Synaptic Dome Design

Physical structure:

From the ceiling of a 16’ dome, hangs network of neurons, that are best described, physically, as a series of nodes with connectors. The nodes are a cluster of LEDs that mimic the cell body (or *soma*) of a neuron, while the connectors are a string of LEDS that mimic the projecting limbs (*axons* and *dendrites*) of a neuron.

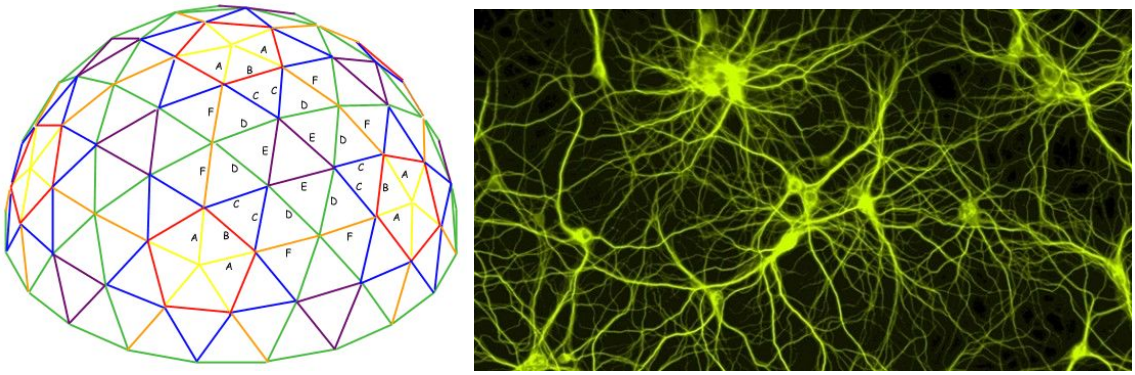

Figure 1 - (*Left*) Schematic of 4V type 16’ geodesic dome. (*Right*) A biological representation of Synaptic Dome neural network. Visually, our prototype closely resembles this network.

There are two different types of light assembly:

1. Nodes (soma)
2. Projections (axons/dendrites)

Exhibit output will resemble real life scenarios. Below are examples of calcium signaling in the following sensory modalities:

- Olfaction
- Vision
- audition

Building the network this way allows for a large display of things that look like neurons (allowing people to quickly interpret that we’re trying to model neural behavior), and a decrease in cost, as the number of neurons/lights will be low. Thus, we are looking to model basic, circuit-level dynamics or states (something more like this and less like IBM’s Blue Brain project, which attempts to model whole chunks of cortex in three dimensions). Here’s a schematic of a neural network. Multiple inputs converge on outputs sometimes! Sometimes they don’t.

The build is broken down into two parts:

1. *Hardware (Lighting System (includes embedded software to run the lights)* - designing physical networks, modeling, building and breakdown for travel/installation .
    a. All lighting is produced by individually addressable RGB LEDs (WS2812 chip).
    b. The entire setup, except the dome and computer, is housed in padded tour racks cases
    c. The somas are made from custom-designed plastic balls, of varying diameters (6”, 8”, 10”). 10-30 LEDs are housed per soma.
    d. Axons are made of single strings of LEDs, that are fed through clear, PVC tubing.
    e. The entire network is hung with airplane wire from the vertices of the dome. The network may also be hung from lighting scaffolding and other infrastructure.
    f. Entire exhibit weighs 150 lbs.
2. *Software (Neural Model)*- writing code for neurological phenomena, any platform, your code should produce an output for color matrix to a grid, (n x 3, where n is the number of points in the grid, and 3 designates rgb values). The grid will be exploded and sent among the nodes in the network.

Neural Phenomena (Software):
We’ve come up with the following neural phenomena to model.

1. Background
    a. Neurons produce (or fire) an electrical pulse called an action potential. This is how they communicate, mostly by triggering release of neurotransmitters. Sometimes we call electrical pulsation “firing,” “firing state,” or “firing rate” depending on dynamics.
    b. Neurotransmitters are chemicals that augment the behavior of a cell. Dopamine, serotonin, GABA and glutamate are the ones we’re going to focus on. GABA makes cells less likely to fire an action potential, while glutamatergic makes cells more likely to fire an action potential. Cells that produce GABA are called inhibitory. Cells that produce glutamate are called excitatory. Dopamine and serotonin neurons have more subtle, “modulatory” effects on downstream neurons: they will change the behavior of firing or sensitivity to other inputs rather than directly induce or block firing.
2. Cell firing
    a. General firing behaviors
        i. *Random firing using black out CCD gamma* - digital camera covered with opaque surface will detect background radiation, which is truly random. This can be considered a sort of background or baseline activity behavior for the exhibit.
        ii. *Pacemaker* - Audio input from outside source (such as DJ deck), brightness of neurons matches beats from music. This can be considered a basic activity behavior when there is music playing.
        iii. *Neuroplasticity* - A series of buttons are placed around the dome, without labels. Visitors can look for these buttons or happen upon them. When

pressed, cells/regions will activate. The dynamics will change day to day plasticity (different behaviors or “learning”), and with repeated button-presses (adaptation).

3. Transmitter release
    a. Probably ~4 cell types
        i. excitatory (glutamatergic) - encouraging other neurons in circuit to fire
        ii. inhibitory (GABAergic) - encouraging other neurons to not fire,
        iii. dopaminergic / modulatory - generally stimulating an upstate (increased firing rates)
        iv. serotonergic / modulatory - generally stimulating dopaminergic cells, while otherwise stimulating a downstate (decreased firing rates, increased synchrony)
    b. These different cell types would probably be indicated by different colors
    c. Different transmitters would alter firing patterns of downstream cells in a manner appropriate to the transmitter
    d. Show firing via cascading increase in brightness along axons (connectors)
    e. For other neuroscientists, I think we will just ignore the existence of different receptor types

4. Drug effects
   The Synaptic Dome stands to educate about drug interactions in the brain, both positive (therapeutic) and negative (chemical dependence).
    a. Drugs we’d like to model:
        i. Stimulant (coffee, cocaine)
        ii. Depressant (alcohol, sleep aids)
    b. Users can "Inject" drugs in the system. Activation of drugs would change firing in a manner commensurate with the drug in question.
       Explicitly:
        i. Stimulants would increase the effects of dopamine neuron activation (while decreasing activation of dopamine neurons)
        ii. Depressants would increase the effect of inhibitory (GABA) neuron activation
    c. Neurotransmitter activity will not be represented, however the activity of excitatory, inhibitory, dopaminergic cells can be depicted through color (e.g., red = excitatory, blue = inhibitory, yellow = serotonergic, pink = dopaminergic). Color considerations should be colorblind-friendly.

FUTURE DEVELOPMENTS

5. Neurotransmitter knob panel
    a. Visitors can augment glutamate, GABA, dopamine, serotonin using an interactive knob panel placed somewhere in the dome

i. For example, cranking down GABA or increasing glutamate would induce a seizure.