signal occurs by moving the stick over surface-distributed neodymium magnets, which, with their distribution and orientation of magnetic poles, creates basic orientation pictograms. This detection and identification of magnetic pictograms results in warning signals, which are transmitted to the blind individual via a small vibration motor located in the handle of the blind stick. The individual is then able to interpret several different warning or navigation signals, according to the intensity and quality of the vibrations. This article describes the detection and identification algorithm that has been implemented into the control microcontroller. The article is supplemented with measured courses of magnetic induction for basic orientation pictograms and with photographs of the realized orientation stick sample.

Keywords: **A**ssistance, Remote guidance, Visually impaired people, Magnetic navigation

1. INTRODUCTION

Along with the development of electronic systems, the field of guidance systems for visually impaired people has been developing in recent decades. Although we may not know it, there are almost 200,000 people living with this handicap in the Czech Republic. The free service of the SONS navigation centre has been introduced in the Czech Republic and it is based on GPS – GSM technology. The blind person sends his or her position to the control station by mobile phone and GPS receiver, and a trained staff member gives him/her advice by phone as to the most convenient way of getting to a destination. TYFLOSET® – an electronic orientation and information system for the blind and people with heavy visual impairment, has spread widely. TYFLOSET is made up of a set of technical portable, mobile and stationary means, which serve for the transmission of acoustic and voice information and easier orientation of the blind in built-up areas, mass urban transportation means, suburban and rail transport, and at crossroads, in underpasses, in the underground, around offices and hospitals, etc.

2. NAVIGATION VIA MAGNETIC PICTOGRAMS

There are now numerous possibilities for guiding people with visual impairment [1-7]. The concept of the Dinasys guidance system was based on creating guidance and warning lines – pictograms, made of neodymium permanent magnets. This situation is shown in Fig. 1.

This design solution is advantageous for several reasons:

- easy integration into the existing infrastructure,
- no power supply required,
- function is guaranteed even if pictograms are snowed-in or under a layer of ice,
- several basic warning or guidance pictograms can be created by a combination of magnetic poles.

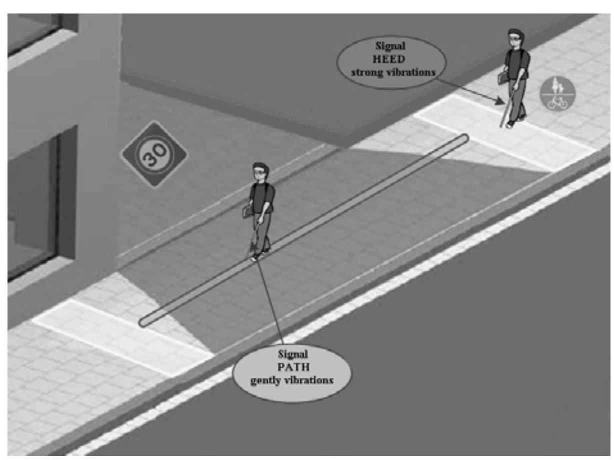

Fig.1: Use of magnetic pictograms for orientation and guidance

However, the relatively easy creation of magnetic pictograms is counterbalanced by difficulties with the detection and analysis of the signal type. The basic difficulty consists in the fact that orientation sticks are used by people with visual impairment for both swinging and sliding techniques. In other words, the orientation stick may be inclined from 0° up to 45° and the movement around the pictogram may be both longitudinal and transversal.

First, magnetic induction values were measured by a Tesla-meter for different types of neodymium magnets and for different vertical and horizontal distances, as shown in Fig. 2. The magnetic induction values ranged from 30uT to 250mT depending on the distance of the magnetometer from the magnet. The lowest values of magnetic induction are almost equal to the amount of the Earth’s magnetic field.

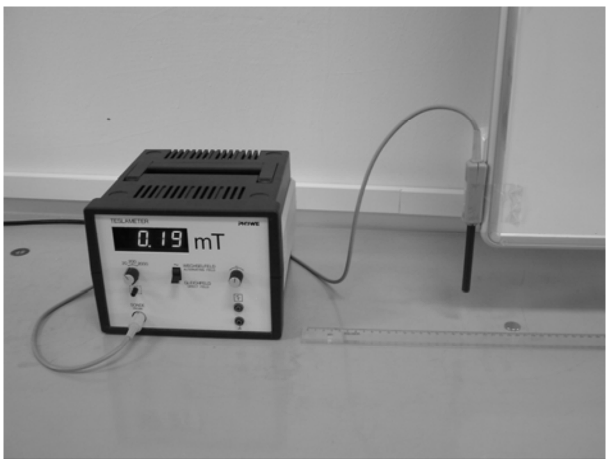

Fig. 2: Measurement of the magnetic induction of a permanent magnet

The typical characteristics of values measured by the magnetometer, located at the end of the orientation stick, are shown in Fig. 3.

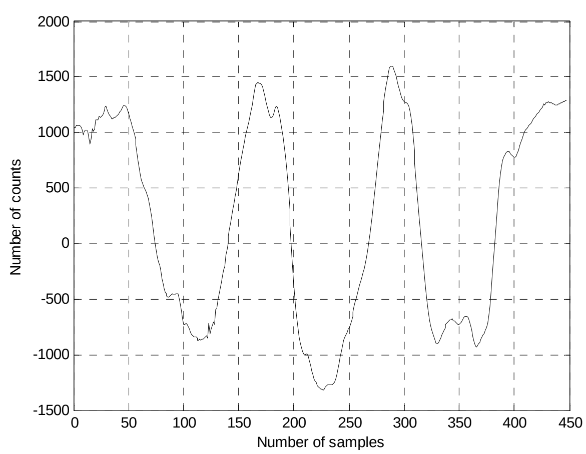

Fig. 3: Typical characteristics of values measured by the magnetometer

It is apparent from the characteristics in Fig. 3 that the measurement of magnetic induction values of permanent magnets located on the ground is largely influenced by the Earth's magnetic field. Also, it is apparent that the magnetic induction amount is influenced by both the stick’s orientation towards the Earth’s magnetic field and the stick’s inclination towards the surface.

To eliminate the undesirable values of magnetic induction that depends on the orientation of the cane to the magnetic pole of the Earth, especially when the toggle device is used, the application of two independent, spatially separated magnetometers has proved to be an efficient solution. One magnetometer shall be placed at the end of the orientation cane, while the other shall be displaced by a distance of 43cm (17 inches). The measured values of magnetic induction shall be deducted one from the other. The resulting values of measured magnetic induction will, only to a very small extent, depend on both the orientation of the cane to the Earth’s magnetic pole and the incline to the Earth’s surface. Fig. 4 illustrates the curve of the magnetometer’s values for the rotation of the orientation cane 0-360°, with a cane incline of 0°-45°.

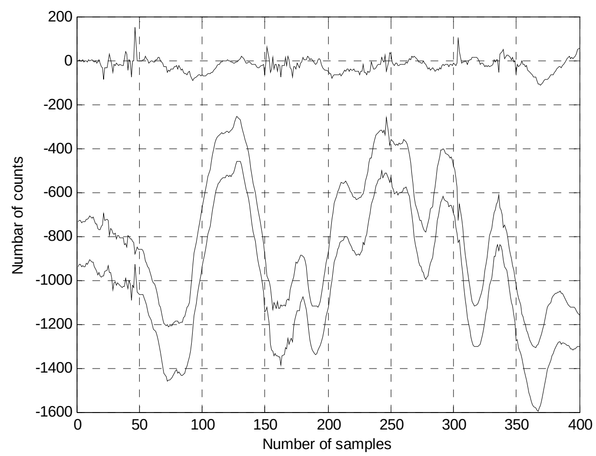

Fig.4: Typical curve of measured values of the compensated magnetometer (top)

For the necessary detection and recognition of the orientation of the placed permanent magnet, the cane inline has proved to be a more serious problem.

With respect to its small mechanical dimensions, the magnetic field sensor is sensitive to the orientation cane incline. At the application of a toggle device, the practical values of incline equal approx. 45°; when a sliding device is used, they are less than 15°.

The magnetometer’s sensitivity to the orientation cane incline is documented by measurements the results of which are shown below. Fig.5 shows a curve of magnetometer’s values for one permanent magnet (north) and a cane incline of 0°, while Fig.6. shows the values for a cane incline of 45°, with the same magnet orientation. Fig. 7 shows a curve of the magnetometer’s values for one permanent magnet (south) and a cane incline of 30^0, while Fig. 8 illustrates a cane incline of 45^0 with the same magnet orientation.

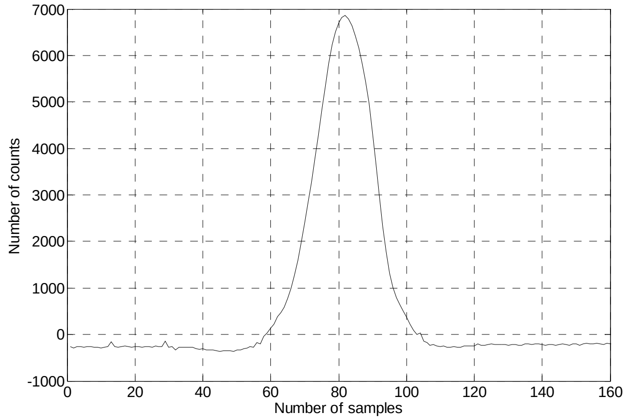

Fig.5: Typical curve of measured magnetometer values, north, at a cane incline of 0°

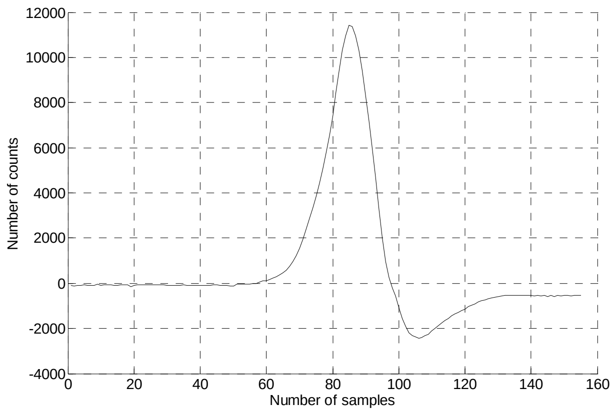

Fig.6: Typical curve of measured magnetometer values, north, at a cane incline of 45°

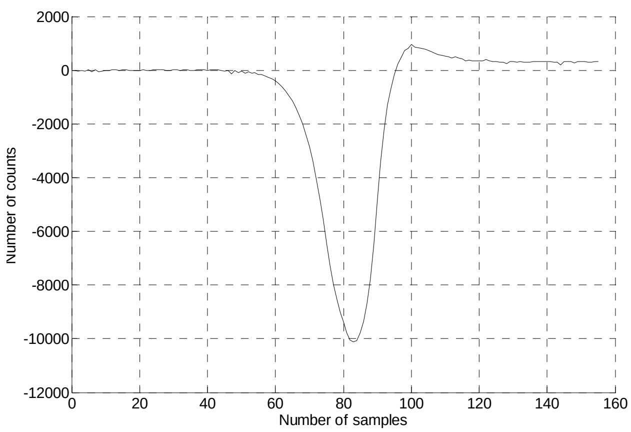

Fig.7: Typical curve of measured magnetometer values, south, at a can incline of 30°

Referring to the measured curves of magnetic induction as shown in Fig. 5 through 8, it is clear that the detection of a permanent magnet presence at an orientation cane incline of 0° is trouble-free, but at a cane incline greater than 30° a transient opposite value almost equalling 30% of the maximum value occurs at passage.

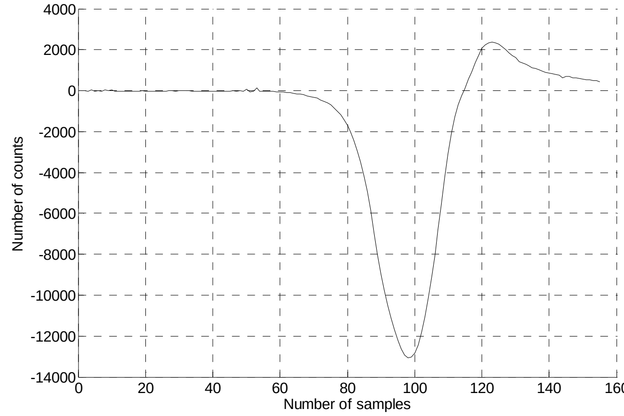

Fig.8: Typical curve of measured magnetometer values, south, at a can incline of 45°

Since it is necessary that the detection distance between the placed permanent magnets and the orientation cane tip be at least 15cm (6 inches), the detection algorithm shall adaptively change the detection thresholds of both values of magnetic induction in accordance with the instantaneous incline of the orientation cane.
Based on the practical measurements, an analysis of disturbing influences, and the practical experience of users with visual impairment, the block diagram of the orientation cane electronic wiring has been prepared – see Fig. 9.

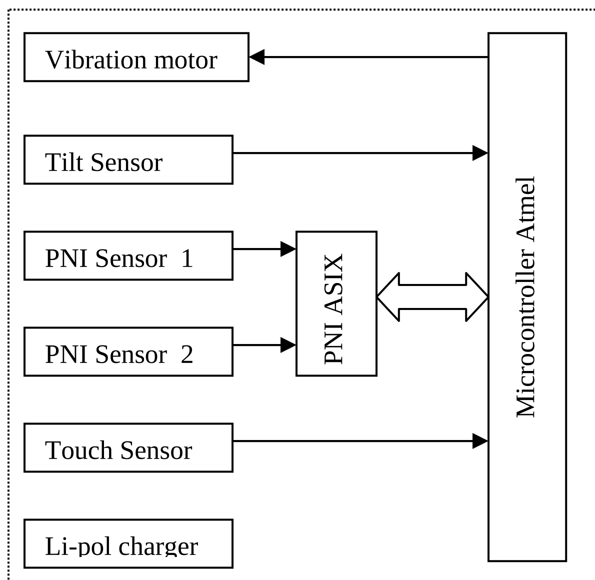

Fig.9: Block diagram of the orientation cane electronic wiring

The detection element designed was a module of a sensitive dual-axis digital magneto-inductive magnetometer with an PNI-ASIX control circuit and a control microcontroller that performs the digital measurement of magnetic induction, detection and identification of the type of pictogram, and generating the control signal for the small vibration motor.
The type of vibration generated warns the user of a possible collision on his/her route.

The adaptive algorithm of detection and identification of the type of magnetic pictogram efficiently suppresses the influence of magnetic field changes on the orientation stick and, at the same time, adaptively sets the amount of the decision threshold depending on the stick inclination.

Another problem to have arisen from the practical experience of the cane users with visual impairment consists in the principle of switching the orientation cane electronics. It would happen that the user either switched off the cane inadvertently, or let it switched-on for a period of several days so that upon application the battery was already discharged. Therefore, a module of capacitance touch sensor has been integrated into the orientation cane electronics to ensure that the cane electronics are automatically switched on upon the cane being grasped by hand. This solution has facilitated and simplified users' handling of the orientation cane.

In the handle of the orientation stick there is a small vibration motor and a Li-Ion battery with an automatic charging system. All electronic equipment is designed and made in such a way that it can be inserted and mechanically fixed in the standard orientation stick with an inner diameter of 8.2 mm (.326 inch).

A photograph of the magnetometer module, including all auxiliary circuits, is shown in Fig. 10, and a photograph of the electronic orientation stick is shown in Fig. 11.

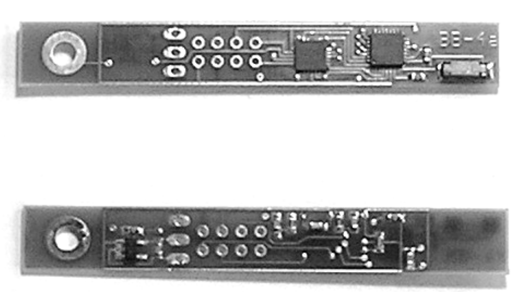

Fig. 10: Two-axis digital magnetometer module

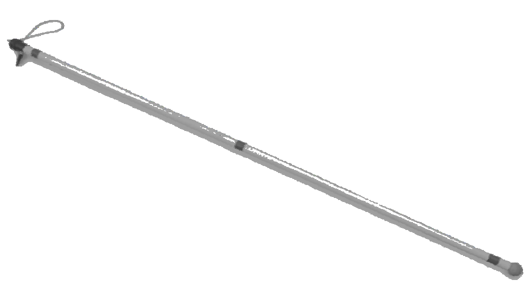

Fig.11: Electronic orientation stick

3. CONCLUSION

This article describes the principle of a possible guidance system for people with visual impairment using magnetic pictograms.

This guidance system works in cooperation with the Dinasys information system, which was presented at the ICSIT-2010 conference last year. The concept of the guidance system shown in Fig. 1 is protected by the Industrial Property Office [8].

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