Lateral Superior Olive based Spatial Mapping System

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***Abstract*— This paper illustrates the use of an electronic lateral superior olive (LSO) to create map of obstacles in the environment.**

I. INTRODUCTION

With increasing focus on autonomous spatial navigation, spatial mapping is very important. Most of the vehicles do this by combination of strategies like ultrasound, LIDAR, RADAR etc. In this paper, we explore the use of bat lateral superior olive for spatial mapping. Bats send ultrasonic beams from a single transmitter, their larynx and sense the echoes reflected from their environment with two sensors, their ears. The LSO column of neurons process the aural inputs using delay line principle and calculating difference between log intensities of two aural inputs [1]. In this work, the LSO designed in silicon [2], [3] is used to map the environment.

II. METHODS & RESULTS

Our system has an LSO column with an array of 32 neuron circuits. Each neuron receives excitatory input from same side ear and inhibitory input from opposite side ear and calculates interaural level difference (ILD) of echoes received at both ears. The ultrasound echoes from objects were converted to spiking inputs to excitatory and inhibitory synapses in the LSO neuron array. Synaptic inputs were graded in opposite direction using resistor ladders that act like delay lines. The neurons along the column fire until they attain ILDci (ILD of complete inhibition). This enables neuron array to code for different obstacles and hence map them. The LSO circuit [2] was designed in SPICE (synapse: Vspk- pulse input, 4V, 10us, duty cycle=50%, Vt1=5V, Vt2=5V, C=0.1pF, transistors- W/L=2.4um/2.4um. Neuron: Vthr=0.65V, Vref=4.1V, Vwe=4.1V). An illustration of the system is shown in Fig. 1(a). In this figure, three obstacles and the left LSO are shown. When the obstacles are present at the red, black, and yellow positions, neurons with corresponding color in the LSO column stop firing, i.e., achieve ILDci).

The frequency of spiking inputs to inhibitory and excitatory synapses in the array of LSO neurons was changed corresponding to the intensity of reflected echo. The corresponding neuron that attained the ILDci is reported in fig. 1(b). There were 23 neurons which experienced ILDci, so the entire 180 degrees can be divided into 24 intervals, each of which is 180/24=7.5 degrees. Each neuron in the LSO column represents one interval. When the object was between 0 to 7.5 degrees, we input spikes of 100KHz to both the excitatory and inhibitory synapses and 9th neuron experienced ILDci. When the object was between 67.5 to 75 degrees, we input spikes of 1000KHz to excitatory synapse and 100 KHz to inhibitory synapse and 19th neuron experienced ILDci. When the object was between 142.5 to 150 degrees, then we input spikes of 2000KHz to excitatory and 100KHz to inhibitory synapse and 29th neuron experienced ILDci.

III. DISCUSSION & CONCLUSION

In conclusion, each of the neurons in the array represents a certain position of object in the environment. This information can be stored in memory as a spatial map, which can be updated dynamically and used for navigation. In this work, we have successfully used the VLSI design of the LSO in a system that can help map objects in an environment. This system of mapping the environment is better than one used currently because it requires single signal source and two sensors. Future work involves building a front-end ultrasound sensor and a back-end memory bank to store locations.

REFERENCES

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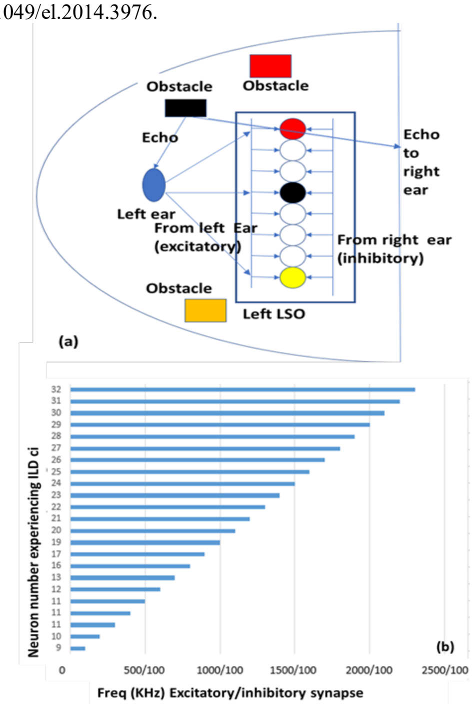

Fig. 1 Illustration of (a) the system and (b) its working.