USING NEURAL NETWORKS TO IMPROVE COCHLEAR IMPLANT SPEECH PERCEPTION

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A number of people suffer from sensorineural deafness and the possible solution to this problem is the **use of cochlear implants as prostheses**. But there are some factors that need to be taken care of and they are *spectral, amplitude/intensity, and temporal dispersion*, the **Speech coding strategies** suggests that it is necessary to stimulate the temporal dispersion and other phenomena found in the natural receptors for effective coupling with the natural speech perception system.Present cochlear implants have no dispersion at all.
Using these the acoustic signal is converted to electrical stimulations by converting them to electrical signals using the microphone, which sends it to an AM oscillator.Modulation step is necessary to induce an electromagnetic coupling between the external and internal coil. After the implant, the remaining peripheral auditory nervous system is used to detect the sound through its electrical stimulation.
We have also discussed **the computational model using ANN to incorporate the natural phenomena in the artificial cochlear** as it has a lot of advantages to the implementation of such systems like ANN model carries the necessary ingredients and is a close mapping for implementing the necessary functions. Also processing like sorting and majority functions could be implemented more efficiently using local decisions only. This model also allows function modifications through parametric modification.
The further discussion is based on how the study of sensory implants can enhance our understanding of the representation schemes used for natural sensory receptors.The model of sensory receptors can be understood either by the construction of artificial replacements, where we want to know up to what extent those artificial counterparts have the ability to replace the natural receptors or by understanding how the natural receptors process incoming signals and build a representation code.

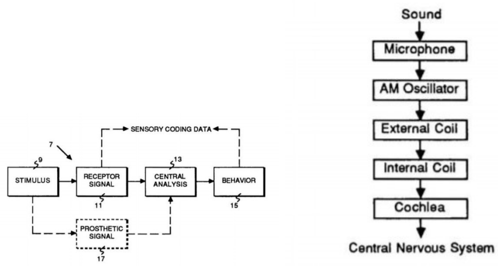

Figure 1: (a) Path of Natural and Prosthetic Signals (b) The House-Urban Cochlear Implant

The major concern is that no useful speech recognition has been attained with either single or multi-channel cochlear implants like only partial acoustic information is obtained with a cochlear prostheses. Any useful patterns for speech communications are not yet fully recognizable through auditory prostheses. The problem of artificial cochlear implants here is tackled through the use of **the neural model, the neuromorphic computing paradigm** whose results and impacts have also been discussed.
Before that, it is important to mention, **the receptor model** used here was *developed by Gerald Wasserman of the Sensory Coding Laboratory, Department of Psychological Sciences, Purdue University [20], and the implants were performed by Richard Miyamoto of the Department of Otolaryngology, Indiana University Medical School*
In further sections of the paper, various parts of the receptor model, and the block diagram of the implant are discussed. It covers the limitations associated with the technique, and discusses the results obtained with a single neuron and one feedback loop. Further, it discusses **the implementations of these models using the feedforward neural networks, and the computational advantages for doing so.**As mentioned earlier, there are operations like selection of a portion of the spectrum, rectification,compression, and temporal dispersion that need to be considered. In figure 2(c), a modified implant is shown, which takes into consideration some of these operations. It is depicted as a single-channel implant, although the ultimate goal is to make it multi-channel. Most importantly, the implant would also have a compression/rectification function that would receive a feedback from the integrator stage in order to control its gain

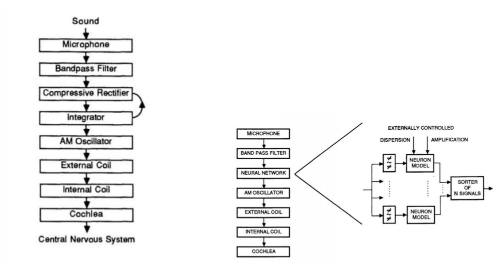

Figure 2: (c) Modified Implant Model (d) Feedforward Neuron Model Implant

But it is not easy to define the amount of feedback that is needed in the system or the amount of temporal dispersion. Patients, drawn from a population were given spoken sentences processed off-line, and simultaneously presented with a couple of words related to the context. Only one of them was the correct answer. The patient had two buttons, one for each alternative. The results of the implementation of the transfer function are shown below.

Patient 1 (Average of the population)

Dispersion	Percentage of correct alternatives	
No disp.	67%	
0.1 msec	78%	
0.3 msec	85%	Best performance
1 msec	76%	
3 msec	72%	

Table I: Phoneme discrimination in a two-alternate task.

Patient 2

Dispersion	Percentage of correct alternatives	
No disp.	50%	
1.0 msec	76%	Best performance

Table II: Sentence comprehension in a two-alternative task.

A lot of variations in the performance of different patients were noticed and thus it is hard to predict the ideal values for a given patient. To note, the improvements observed are of undeniable value in improving speech perception. The use of the first on-line portable model will start soon using a single processor and in order to study their implementations, we looked at feed-forward neurocomputer models as a possible answer in the paper (Figure-2(d)).
Another way for the use of neuromorphic computing here is possibly the use of sensory recordings from healthy animals to train self organizing adaptive learning networks, in order to design the implant transfer functions.

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