Docket #: S18-465

Greedy dictionary-based encoding enhances visual perception in artificial retina

Stanford researchers at the Chichilnisky lab have developed a novel framework for a far superior artificial retina with strikingly near optimal efficiency (96%) of visual perception. This retinal prosthesis prototype vastly improved visual sequencing compared to other types on the market by using a closed-loop device with a greedy dictionary-based encoding system. Discovery of this system allowed precise and realistic selection of retinal ganglion cell (RGC) electrical stimulation patterns in the eye. This is a critical step in artificial vision as RGC's (20 different types) are directly degraded in individuals with loss of vision and has been historically impossible to simulate with any accuracy in a retinal prosthesis until now.

Researchers first developed a realistic model of visual perception, then utilized the electrical stimulation and recordings to create calibrated dictionaries of RGC activity patterns with the device. Finally, inventors processed the incoming visual image with the highest fidelity by using the personalized dictionaries. Remarkably, the electrical stimulation was optimized with near perfect efficiency by the greedy algorithm.

This invention successfully bypassed difficulties of other artificial retinas many-fold by producing less heat, decreasing lag time of visual communication, and creating an algorithm that can be applied to future technologies. Please see extensive list of applications and advantages.

Figure:

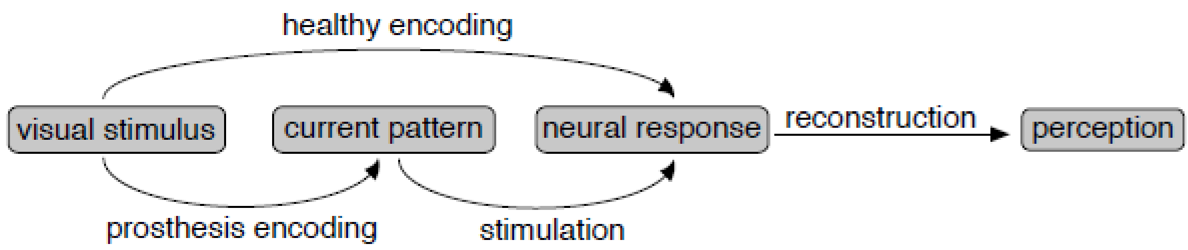

Figure Description: The diagram indicates the steps of visual encoding in a healthy retina and with a retinal prosthesis to give rise to visual perception. (Image credit: Inventors' publication listed below)

Stage of Development:
Proof of concept was completed by using a primate retina and a dense electrode array. Ongoing work will further address methods, image quality, refine algorithms, and dictionaries of multi-electrode stimulation patterns. Researchers will also delve further into the retinal signals of the brain.

Applications

- **Blinding retinal diseases** such as (but not limited to) Retinitis Pigmentosa, Diabetic Retinopathy, and Macular Degeneration
- May **guide implantable chip design** (in ophthalmology, neurology, and audiology) with the algorithmic framework – **more efficient hardware and higher resolution**

Advantages

- **Near optimal** single electrode stimulation (96% efficiency) -- with greedy algorithm
- Dictionary-based stimulation algorithm to **optimize sequences**
- **Computation of dictionaries locked to eye movements** – similar to a normal eye pattern
- **Less heat generated** – no damage to structures inside the eye
- **Clearer visual perception** -- Less lag time with visual processing from inside to outside of the eye and faster sequential stimulation

Publications

- Nishal P. Shah, Sasidhar Madugula, Lauren Grosberg, Gonzalo Mena, Pulkit Tandon, Pawel Hottowy, Alexander Sher, Alan Litke, Subhasish Mitra, and E.J. Chichilnisky, "Optimization of Electrical Stimulation for a High-Fidelity Artificial Retina," 9th International IEEE EMBS Conference on Neural Engineering (published 20-23 Mar 2019).

Patents

- Published Application: WO2020191408
- Published Application: 20220168571
- Issued: 12,151,103 (USA)

Innovators

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