Modeling Neuralink's Blindsight through a Synthetic Visual Cortex

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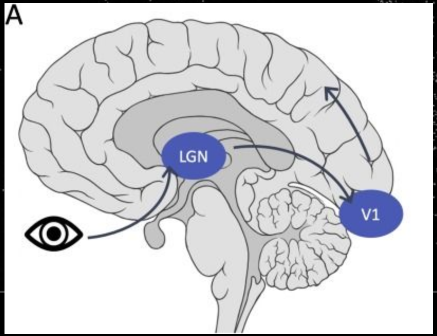
What is the blindsight phenomenon?

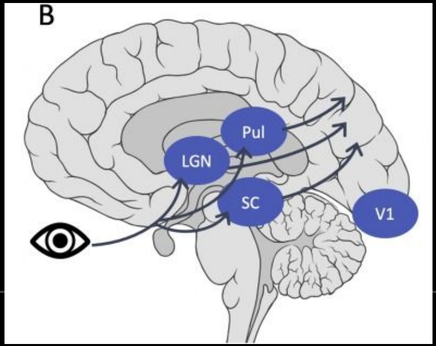
Blindsight is a symptom where people with *damage to their primary visual cortex* can respond to visual information—like detecting movement or locating objects—**without consciously seeing anything.**

They behave as if they can see, even though they report no visual experience.

No damage



Blindsight



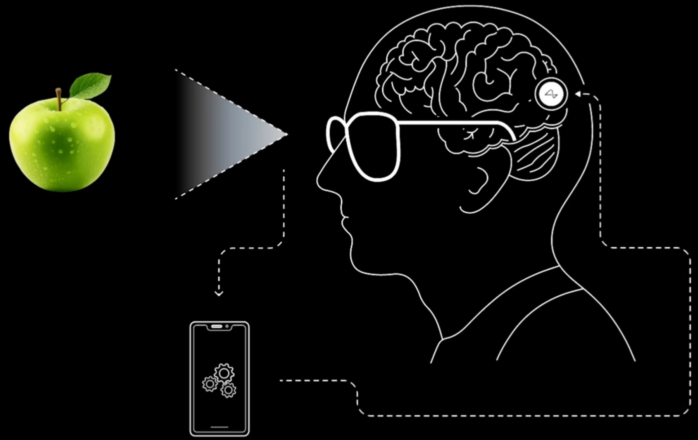
70%

of people with hemianopia (vision loss where 1/2 of the visual field is affected) have blindsight

Sahraie, A., Trevethan, C. T., MacLeod, M. J., Urquhart, J., & Weiskrantz, L. (2013). Pupil response as a predictor of blindsight in hemianopia. Proceedings of the National Academy of Sciences of the United States of America, 110(45), 18333–18338. https://doi.org/10.1073/pnas.1318395110

Neuralink's Blindsight

Bypassing the natural eye-to-brain pathway, Neuralink's Blindsight uses a video camera embedded in a pair of glasses to capture images of one's surroundings and wirelessly transmits them to the brain via their specialized implant, placed inside the visual cortex



NEURALINK

Our Goals

- Build a synthetic system that mimics early visual processing
- Replicate core computational logic of the visual cortex rather than using biological signals
- Transform camera-based sensory input into cortical-like neural activity
- Generate subjective "perceived" imagery based on modeled neural representations

The Model

MDPI2021 V1 Cortex Model

Layer 4 - 324 Spiny Stellate Cells (SS4)
with intrinsic excitability

Layers 2/3 - 324 Pyramidal cells

Layer 5 - 81 Pyramidal cells

Layer 6 - 243 Pyramidal cells

Inhibitory and excitatory neurons in each layer

Python Computational Model

Layer 4 – 144 Spiny Stellate Cells (SS4)
Simplified LIF neurons, no intrinsic excitability

Layers 2/3 – 144 Pyramidal cells
Reduced grid (12×12) for real-time speed

Layer 5 – 81 Pyramidal cells
Feedforward only (no lateral dynamics)

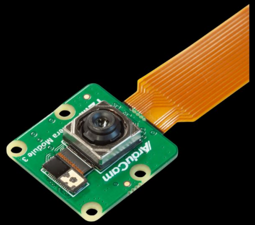
Layer 6 – 243 Pyramidal cells
No synaptic delays; simplified update rules

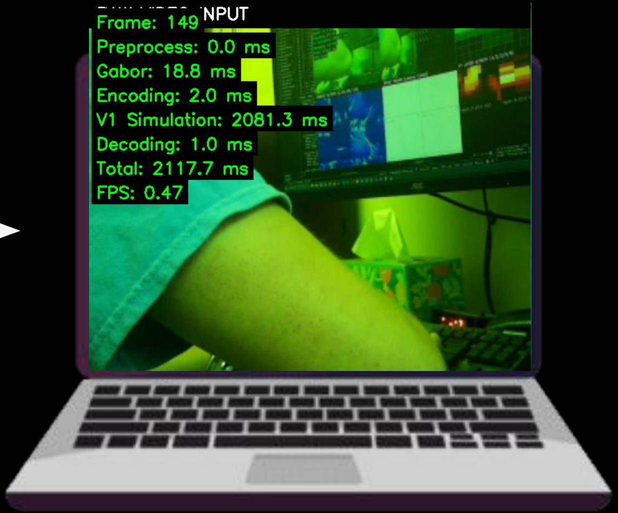
Inhibitory neurons present but disconnected
(no inhibitory or lateral pathways)

Methodology

Step 1: Setting Up Camera

Paired a Pi Zero 2 W with a 12-megapixel Arducam module to capture real-time visual scenes.



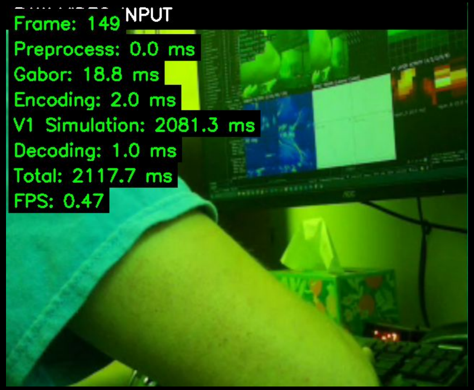


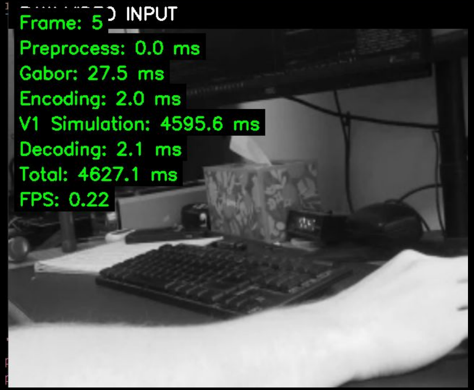
Step 2: Early Processing

Converted the Pi camera image to grayscale (V1 doesn't care about color)

Cut the image into an 12 × 12 grid = 144 pieces ***(input layer)***

- Each piece is one "receptive field" simulating a retinal ganglion cell/LGN neuron





This step replicates simple retinal processing before cortical input.

Step 3: Applying Gabor Filters

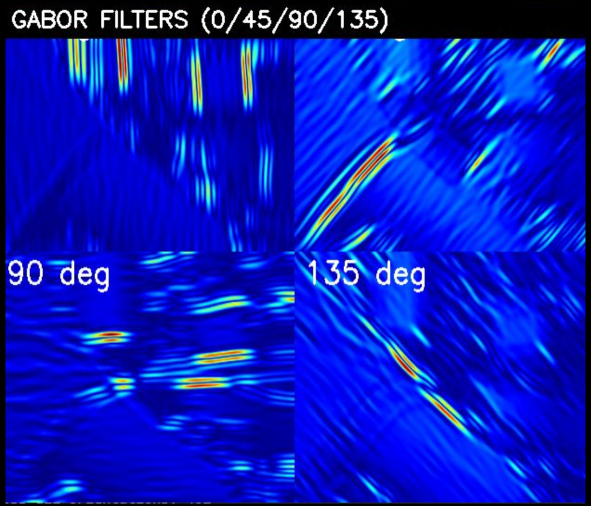
Gabor Filter: a linear filter used for edge detection

Applied 4 Gabor filters to each patch (1 for each orientation)

0°   45°   90°   135°

The output tells you:

- Is there an edge?
- Which direction is the edge pointing?
- How strong is it?



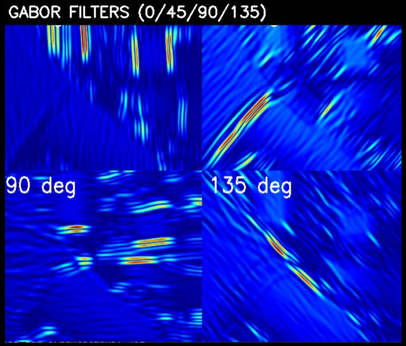
This step models V1 simple cells that detect oriented edges & how our brains decompose scenes into oriented components.

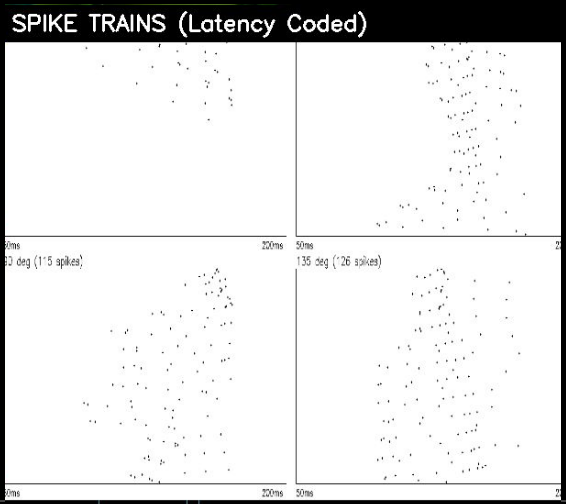
Step 4: Converting into Spikes

We need to feed our model **spike trains:** times when simulated neurons fire

Converted each patch's strongest response into spikes

- Brighter / stronger edges → earlier spikes
- Weaker edges → later spikes





This imitates how real V1 neurons encode stimulus strength through spike timing.

Step 5: Feeding into V1 Model

Model Inputs:

Spike trains

→

Model Outputs:

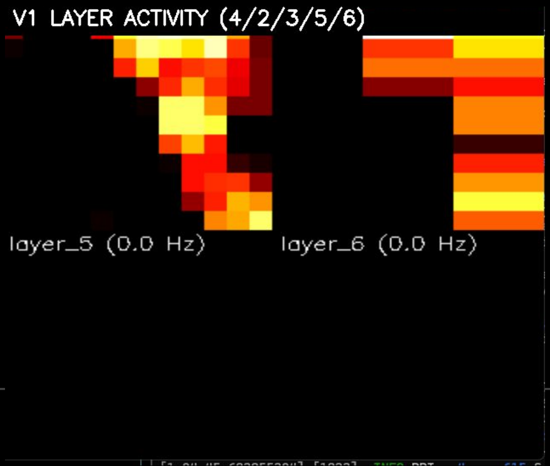
12 x 12 map of spiking activity where the intensity of firing tells you **which orientation is present and how strongly**

Step 6: V1 Simulation

The model includes multiple laminar layers of V1 simulating a real brain structure:

- Layer 4 → main thalamic input
- Layers 2/3 → feature integration
- Layer 5 & 6 → feedback and long-range projections

The heatmaps show **activity levels in each layer (spikes per region).**



Step 7: V1 Orientation Map

A map showing **which orientation each spatial patch of the V1 model prefers.**

- Each pixel represents a group of V1 neurons
- The colors indicate which orientation fired most strongly:
  - Red = 45°
  - Green = 90°
  - Cyan = 135°

Thank you!