Guidance – Assist system for the blind

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Guidance – Assist system for the blind

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ABSTRACT

We propose navigational aid systems for the blind relying on active laser profilometry and infrared proximetry with a real time vibrotactile interface. The "Teletact" and the "Vigitact" are small hand held or badge worn devices to improve the spatial perception, the mobility and the security of blind people. The "Teletact" is a hand held laser telemeter and gives an accurate three dimensional spatial perception up to ten meters. The Vigitact is an infrared scanner and provides an automatic vigilance from knees to head up to two meters. Both devices are now commercially available. We will report on the basic functional parts of these devices, the results of everyday use by blind people, and future technological improvements.

Keywords : Laser profilometry, optical telemetry, infrared proximetry, blindness, visual substitution systems.

1. INTRODUCTION

We have developed a triangulating laser telemeter adapted to the space perception for the blind: the "Teletact". In a previous communication [1], we detail the structure of the telemeter. About fifty blind persons in everyday life now use this device. They give us feedback on their use and some of them ask for improvements we will describe here. Learning how to use correctly the device is not so simple, and we feel the need to build a simpler device to make initiation to electronical vision substitution easier. So we report too here on a new simpler device: the Vigitact.

2. THE "TELETACT"

2.1 Basic system

The "Teletact" is a hand held laser telemeter. The distance to the first obstacle encountered by the laser beam is measured with about 1% accuracy in the 10cm – 10 m range. Figure 1 gives the basic scheme of the telemeter, and figure 2 is a photography of the commercial device. The blind perceives the direction he points the laser beam thanks to the internal consciousness of the position of its members (proprioception). To communicate to the blind the information of distance, we use 28 different musical notes which correspond to 28 unequal intervals of distances (intervals are smaller at short distances), the higher the tone, the shorter the distance. To identify an obstacle its necessary to scan the environment. So, the rate of distance measurements is 40 measurements per second. The most important information is not identification of musical notes but the sense and the rate of their variations, in other word the transcription of the profile of the obstacles into a "melody".

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Combining the musical perception and the proprioception the user acquires the form of the obstacle and the position of his body relative to it.

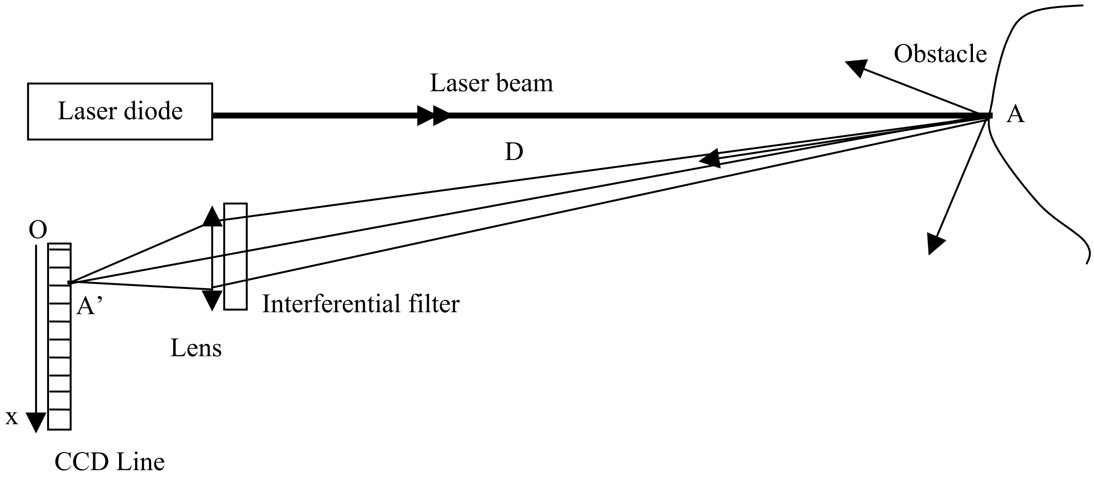

Figure 1: Basic principle of the Telemeter :
The laser diode emits a collimated one milliwatt 670 nm laser beam. The beam meets the obstacle at a distance D and creates a laser spot A. The image of the laser spot A through a the lens on the CCD line is A'. The position of A' on the line gives the distance D. As we can see on the figure, for $x_{A'}$ *great, D is short. The basic principle is very simple, the main difficulty is to achieve immunity to diurnal light (ie up to 200klux summer sunny days), that need some optical and electronical additive systems.*

Figure 2: Photo of the "Teletact"

2.2 Detection of discontinuities [2]

Cutting the 10 cm - 10m range into 28 interval leads to a lack of precision on distance sensing. One cannot detect a small hole or a small embossing on the ground. Therefore, it is possible to use a second signal to prevent from discontinuities on the floor. A regular movement of the wrist scans the floor, and we can consider that the angular speed is more or less constant. Therefore, we can replace the derivative of distance versus angle of the beam by the derivative of distance versus time. The microprocessor calculates the numerical second derivative d of distance versus time. When d reaches an adjustable threshold, the "Télétact" emits a battery sound clearly different from musical notes. By this way, the blind detects up or down stairs, familiar objects fallen on the floor…

2.3 Window-pane detection

The 670 nm laser beam generally doesn't detect clean windows, especially with important incidences. Things behind the windows are detected. Although we get some persons taking advantage of this defect to scan underground station from the window of the train or to do shopping, to know that windows can not be detected make people anxious. We get a similar problem with black metalled painted cars upon high incidences that doesn't give a retrodiffused signal. To avoid this problem, we add to the telemeter a strong infrared superluminescent 950 nm proximeter. In case of proximeter and laser telemetric detection, the information transmitted is the one of the telemeter. When we only get the signal of the proximeter, we send to the user the "window warning" signal. The proximeter works up to 3 meters, and give a secured window panel or black cars detection up to two meters. The efficiency of the proximeter is due to the wavelength 950nm and to the wider angle of the beam (about 0.3 rad). Effectively, in a 0.3 rad angle at two meters, there is generally some "co-operative obstacle" in the field: very large clean windows, without something visible inside, are no more allowed ; for cars you generally get the handle of the door etc…

2.4 Vibrating interface

The sonorous interface has various defects. To make the difference between musical sounds and street sounds is not a problem. To clearly ear the information an earphone is used. When the ambient sonorous level often fluctuates you have to adjust your proper sonorous level, efficient automatic control in this cases is very difficult. Some people have difficulties to merge rapidly the sonorous information with the proprioceptive one (movement of the wrist) to deduce spatial data. This information merge has to become instinctive after learning, and if the person has to thing about it, using the device becomes a too difficult intellectual work.

To obtain a silent device we replace the sonorous output by two vibrating devices localised under the fingers. To code the distance we use two effects on the first vibrating device: the vibrating amplitude increases as the distance to the obstacle decreases, at the same time the period of the vibration decreases. So a decrement of the distance to an obstacle is coded by an increment of the amplitude of the vibration and a decrement of the vibrating period. The second vibrating device is used to code the detection of discontinuities on the floor, we use a 50 ms strong burst of vibration.

Using the vibrating interface is easier, the perception is more direct and intuitive. Beginners generally prefer it. People trained to sonorous output says it's less precise and do not want to change their interface.

2.5 Preliminary conclusions

The device in the everyday life of the first users is only two year old. Blind people still discover every month new ways of using it. However we are now sure of different points: in is actual form, using the "Teletact" needs a good spatial representation, a good proprioception (a good audition or vibration is secondary), and an active attitude: to scan to look for obstacles. It's very difficult for blind from birth to use it because of lack in spatial representation, for old persons (although we get some exceptions) it is difficult because of the long learning period. The main advantage of the device is the good anticipation you get and the optimisation of the navigation. But we have to remain that most blind people don't move alone and therefore don't have notion of what is to anticipate an obstacle, so to detect at ten meters something don't have sense for them. For the moment it's a system for typically very active 20-40 year blind persons who have seen before. The price of the device is 2500 Euro, but the most expensive thing is the instruction. To be sure of effective results, 50 hours of individual lessons over a three months period are recommended. The device is not a signalisation for blindness as the long cane, so people have to use too the cane every time you get a mobile external danger (cars, bikes, crow etc.).

For people having difficulties with the "Teletact", we develop a simpler device called "Vigitact".

3. THE "VIGITACT"

3.1 Basic principle

The device is intended to detect obstacles which cannot be detected by the blind when he scans the floor with his long cane. A typical example is a large panel whose legs are very distant. The blind has to be protected from the knees to the top of the head and on the width of his shoulders. The device (cigarette packet size, 100 g) is worn as a badge. Five near Infra-red beams (at 950 nm) are generated by collimated Leds, in different directions and at different emission power, to cover the protected field. Light back - scattered by obstacles is received onto detectors. Figure 3 shows the basic scheme of emission - reception.

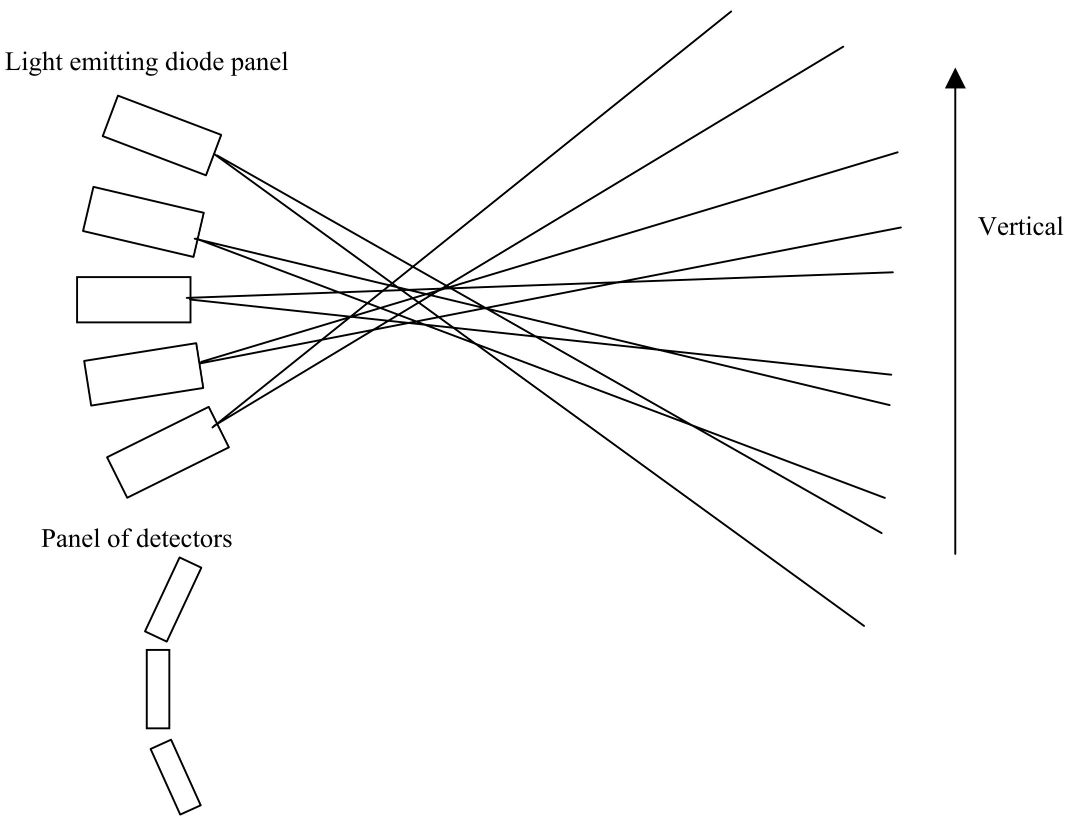

Figure 3: Basic scheme of the "Vigitact"

If the photoelectric signal is greater than a fixed threshold it means that the distance to the obstacle is smaller than a certain value. Then the device vibrates to alert the blind. It is not a true measure of distance because the quantity of back scattered light is obstacle dependant. However the dependence upon distance D of back scattered light varies with $1/D^4$ and at 950nm albedos under 20% are not current. For most obstacles you get a global 20% incertitude about distance, enough for the use of the device. There are three possibilities for the distance of detection, adjustable upon request : 50 centimetres, 1,5 meters, 3 meters. Figure 4 show a commercial device.

Figure 4 : The “Vigitact” badge worn

To avoid diurnal light, an optical filter with a band pass centered to the led wavelength is placed in front of the detectors. But it is not enough in the case of a summer sunny day in the street. So the device comprises a phototransistor to evaluate the level of ambiant light that reduce the dynamical range of the receptors. Its signal automatically adjusts the emission power of the leds to maintain the same range of length detection. Different algorithms of the microprocessing unit eliminate the other effects of direct illumination by a strong sun.

We began to sell the system four months ago at a price of 500 Euro, our first production of 50 pieces is sold out. The device is easier to introduce than the “Teletact”. However some training by a qualified person remains indispensable, and to do it correctly remains more expensive than the device. More or less, for the half part of the users it’s badge worn (especially blind from birth), for the other they take it with the long cane as it is shown in figure 5. This device is too used by low sighted persons, with a small angle of vision, the system is hand held and acts as a warning to say in what direction to look, it’s a kind of substitution of peripheral vision.

Figure 5 : the "Vigitact" hand held in association with the long cane.

All users recognise less stress, more security, and useful indications during walking and after a few weeks they consider that the device is indispensable.

3. CONCLUSION

We have described two devices effectively used in everyday life by blind people. These devices still have large possibilities of improvement. The first requisition of "Teletact" users is a smaller device. For "Vigitact" users, some of them begin to ask functions looking like the "Teletact" ones, but for the moment we don't have any transit user from one system to another. It is clear that we are creating new needs, and it will take several years until we reach the majority of the potential users. One important obstacle is how to pay qualified instructors. We are trying to enlarge possibilities, combining the system with additional sensors like cameras etc. We know too the limits of these devices, it will never replace the will of the person to be autonomous in walking. As surprising as it can be, the family has a lot of difficulties to accept these systems, the blind person has to fight for it, even a blind mother with her young sighted children.

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