Retinal Prosthesis

Matin Amani, Department of Biomedical Engineering

Most current methods used for visual prosthesis are based on direct neuronal electrical stimulation at along the visual pathways within the CNS. Visual prostheses can be broken down into cortical, optic nerve, subretinal, and epiretinal. Vission loss caused by retinal degeneration can be reversed by direct electrical stimulation of the retina or the optic nerve. However, visual loss caused by eye loss, tumors, ischemia, inflammatory processes, or diseases of the CNS can be reversed by a cortical prosthesis.

Electrical stimulation of the visual pathway using a small number of electrodes cannot be expected to provide independent understaning of visual data. Several psychophysical experiments have been performed to provide the minimum resolution required to recover a imgage. As ealy as 1965, it was suggested that 600 points of stimulation (think of these as pixels) would be sufficient for reading ordinary print. Others suggested that 80120 points are sufficient for large-print reading, while 200 points may allow recognition of simple obstacles.

Fairly recent studies simulating pixelized vision show that 625 points of stimulation or more is requrired to perform certain tasks. These experiments were performed using a phosphene simulator, which is essentialy a small video camera and a monitor worn by a normally sighted human subject (the cammera is mounted to the subject). To simulate a pixilated viewing field, an opaque perforated film mask was used to cover the monitor. The angle subtended by images from the masked monitor was on the order of two degrees, depending on the mask and the fovea of the patient. It was concluded that at least 625 electrodes implanted in a 1 cm^2 area near the foveal of the visual cortex could potentially produce an image. This could provide useful restoration of functional vision for the profoundly blind.

The three levels of hierarchy in the sensory systems: receptor organ, sensory pathways, and perception suggest a similar architecture for artificial and prosthetic sensory systems. Accordingly, artificial systems should include a transducer corresponding to the receptor organ, an encoder corresponding to the sensory processing system, and finally an interpreter corresponding to perceptual functions. In other words, the visual environment will be captured and processed by a photosensing device such as a digital camera or photovoltaic units. This pixelized information is then transformed to electrical energy by microphotodiode array or conducted to a stimulating component that in turn activates an electrode array with a similar pixelized pattern. Adjusting pulse parameters and minimizing interactions between pulses on adjacent electrodes can improve the neural response. The electrical stimulator device output should be characterized by the flexibility of several parameters such as amplitude, pulse width, repetition rate, pulse shape, and so on. Attempts at implanting electronic devices at various parts along the visual pathways were discussed. Both major achievements and obstacles remaining were summarized. Given that intact neurons along the visual pathways can be found in almost all blind patients, only our lack of experience and capabilities in physiology, biocompatibility and device tissue interfacing is preventing us from stimulating them in a safe and effective manner. Given the advances that have been made in this field we can predict that the day such devices will be widely used in the near future and not decades away.

REFERENCES

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