A Bio-inspired Collision Avoidance System Concept for People with Visual Disabilities

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***Abstract*—** Nature offers a great source of inspiration to create robust systems that can assist humans to achieve different tasks. Neuromorphic engineering is an emerging field and when it comes to create a device that could assist a blind or a visually impaired human and also replace the traditional tools like white canes or guiding dogs, this can be really challenging. Even if insects are considered inferior species in comparation with vertebrates, they poses a visual system that colud be used in such an applications. An important condition for a person to move freely in an enviroment is to be able to detect any obstacle which may interfere with the trajectory of motion in order to avoid a possible collision with that obstacle. This article presents a possible implementation of a collision avoidance system inspired from the insects visual system with some specific modifications, in order to be useful for human applications in an real enviroment.

***Keywords*—** bio-inspired, insects, vision, collision detection, obstacle avoidance, EMD, Reichardt correlator

I. BIOLOGICAL BACKGROUND

DURING the evolution period, insects have developed into more than one million species and they are found in almost all environments of the planet.

Studying insect vision is very important due to the fact that are more simple that another species, but complex enough to be a source of inspiration in creating robust visual system.

The fly eyes are constructed from multiple elements called ommatidia or facetes. Each facet contains its own lens and its own set of photoreceptors [10]. The different photoreceptors in one ommatidium have different optical axes, but there are groups of photoreceptors within neighboring ommatidia which have parallel optical axes. These group of photoreceptors are connected to the same postsynaptic target (Fig.1) resulting in the possibility to increase the sensitivity without sacrificing acuity[11], [12],[13].

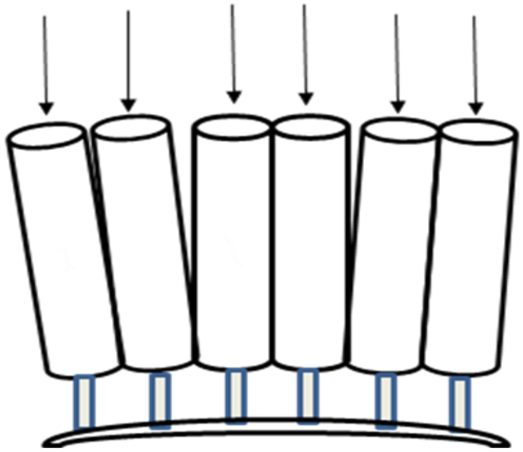

Fig.1 Diagram structure of the Drosophila’s fly eye

The image is projected onto the tips of an array of photoreceptors, forming a neural representation of the environment.

The visual system of the fly, as seen in Fig.2, has a hierarchical organization and consists mainly of the lamina, medulla and complex-lobula, which is further subdivided into an anterior lobula and a posterior lobula plate. Each of these lobes forms a retinotopic map, built from repetitive columns and each of these structure contain specialized cells fullfiling different functions.

Some of the photoreceptors cells from retina are connected with the cells from lamina while others run through the lamina without making synapses and terminate in specific layers of the medulla.

All of the lamina cells ramify in different layers of the medulla suggesting that the photoreceptor signals split into parallel pathways there. [14]Each medulla column houses, in addition to the terminals of lamina neurons, about 60 different columnar neurons, that collectively can cover the whole visual field. The cells performs as motion detector systems. The dendrites of tangential cells located in the posterior part of the third visual ganglion, called the lobula plate, have the role to spatially integrate the local motion detectors [15], [16].

There exists a set of such a tangential cells that can be

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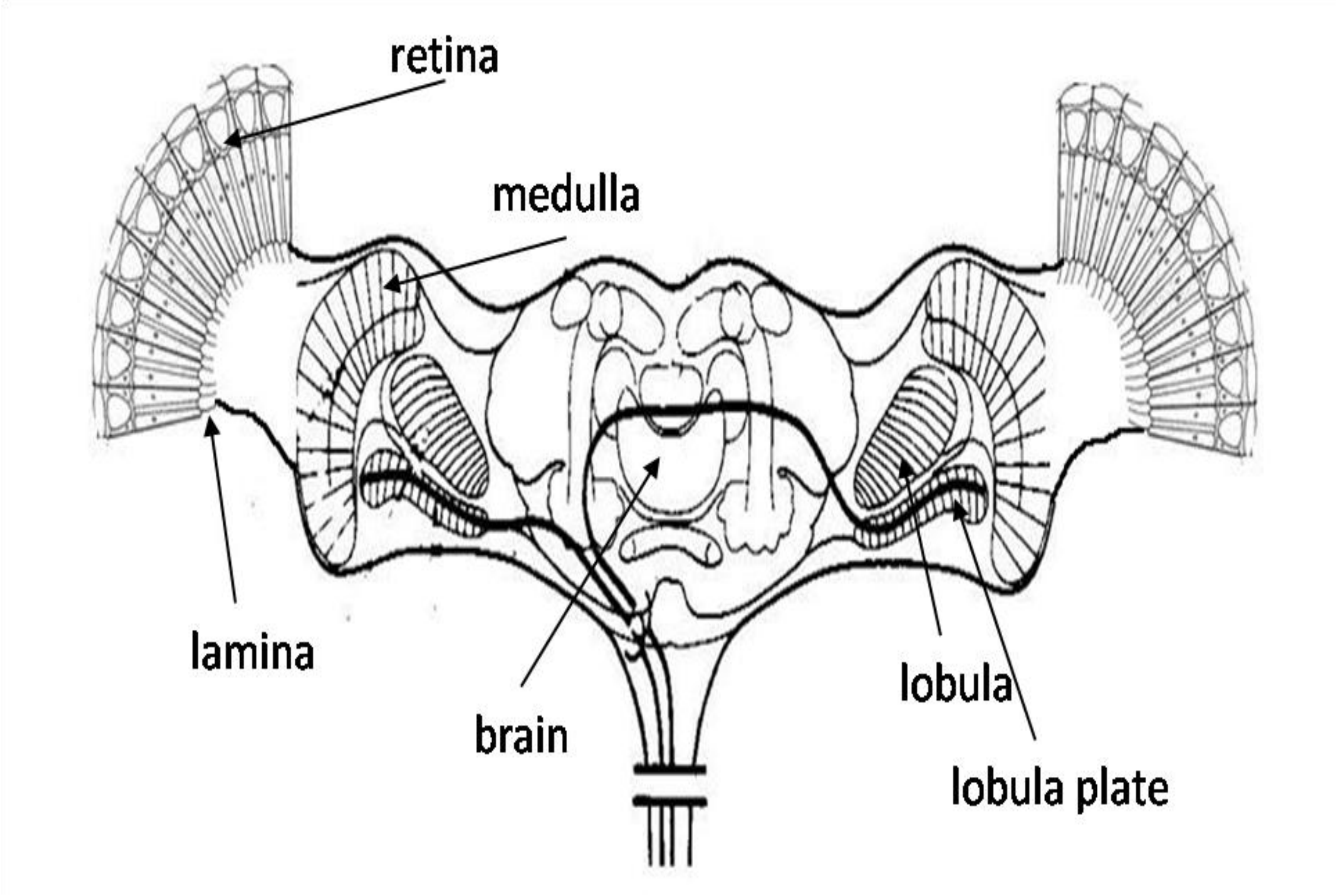

Fig.2 Anatomical structure of the the Drosophila's visual system

grouped according to their preferred direction of image motion, some of the cells respond preferentially to horizontal image motion from front to back (the HS-cells), others to horizontal image motion in the opposite direction, others respond selectively to vertical image motion from top to bottom (the VS cells) [17].

The connections between the tangential neurons of the left and the right lobula plate as well as between neurons within one lobula plate tune many tangential cells responsive to specific motion signals in front of both eyes, and others that are selectively responsive to motion of small moving objects or relative motion [18], [19].

Tangential cells have been shown to synapse onto descending neurons which connect either to the flight motor in the thoracic ganglion of the animals controlling the various flight maneuvers, or to specific neck muscles controlling head movements[20], [21].

When an animal moves in an environment or is moving his eyes or an object is moving in front of the eyes, the visual system is faced with motion perception [22], [23]. Even so, this movement is not represented in two-dimensional pattern on the retina of enlightenment but is processed in time of lighting the image crossing the retina. This is one of the first and most basics step performed by the visual system. This primary motion detection is a key to neural processing and this algorithm, although not yet understood at the cellular level is supposed to be at any species. In literature, the development of models for motion detection has been experienced in particular by investigations on two systems: rabbit retina and insects.

Insects process visual motion information in a local hierarchy. Although the compound eye has a construction with multiples lens, the pattern projected on the retina which is under the lens is a single image of the visual scene [24]. Photoreceptors in the retina adapts to the ambient light, signaling deviations from this level. These signals are transferred to the next level of cells, lamina (Fig.2). These cells have a character of a time-pass response, with emphasis on temporal changes. The next level is in the medulla processing, a layer of cells that are very difficult to study because of their small size. However, indirect evidence suggests that there is local motion processing (of adjacent photoreceptors). These estimates of motion are integrated into the tangential cells of the lobula. The domestic fly has 50-60 such cells present in each half of the brain. These are the best-studied cells in the fly visual system, best known of their properties [25], [26]. Cells in the lobula generally respond to the movement of large parts of the visual field. Some of these cells appear to be adapted filters for optic flow patterns produced by rotation or translation on some particular axes. Some of these cells are most likely compensating the control to prevent rotation motor reflexes during flight. Others are sensitive only to small objects that move in the field of vision.

It is assumed that this type of cells allows the fly to locate nearby objects. All these sensory abilities require the movement is initially detected locally between each pair of photoreceptors [27], [28].

The locust visual system structure has many similarities but the interest comes in the identified two neurons, the DCMD neuron, known as descending contralateral movement detector, localized in the postsynaptic area, and the LGMD neuron known as lobula giant movement detector respond selectively to the images of an object approaching towards its eye [9].

LGMD neuron is excited by the related elements that are arranged in the retina. Excitation is given as a pulse or a potential. Number of related elements excited depends on the angle of the object defined by eye, so when an object is approaching the neuron excitation increases very rapidly, as they approach. Objects that are not on collision course do not show the same increase in excitation and thus is unlikely to trigger avoidance reactions.

The principle of operation of the neuron is relatively simple. For collision detection method can also be used a method which calculate the increase in size of the object to determine if this is the direction of collision, but such a method requires the detection and the recognition of the object’s shape that is approaching. Such tasks are very expensive in terms of processing and even using the latest and fastest computers would run very slowly.

LGMD neuron provides several methods to eliminate responses from objects that come near, methods that are simple both in terms of cognitive and computing. The most studied are lateral inhibition between pre-synapses involved and the "feed forward" post-synaptic inhibition of the LGMD neuron.

The reaction of the neurons is more intense when the object is approaching on a collision course. In this case appears a race between excitation caused by edges moving over successive photoreceptors and inhibition spreading laterally. Experiments showed that the more edges contain the object the more intense is the response of the neurons [5], [8].

II. ELEMENTARY MOTION DETECTOR

Moving in a real environment of a person suffering from visual disability is conditioned primarily by the ability to detect obstacles that appear on walking path.

Making an assistive device inspired by the visual system of insects is justified by the fact that insects although considered inferior beings, possess a neural structure and a visual system that allows them to perform important task such as landing, secure takeoff, visual navigation with obstacle avoidance and flight stabilization.

In the last few years, the most studied insects related to the visual system were the locust and the fly. These studies showed that motion processing in insects is mainly based on an Elementary Motion Detector (EMD). This Elementary Motion Detector also known as Hassenstein-Reichardt detector is supported by the behavioural and physiological model, which was revealed from the investigations on cells in the optic lobe of the insects and is considered that their role is to correlate the information from the photoreceptors in the retina, in order to encode the motion information.

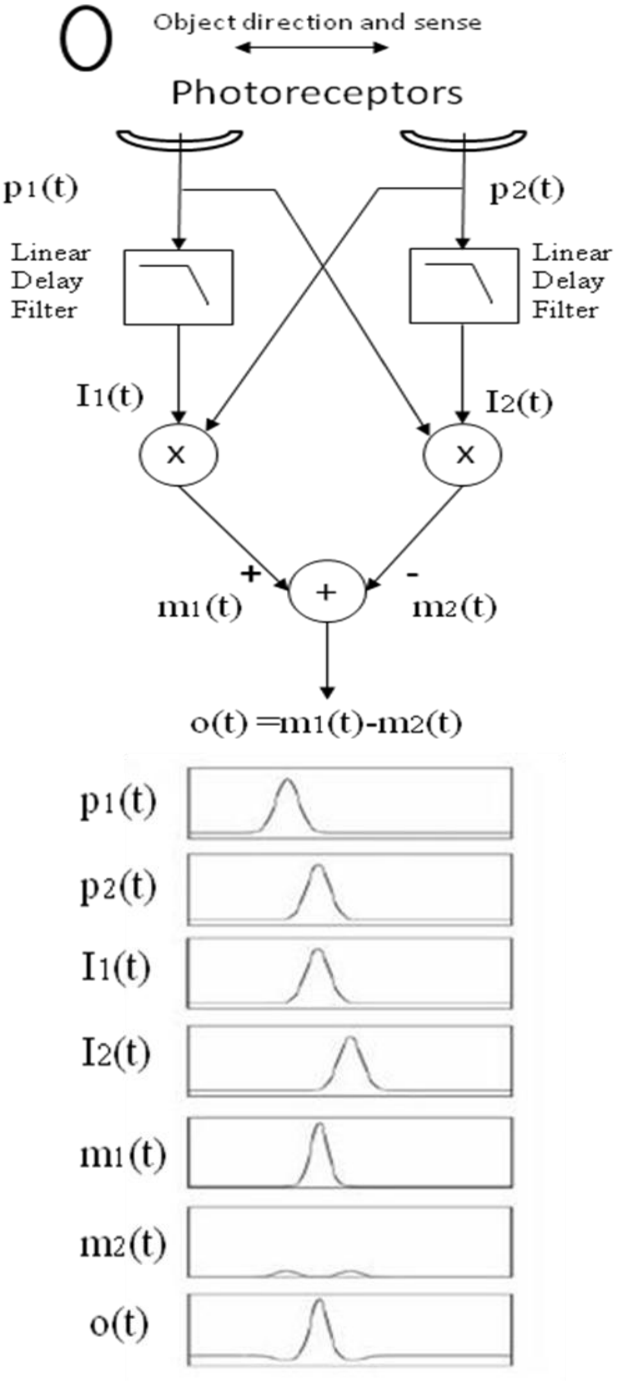

Fig.3 Functional block diagram for the Elementary Motion Detector and the related signals for each block

The EMD structure is showed in Fig.3 and is basically formed from two channels where the signal received from the photoreceptors is delayed in each channel and multiplied with the non-delayed signal from the opposite channel, then are subtracted in order to receive the motion information [1]-[3]. If the result has a positive value means that an object has passed in front of the sensors from left to right and if the result has a negative value then the object has passed from right to left.

If we consider the pattern of input a sinusoidal signal with wavelength λ moving with speed v [° / s]. Image intensity I (x, t) can be written as:

$$i(x,t) =I+\Delta I sin(2\pi f_s(x+vt)) \tag{1}$$

where I is average intensity and spatial frequency f_s. The contrast pattern is and ΔI/I. In each photoreceptor, this moving pattern produces a sinusoidal signal temporal with the frequency $f_t = vf_s$. Thus we can rewrite (1) as:

$$i (x,t) =I+\Delta I sin(\omega_t t+\omega_s x)) \tag{2}$$

where $\omega_t = 2\pi f_t$ and $\omega_s = 2\pi f_s$. If two receivers have a separation angle of Φ, the signals measured by the two photoreceptors can be expressed as:

$$p1=| H(\omega_t)| \Delta I sin (\omega_t t-\omega_s \phi/2) \tag{3}$$

$$p2=| H(\omega_t)| \Delta I sin (\omega_t t-\omega_s \phi/2) \tag{4}$$

where we have introduced H (ω_t) as the frequency response of the photoreceptors. If using low-pass filters of first order, we get signals:

$$I_1(t) = |H(\omega_t)| \Delta I(\tau^2\omega_t^2+1)^{-0.5} sin(\omega_t t-\omega_s \phi/2 -tan^{-1}\tau\omega_t) \tag{5}$$

$$I_2(t) = |H(\omega_t)| \Delta I(\tau^2\omega_t^2+1)^{-0.5} sin(\omega_t t-\omega_s \phi/2 -tan^{-1}\tau\omega_t) \tag{6}$$

Correlation is performed by multiplying the out of phase signals with adjacent non-delayed signals. The results are :

$$m_1(t) =G[cos(\omega_s \phi+P) -cos (2\omega_t t-P)] \tag{7}$$

$$m_2(t) =G[cos(\omega_s \phi+P) -cos (2\omega_t t-P)] \tag{8}$$

where G and P are:

$$G= (|H(\omega_t)| \Delta I)^2(2(\tau^2\omega^2+1))^{-0.5}$$

$$P=tan^{-1}(\tau\omega t)$$

So, the final answer becomes:

$$o(t) = (\Delta I)^2 |H(\omega_t)|^2 \tau\omega_t(\tau^2\omega_t^2+1)^{-0.5} sin(\phi\omega_s) \tag{9}$$

III. BIO-INSPIRED COLLISION AVOIDANCE SYSTEM CONCEPT

The Elementary Motion Detector can be seen as a system whose role is to identify an object's movement in the visual field with the additional possibility to specify the direction of motion of an object in a certain sense. If instead of using two visual sensors to provide information for the Elementary Motion Detector we use one sensor but always correlate the actual acquired image with the enlarged image by both axes, the system will detect if an object is approaching relatively to the visual sensor [4],[6]-[8].

The block diagram of the proposed bio-inspired obstacle avoidance system is presented in Fig.4. The information received from the visual sensor is pre-processed in order to be successfully used in the proposed application, namely to guide visually impaired people. There are two types of redundant information, one comes from the obstacle detection function and the second comes from the application itself. The first one is eliminated using an edge detection algorithm in the pre-processed part, and the second by extracting from the entire visual field only the area of interest, which in this case is the walking path area. Next, after eliminating the redundant information, the result of the pre-processed data is distributed at three channels where is computed differently.In one channel, the extracted area is enlarged by both axes (zoomed area), while the others two channels leaves it unchanged. The EMD block compute the information received from the first two channels pixel by pixel. The summation of all pixels provided by the EMD's output represents an excitation signal (e(t)) that shows the closeness or distance of an obstacle on the walking path, while the summation of all pixels from unchanged area of channel three (i(t)) represents an inhibition signal.The variation of the difference between the excitation and the inhibition signals contains the information about a possible collision with an obstacle. When the subject is approaching to an object, the difference between the excitation and the inhibition signal will increase, and this is captured by the window comparator if the lower threshold (VthL) and the upper threshold (VthH) are properly adjusted. One of the problem here is that the variation of the difference between the excitation and the inhibition signal (e(t) – i(t)) changes the mean value continuously according with the environmental light, so using fixed thresholds for the window comparator would lead to wrong decisions for the system. We improved this condition by extracting the mean value from the [e(t) – i(t)] signal and used it to generate the threshold for the window comparator. So, in this case the lower threshold for the window comparator is obtain from the sum between the mean value of the excitation and the inhibition signal difference, plus a threshold value, while the upper threshold for the window comparator is obtain from the difference between the mean value of the excitation and the inhibition signal difference minus a threshold value.

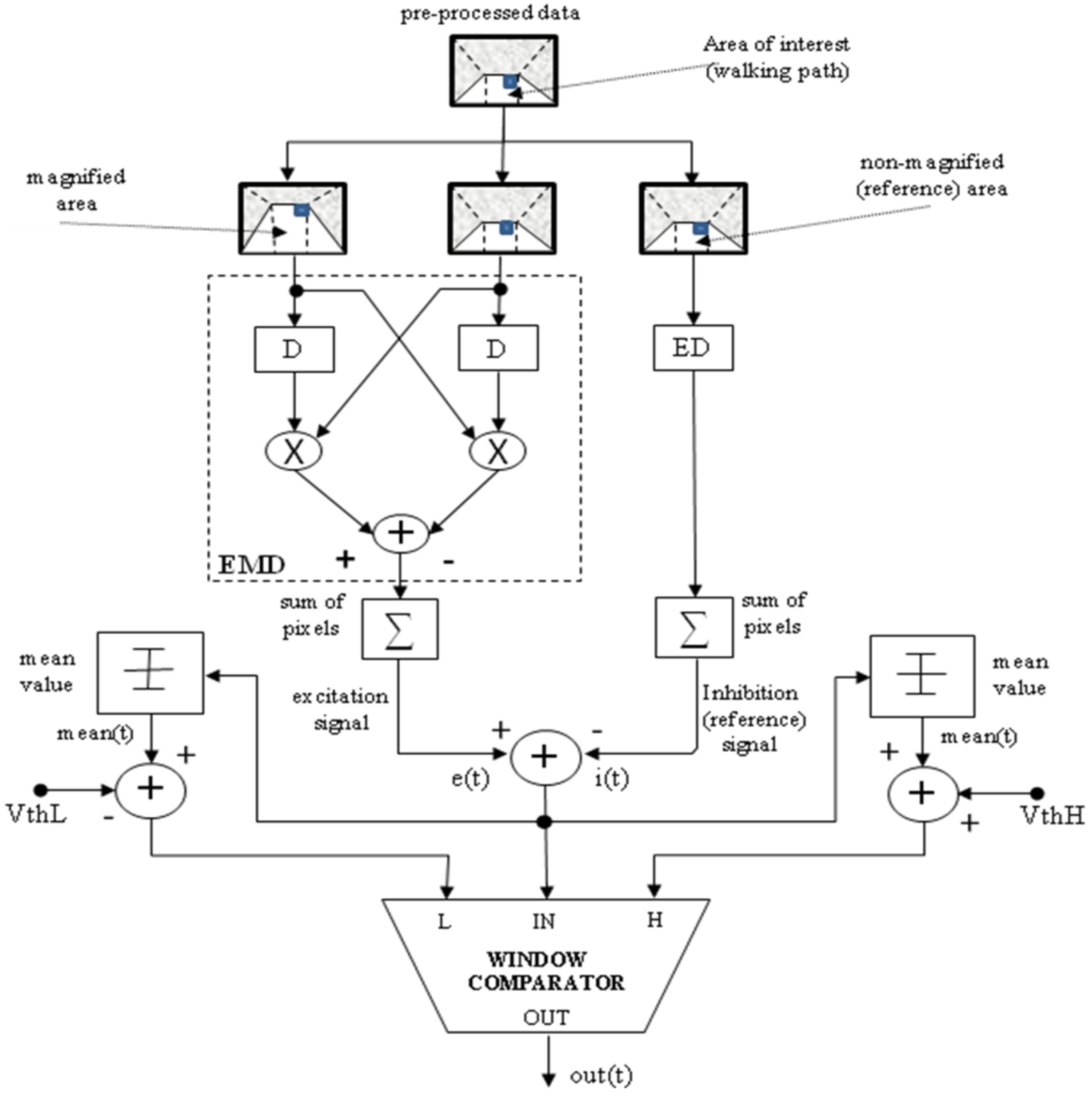

Fig.4 Bio-inpired collision avoidance system concept

IV. SIMULATION OF THE BIO-INSPIRED COLLISION AVOIDANCE SYSTEM

For the simulation of the bio-inspired obstacle avoidance system we used situations that were recorded in a real environment. We used two examples in this paper, a recording made by a camera mounted on a subject that moves on an alley in the park and the second one, in which the subject moves in the parking area.

In Fig.6 are recorded frames that were taken during the subject's movement along the alley, while in Fig.5 are the corresponding areas for the variation between the excitation and the inhibition signals, and also the impulses generated by the window comparator which signals an approach with an obstacle on the pathway. As can be seen in Fig.5, the average difference between the excitation and the inhibition signal is changing continuosly during the subject's movement along the alley, so by doing the thresholds of the window comparator depend on this value we are able to detect more accurately the proximity of an obstacle. In the frame A from Fig.6, there are no obstacles so the output's system will not generate any pulse. Next, the subject is approaching a hedge and the system starts to generate pulses (frame B), moment when the subject changes the walking direction and the system stops generating pulses because there are no obstacles in the vicinity (frame C).The subject continues to walk on the pathway and aproaches a new obstacle, in this case a concrete pillar (frame D),and the systems starts again to generate pulses. As continues to approach the pillar, the systems generate a longer train of pulses (frame E) indicating a frontal collision with the obstacle.

In the second example (Fig.7 and Fig.8) the recorded frames were taken during the subject's movement along the parking area. Initial, when the subject start walking, there are

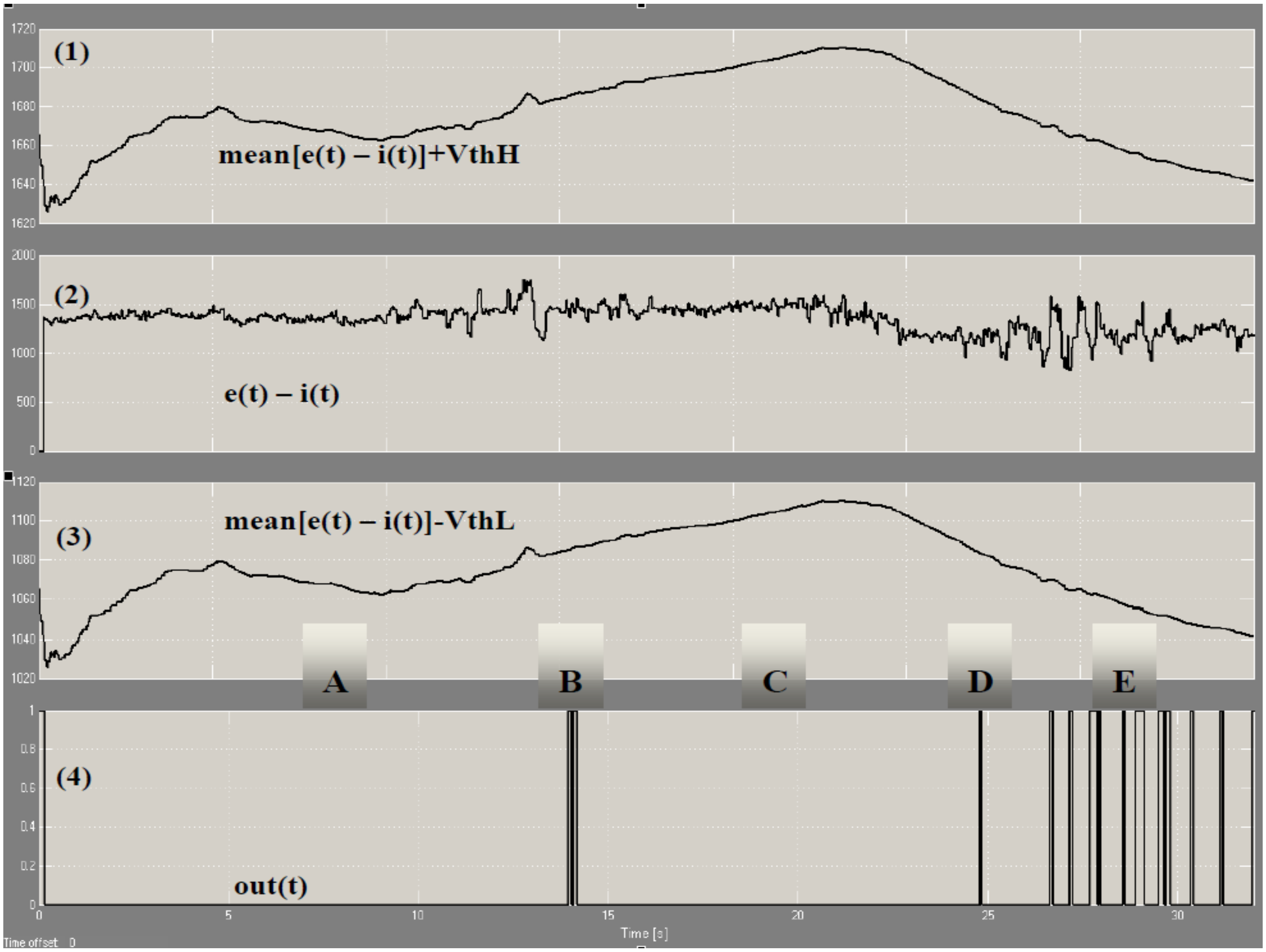

Fig.5 (1) The sum between the mean value of the excitation and the inhibition signal difference plus the upper threshold value:mean[e(t)-i(t)] +VthH. (2) The difference between the excitation and the inhibition signal: e(t) – i(t). (3) The difference between the mean value of the excitation and the inhibition signal difference minus the lower threshold value:mean[e(t)-i(t)] -VthL (4) Decision made by the window comparator: out(t).

Fig.6 Different frames recorded during the subject's movement along the alley

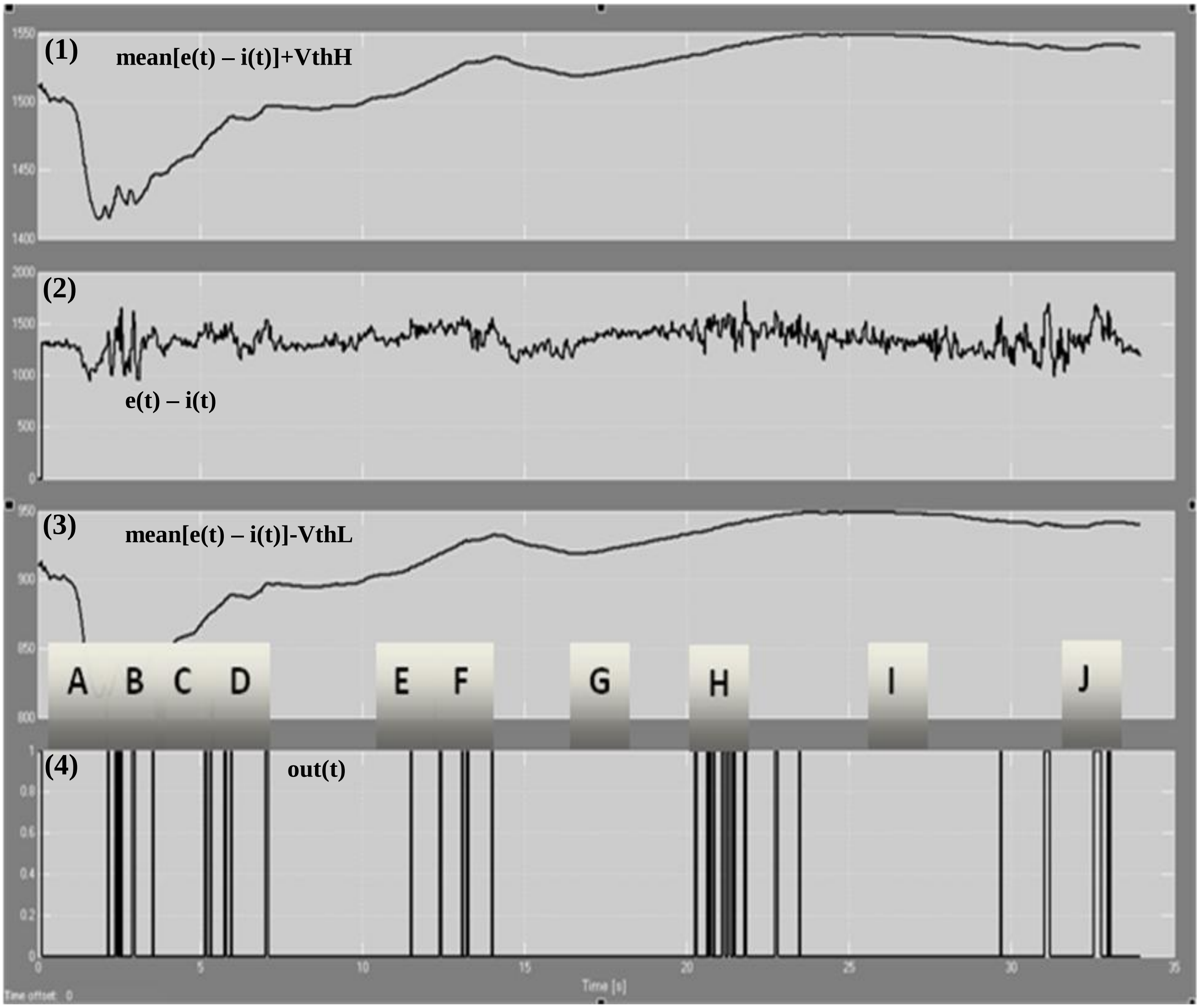

Fig.7 (1) The sum between the mean value of the excitation and the inhibition signal difference plus the upper threshold value:mean[e(t)-i(t)] +VthH. (2) The difference between the excitation and the inhibition signal:e(t) – i(t). (3) The difference between the mean value of the excitation and the inhibition signal difference minus the lower threshold value:mean[e(t)-i(t)] -VthL (4) Decision made by the window comparator: out(t).

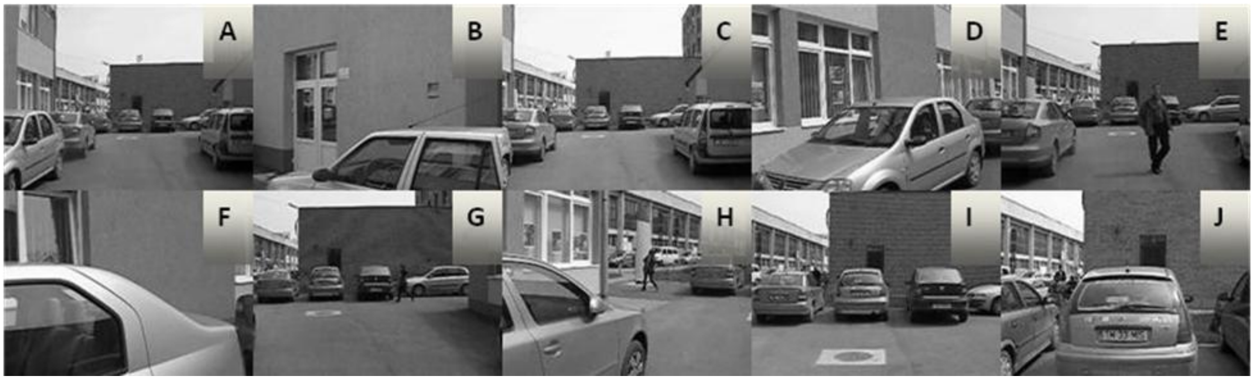

Fig.8 Different frames recorded during the subject's movement along the parking area

no obstacles in front of him (frame A) so the system doesn't generate any pulse. Next, the subject changes the walking direction at the right side where is a stationary car (frame B) and the system starts to generate pulses. The subject is returning to the initial trajectory (frame C) so the systems stops generating pulses. In frame D is changing again the walking path direction and approaches another car from a different angle and the system generates again a train of pulses. When the subject returns again to the initial trajectory (frame E) encounters another person who is walking in front of him and also in this case the system recognize the person as an object that can collide with and respond with pulse generation. In the next frames (F, G, H, I, J) the procedure is repeated and the system responds accordingly.

V.CONCLUSION

In this paper we presented a bio-inspired obstacle avoidance system, in the idea of creating a device that could be implemented and used in the guidance of the visually impaired people. The main core of the system, the Elementary Motion Detector (Reichardt correlator) is inspired from the insect's visual system. Based on previous researches and applications that exist in literature, we designed and simulated a system that was adapted to the desired purpose. The modifications made were in the pre- processing part by extracting only the area of interest from the entire visual field and by doing this, we manage to get better results in the function of the system and also increase the speed in data processing. The second improvement was made in the decision part by creating a dependency for the thresholds with the signal itself, resulting in a more accurate obstacle detection.

We are looking forward to bring more improvements and to implement the entire system into a single chip, or by using an embedded system.

REFERENCES

[1] Sergi Bermudez i Badia, Paul F.M.J. Verschure A collision avoidance model based on the Lobula Giant Motion Detector (LGMD) Neuron of the Locust, *Neural Networks, 2004. Proceedings. 2004 IEEE International Joint Conference*; Vol.III, pp.1757-1761.

[2] Sergi Bermudez i Badia, Pawel Pyk and Paul F.M.J. Verschure, A fly-locust based neuronal control system applied to an unmanned aerial vehicle: the invertebrate neuronal principles for course stabilization, altitude control and collision avoidance, *The International Journal of Robotics Research* 2007, 26, 759-772.

[3] M.E. Basch, D.G. Cristea, V. Tiponut, T. Slavici, Elaborated motion detector based on Hassenstein-Reichardt correlator model, LATEST TRENDS ON SYSTEMS 2010, Vol.I, pp. 192-195.

[4] M.E. Basch, D.G. Cristea, R..I.Lorincz, A Bio-inspired Obstacle Avoidance System Concept for Visually Impaired People, Recent Researches in System Science, 15th WSEAS International Conference on SYSTEMS, 2011,pp.288-291

[5] Patrick A. Shoemaker, David C. O'Carroll, Andrew D. Straw, Implementation of visual motion detection with contrast adaptation, Proceedings of SPIE,Vol.4951, pp.316-327.

[6] V. Tiponut, D. Ianchis, M.E. Basch, Z. Haraszy, Work Directions and New Results in Electronic Travel Aids for Blind Visually Impaired People, WSEAS TRANSACTIONS on SYSTEM, Issue 10, Volume 9 ,October 2010, pp.1086-1097.

[7] V.Tiponut, A.Gacsadi, L.Tepelea, C.Lar, I.Gavrilut, Integrated Environment for Assisted Movement of Visually Impaired, *Proceedings of the 15th International Workshop on Robotics in Alpe- Adria-Danube Region, (RAAD 2006)*, ISBN: 9637154 48 5, Balatonfured, Hungary, 2006, pp. 234-239.

[8] V. Tiponut, S. Popescu, I. Bogdanov, C. Caleanu, Obstacles Detection System for Visually Impaired Guidance, 12th WSEAS INTERNATIONAL CONFERENCE ON SYSTEMS, Heraklion, Greece, July 22-24, 2008,pp.350-354.

[9] V. Tiponut, D. Ianchis, Z. Haraszy, Assisted Movement of Visually Impaired in Outdoor Environments –Work Directions and New Results, PROCEEDINGS OF THE 13th WSEAS INTERNATIONAL CONFERENCE ON SYSTEMS,2009,pp.386-391.

[10] F. Claire Rind, Motion Detectors in the Locust Visual System - From Biology to Robot Sensors, *MICROSCOPY RESEARCH AND TECHNIQUE*, Vol.56,pp.256-269.

[11] Alexander Borst, Drosophila's View on Insect Vision, *Elsevier Current Biology*, Vol.XIX, 2009,pp.36-47.

[12] John K. Douglass, Nicholas J. Strausfeld, Visual motion detection in flies: parralel direction and non-direction-sensitive pathways between the medulla and lobula plate, *The Journal of Neuroscience*, Vol.XV, pp.4551-4562.

[13] Hausen, K. (1984). The lobula-complex of the fly: Structure, function and significance in visual behaviour. In Photoreception and Vision in Invertebrates, M.A. Ali, ed. (New York, London: Plenum Press), pp. 523–559.

[14] Scott, E.K., Raabe, T., and Luo, L. (2002). Structure of the vertical and horizontal system neurons of the lobula plate in Drosophila. J. Comp. Neurol. 454, 470–481.

[15] Joesch, M., Plett, J., Borst, A., and Reiff, D.F. (2008). Response properties of motion-sensitive visual interneurons in the lobula plate of Drosophila melanogaster. Curr. Biol. 18, 368–374.

[16] Wehner, R., and Labhart, T. (2006). Polarisation vision. In Invertebrate Vision, E. Warrent and D.-E. Nilsson, eds. (Cambridge: Cambridge University Press), pp. 291–348.

[17] Hardie, R.C. (1986) The photoreceptor array of the dipteran retina. Trends Neurosci. 9, 419–423.

[18] Collet, T.S., and Land, M.F. (1975). Visual control of flight behavior in the hoverfly, Syritta pipiens L. J. Comp. Physiol. A 99, 1–66.

[19] Reichardt, W., and Poggio, T. (1979). Figure-ground discrimination by relative movement in the visual system of the fly. Part I: Experimental results. Biol. Cybern. 35, 81–100.

[20] Egelhaaf, M. (1985). On the neuronal basis of figure-ground discrimination by relative motion in the visual system of the fly. I. Behavioural constraints imposed on the neuronal network and the role of the optomotor system. Biol. Cybern. 52, 123–140.

[21] Tammero, L.F., and Dickinson, M.H. (2002). The influence of visual landscape on the free flight behavior of the fruit fly Drosophila melanogaster. J. Exp. Biol. 205, 327–343.

[22] Heisenberg, M., and Wolf, R. (1984). Vision in Drosophila (Berlin, Heidelberg: Springer Press).

[23] Mronz, M., and Lehmann, F.O. (2008). The free-flight response of Drosophila to motion of the visual environment. J. Exp. Biol. 211, 2026–2045.

[24] Sherman, A., and Dickinson, M.H. (2002). A comparison of visual and haltere-mediated equilibrium refelxes in the fruit fly Drosophila melanogaster. J. Exp. Biol. 206, pp.295–302.

[25] Cook, T., and Desplan, C. (2001). Photoreceptor subtype specification: from flies to humans. Semin. Cell Dev. Biol. 12, pp.509–518.

[26] Kalmus, H. (1949). Optomotor responses in Drosophila and Musca. Physiologia comparata et oecologia 1/2,pp. 127–147.

[27] Fischbach, K.F., and Heisenberg, M. (1981). Structural brain mutant of Drosophila melanogaster with reduced cell number in the medulla cortex and with normal optomotor yaw response. Proc. Natl. Acad. Sci. USA 78,pp.1105–1109.

[28] Buchner, E., Buchner, S., and Bu¨ lthoff, I. (1984). Deoxyglucose mapping of nervous activity induced in Drosophila brain by visual movement. J. Comp. Physiol. A 155, pp.471–483.

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