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VIBRATING BRACELET INTERFACE FOR BLIND PEOPLE

ABSTRACT *There are many electronic aids for blind people in both prototype and market state. Most of them use prerecorded voice commands or speech synthesizers and a headset as a user-device interface. In order not to jam acoustic signals from environment, in this paper the authors present a vibrating bracelet as a multipoint communication interface for a mobile safety system for blind people (MOBIAN). By using several vibrating motors and a vibrating signal modulation, more data, commands and alerts a blind user is able to recognize.*

Keywords: *blind people, vibrating bracelet, MOBIAN, navigation assistant device*

1. INTRODUCTION

Electronic devices have blended into people's lives for good. They are present in almost every branch of industry worldwide. The constant technological progress makes everyday life easier for people and also comes in handy for impaired people. Scientists and engineers develop electronic aids for

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handicapped people. All over the world there are many visually impaired people, especially in the developing countries. A common problem for them is their safety outside their houses, particularly in the unknown areas. Therefore, nowadays many navigation assistant devices are being worked on and some of them are already available on the market [1]. Some of those aids use acoustic signals or speech synthesizers and a headset to communicate with a blind user. Consultations with visually impaired people have shown that, although this approach is suitable for familiar and indoor environments, it is not the best solution for outdoors and unpredictable areas to jam raw, acoustic information from surroundings.

Some aids for blind people employ tactile interface for communication. Usually, stimulant points are on fingertips, palms or bellies [1, 2]. Nevertheless, most of these interfaces either occupy a palm or carry too little data, for instance, distance and direction from obstacle.

Electronic devices development for blind people should strongly consider employing only low-power electronic components and techniques to assure the minimum of a whole-day operation without changing or recharging batteries. Nowadays, components manufacturers offer special low-power products lines, therefore creating low-energy devices from hardware which is available on the market is less complicated. Usually, the difficulty is to create some embedded software that drives the whole system in a way that all the low-power functionality is utilized in the optimized way to prolong the battery life. To do that some software creation techniques can be applied. One of these techniques is called energy debugging [3]. By writing the firmware for some device and at the same time controlling the power consumption of that device and if possible change the code to get rid of unnecessary current peaks drawn from the battery, the developer is able to minimize the power consumption. Sometimes, this technique comes in handy while trying to detect why the device resets itself due to the shortterm output current demand which can be far greater than the voltage regulator or the DC/DC converter can provide.

There are some solutions already available on the marker for energy debugging. One of them is Advanced Energy Monitoring (AEM) tool from Energy Micro. Every development and starter kit from Energy Micro has the AEM tool implemented on-board and the supporting software is provided for free.

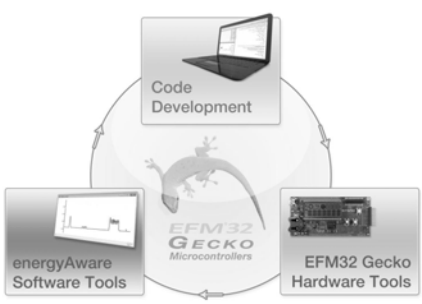

Fig. 1. Energy debugging cycle for minimizing the power consumption of the vibrating bracelet
(source: www.energymicro.com)

The vibrating bracelet interface is based on a microcontroller which can cooperate in the energy debugging cycle (Fig. 1).

First software which was fully operational for the vibrating bracelet was causing too high current consumption. This power consumption made impossible to provide whole-day operation on small rechargeable battery. By using energy debugging technique, unused and unnecessary peripherals were turned off, some low-energy peripherals were used instead of normal ones, various energy modes were applied, DMA and other communication without CPU intervention were used. In result the final software that drives the bracelet is so optimized that the current consumption of the whole device (not including power consumed by vibrator motors) can be practically omitted while estimating autonomous operation time in hours.

2. BRACELET INTERFACE OVERVIEW

There are many interfaces for communication between human and a machine. When it comes to the implementation of one in some device for blind people, a collection of usable interfaces is narrowed down. Nevertheless, there are still some tactile, vibrating and sound interfaces that the developer can employ [4, 5]. All around the world there are groups of scientists that are working on various kinds of brain-computer interfaces. Although these interfaces sound promising and when perfected could revolutionize the way people communicate with machines, it would be hard to implement them in blind people devices. Usually, the brain-computer interfaces make it possible to communicate in a human-to-computer direction and not the other way. The feedback is often created via some kind of display/visual interface, which is useless for blind people. Granted, there are also experiments being conducted to transfer data to a human brain, but the works is proceeding very slow due to the fact that the human brain is highly complex and it is still uncharted for scientists. Therefore, even real-time prototype applications are not on the horizon. That is why interfaces for blind people have to be designed based on traditional and more natural and known for them techniques.

The electronic aids for blind people should interfere with users' movements and perception possibilities as little as they can. Therefore, the authors are presenting a multipoint vibrating bracelet interface for various applications. The bracelet is carried on a wrist, thus is does not restrain movements or occupy a palm. A bracelet scheme is presented in Figure 2.

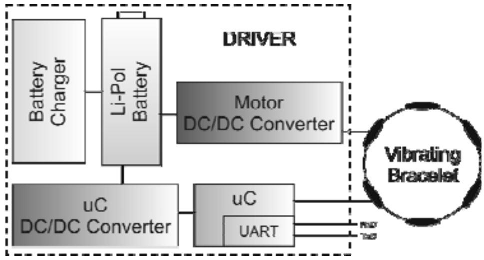

Fig. 2. Multipoint vibrating bracelet scheme

Most people, not only the blind ones, are used to having a watch of some kind on their wrists, so this is a natural place for the bracelet. Some experiments were conducted to assure that the wrist is a good place to feel vibration stimulants [6].

The bracelet prototype includes six vibrating motors, evenly distributed on a wrist. The motors are connected to a driver. The prototype device used in the tests is presented in Figure 3.

Since the whole device should be light weighted, its power supply is a Li-Pol mobile phone battery. To assure a low-glitch level in the driver, the separate DC/DC converters for a microcontroller and for motor transistors were used. A 5 V battery charger chip was also implemented. By programming an onboard low-power microcontroller, a different signaling algorithm can be accomplished. The communication with the vibrating bracelet is done via UART interface.

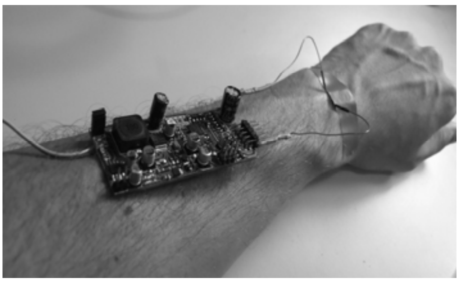

Fig. 3. Vibrating bracelet prototype

3. VIBRATING SIGNAL SCHEMES

In order to pass a lot of information on to a blind user some schemes have to be implemented to drive vibration motors on the bracelet. According to [6], perception threshold level on wrist area can be reached in order to recognize the stimulation source by using signal with frequencies lower than 500 Hz. Therefore, the use of signal patterns with frequencies up to 500 Hz is employed. To inform a visually impaired person about a detected obstacle and its distance, an impulse modulation is used. In a certain period of time a single motor is being turned on and off again. This switching frequency is related to the distance and for the user it is felt like a vibration strength. Since there are six motors, a multipoint vibration is suitable either to inform about an obstacle direction (therefore, a bracelet can inform about multiple objects at the same time) or the height on which the obstacle occurs. Another way to inform about obstacles is to send single, detectable, strong, short vibrating impulses of various frequencies. By changing this frequency a user can also be informed about the distance. Variation of this signaling scheme can be used to warn a blind person about specific, yet frequently recurrent scenario objects, like for instance, stairs going up and down or curbs. This variation utilizes a constant period of time, for example 1 or 2 seconds, and in this time countable, short impulses are being sent. Their number determines a pre-learned object name (stairs, curbs, etc.). In early stages of teaching a blind person how to use the vibrating bracelet, the mentioned pre-learned object vibration can be implemented in all six motors simultaneously in order not to confuse the user and help to differentiate between pre-learned object vibration and the distance from obstacle vibration. Some vibrating schemes are presented in Figures 4 and 5.

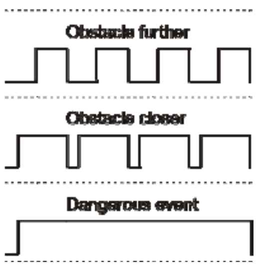

Fig. 4. Vibration schemes for coding detected obstacle distance

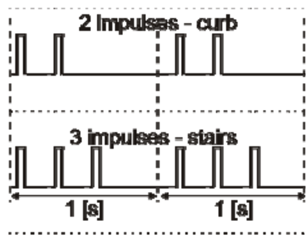

Fig. 5. Vibration schemes for pre-learned objects: curb and stairs

Apart from informing the visually impaired people about obstacles, distances and pre-learned scenario objects, the bracelet is also capable of sending commands and indicators to the users by means of a multipoint vibration. By creating a vibrating pattern, its direction, duration and location, the bracelet can send commands to turn left, right, to inform about transferring navigation data, calculating route and even to inform about an incoming call,

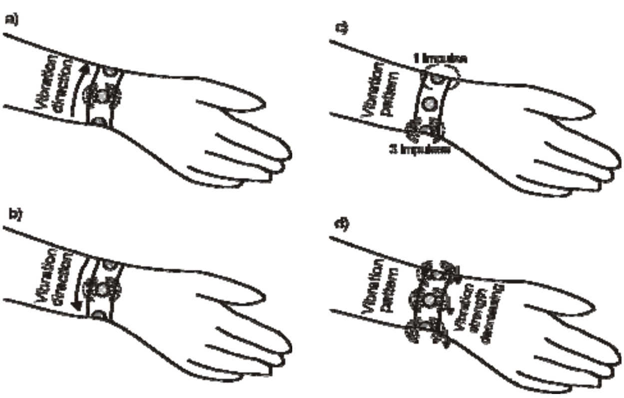

Fig. 6. Vibration pattern schemes for pre-learned commands:
a) counter clockwise signal direction;
b) clockwise signal direction;
c) different impulses values on different motors;
d) vibrating signal strength decreasing on all motors

a received SMS or an e-mail when connected to an external device. Thanks to the commonly used UART interface for the communication with the driver, the bracelet can be used not only with navigation assistant devices, but also with mobile phones (via a BlueTooth SPP protocol) or computers (via a UART/USB converter). Some vibrating commands schemes are presented in Figure 6.

4. TESTS AND RESULTS

Tests have shown that the six vibrating points available in the bracelet seem to be optimal to determine vibration location and to recognize vibration patterns. However, in case of people with thick wrists or people who have tested the bracelet for a while, additional vibrating points can be added to enhance the vibrating patterns set – one driver is capable of controlling up to 10 motors.

Every new user needs time to learn indication patterns and what each vibration motor function means. The recommended experience level is that the user is able to recognize all indications in real-time without breaking one's concentration.

Tests have shown that both vibration strength, minimum impulse time and time between them can be slightly different for each person to be able to differentiate all vibration schemes. Therefore, vibration signal strength, patterns, distance alerts can all be customized to assure a higher user-friendly level and also to reduce learning time. Scheme learning takes some days and it is more efficient when a user learns first by themselves to locate a single vibration or multi source ones and then simple and more advanced vibration patterns. In the end, when one is used to the mentioned schemes, one should learn how to quickly differentiate them and count short impulses. Once a user feels comfortable with bracelet signals and quickly realizes the differences between all schemes, it is time to start real-time tests in the real environment.

After a learning period, the users are able to respond fast to alerts about obstacles and their directions. Indications about detected specific objects like stairs or curbs are also recognized, as well as other scheme commands.

5. CONCLUSIONS

The driver and the bracelet are operational. Tests have shown that after the learning period, the users can be guided by the vibrating points located on a wrist in order to avoid and deal with dangerous obstacles or specific, detected objects. Although, the bracelet was developed for a blind people navigation assistant (MOBIAN project), it is also suitable for the use in other applications, like for instance, mobile phones, computers, etc.

When a blind person gets comfortable with the vibrating bracelet, system developers can easily use more bracelets for one user and put them on the other wrist or even on the forearm, if there is a need for enhancing indications scheme.

Battery lifetime in the presented device depends highly on the working time of the motors. That is why obstacles and commands which occur more often should be coded with schemes that use less motors and vice versa.

There are no objections to narrow down the possible usage of the vibrating bracelet for blind people applications. It can be successfully used for some consumer applications, for instance, GPS devices, devices for runners, etc.

Future development of the bracelet will involve the driver minimization as well as overall current consumption reduction to assure longer autonomy time. All the important guides and comments from the blind people testers will be included in the new version of the bracelet.

Acknowledgements

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WIBRUJĄCA BRANSOLETA JAKO INTERFEJS DLA LUDZI NIEWIDOMYCH

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STRESZCZENIE *Istnieje wiele urządzeń w postaci zarówno prototypów, jak i gotowych produktów, wspomagających osoby niewidome. Większość z nich używa syntezatora mowy albo nagranych komend głosowych oraz słuchawek jako interfejsu użytkownik-urządzenie. Aby nie zagłuszać sygnałów dźwiękowych dochodzących z otoczenia, autorzy stworzyli wibrującą bransoletę jako wielopunktowy interfejs komunikacyjny dla mobilnego systemu bezpieczeństwa dla osób niewidomych (MOBIAN). Poprzez użycie kilku wibratorów oraz modulację sygnału wibracji, osoba niewidoma jest w stanie zinterpretować więcej danych, komend i ostrzeżeń.*

Słowa kluczowe: *ludzie niewidomi, wibrująca bransoleta, MOBIAN, urządzenie do nawigacji*

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