



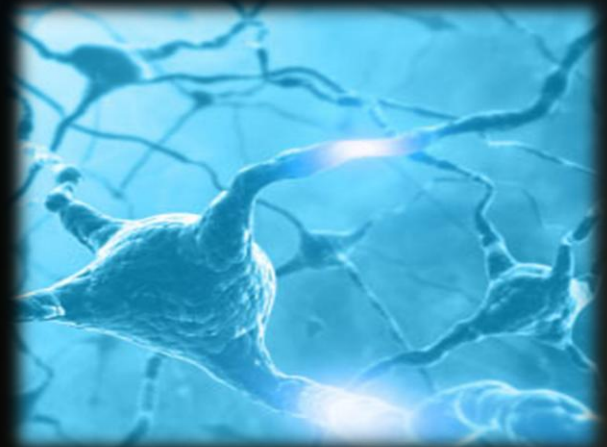
Cerebellum Simulation Demo

Maxeler App

Smaragdos Georgios
Erasmus Medical Center

Brain Simulation

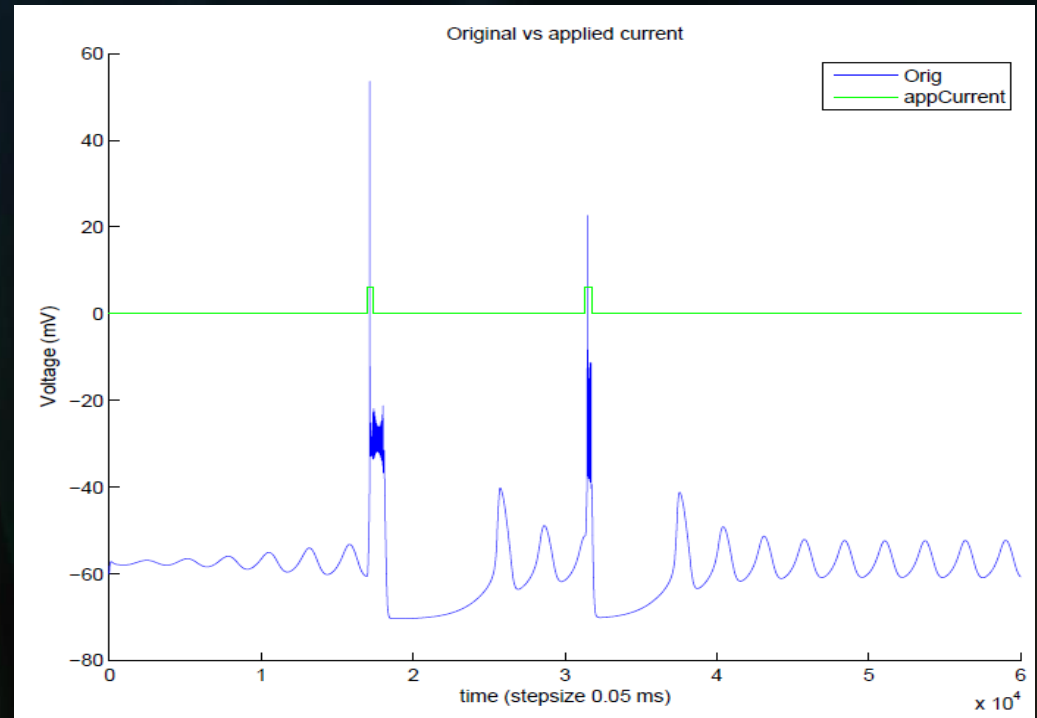
1. Acceleration of brain research
2. Brain-rescue devices
 - Robotic prosthetics
 - Implantable systems
3. Advance of A.I. applications
 - Use of biologically accurate neuron models
4. New computer-architecture paradigms



Levels of Neural Modeling

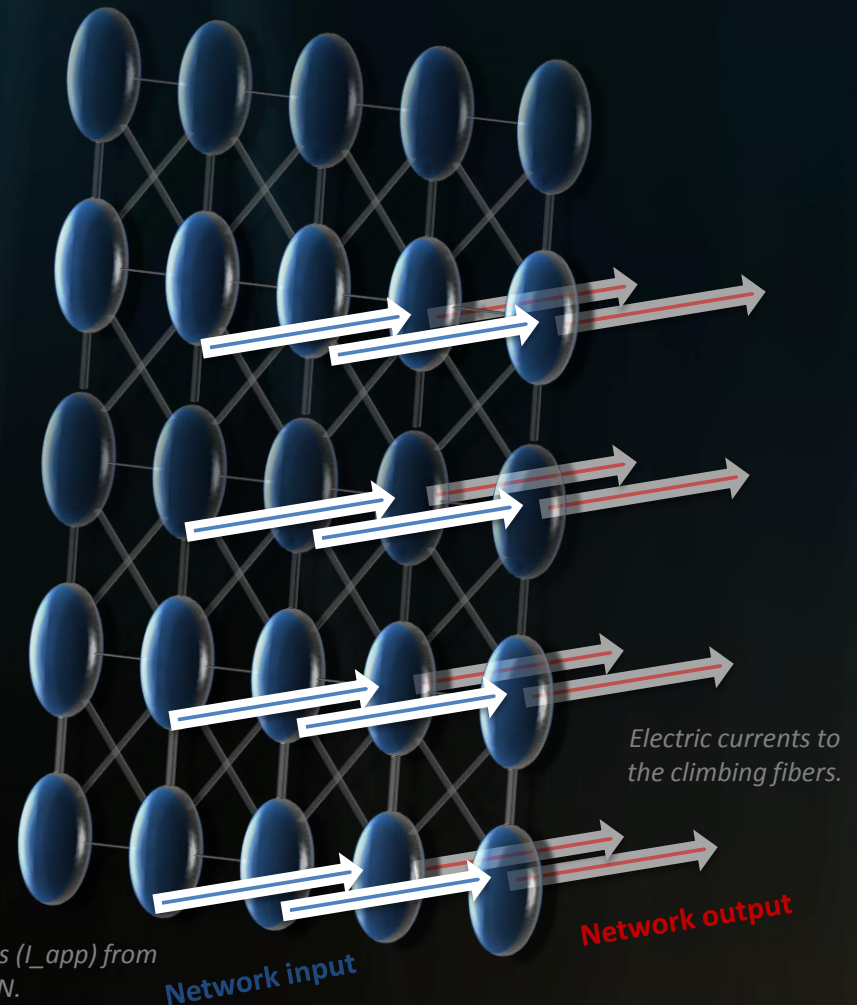
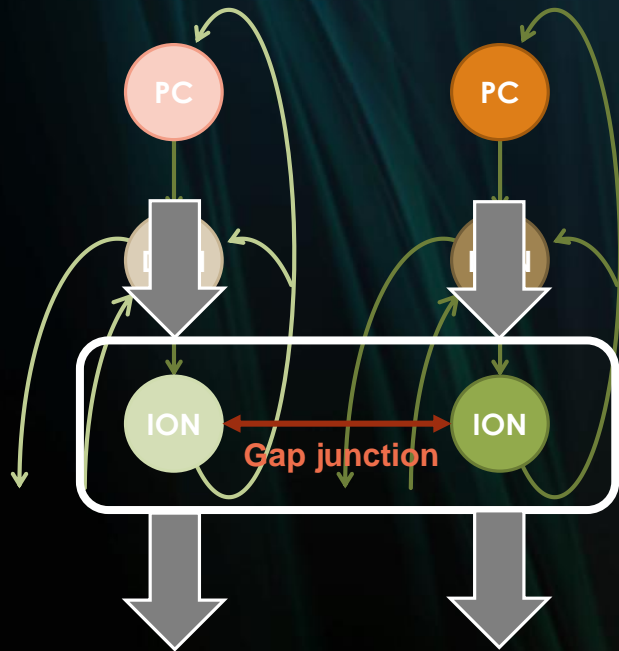
- Different levels of detail. e.g.:
 - Integrate and Fire (I&F): Simple input-integrator modeling. resulting in a fire or non-fire state
 - Izhikevich (Izh): More advanced than I&F; can emulate most biological I/O patterns of biological spiking activity
 - Conductance: Accurate modeling of the internal electrochemical processes of the neuron; can be biophysically-meaningful. e.g. Hodgkin-Huxley (HH)

- Sample of a spike approximated by a HH model



Case study: The Inferior Olive

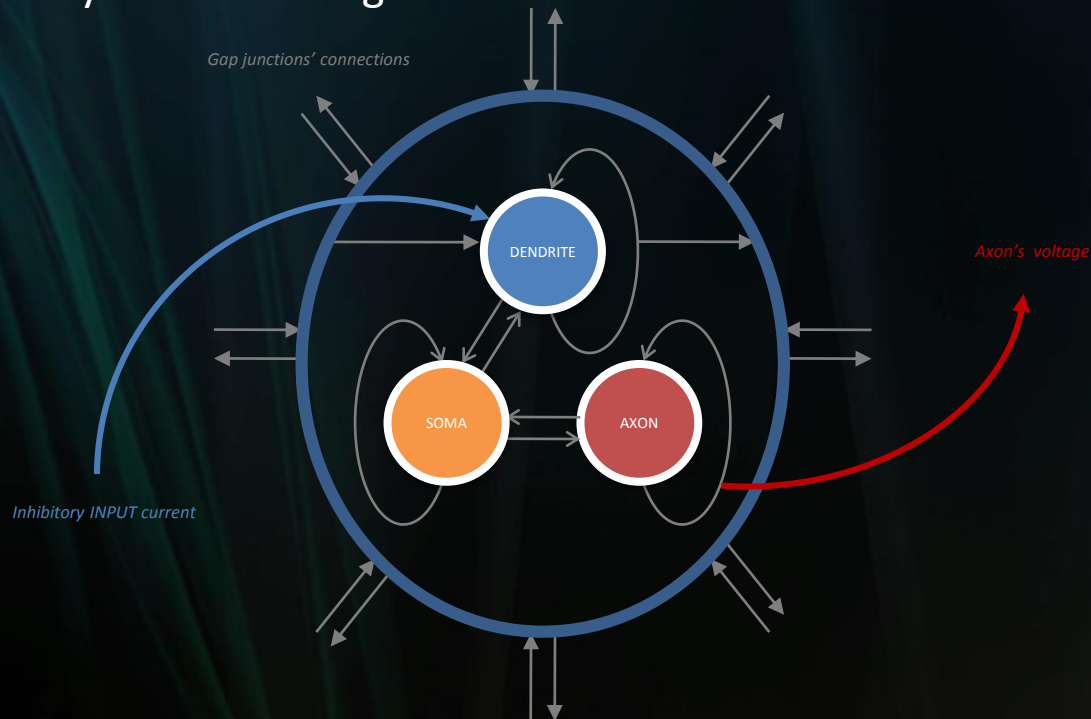
- Inferior-Olive model (eHH) [by Jornt de Gruijl]
 - Detailed and very costly
 - Challenging interactions



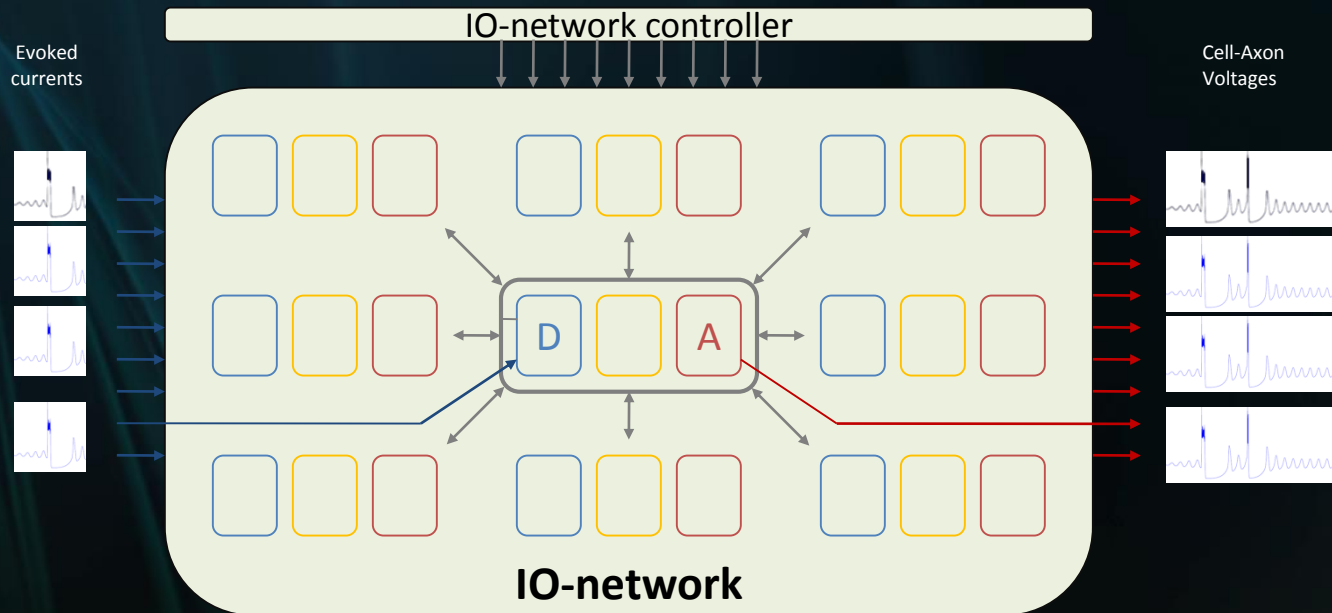
The Inferior Olive Model

Compartmental model of the **Inferior Olive (IO) Network** based on Hodgkin-Huxley ion channels.

- Inputs: Array of applied electric currents.
- Outputs: Array of axon voltages.



IO-Network Model



- Initial interconnectivity scheme – Immediate neighbors
- Larger requirement for experiments –100% interconnectivity on this Demo

Dendrite components

DENDRITE

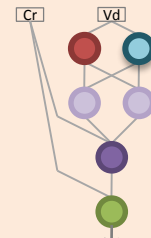
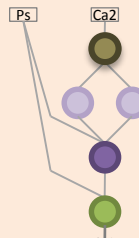
Read cell state: 6 scalars

H current

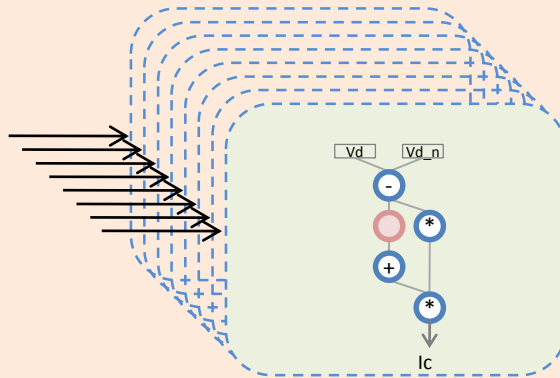
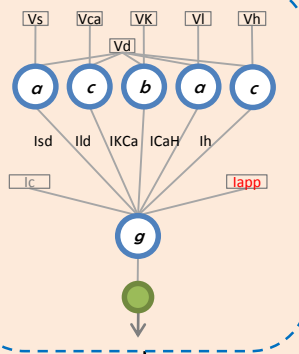
K current

Ca current

Calcium



Dendritic currents and voltage



Gap-junctions with 8 neighbor cells

$$\sum_{i=1}^8 I_c$$

Store cell state: 6 scalars

$$a.) a \cdot (x - y)$$

$$b.) a \cdot x \cdot (y - z)$$

$$c.) a \cdot x^2 \cdot (y - z)$$

$$g.) (t + u + v + w + x + y + z) / a$$

cmp & sel

$$\frac{a \cdot (x + b)}{e^{(ax+b)/c} - 1}$$

$$\frac{x}{y + z}$$

$$\frac{1}{e^{ax+b} + e^{cx+d}}$$

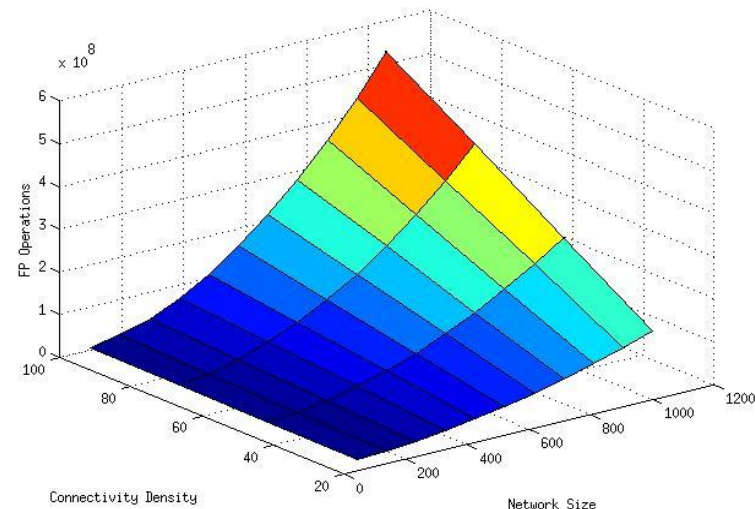
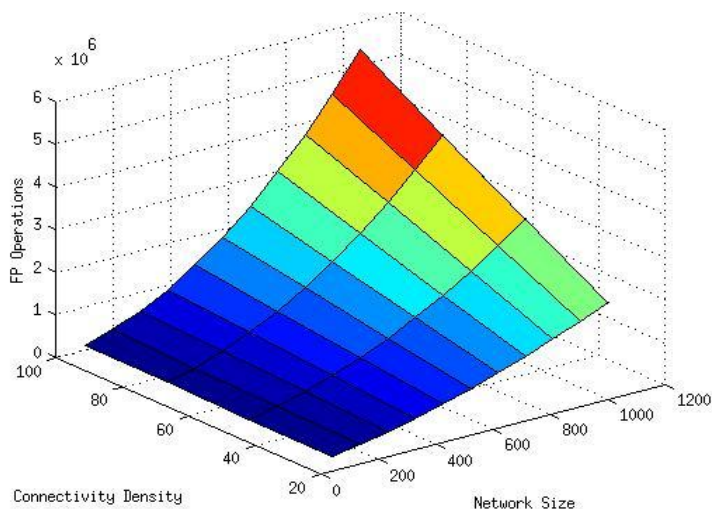
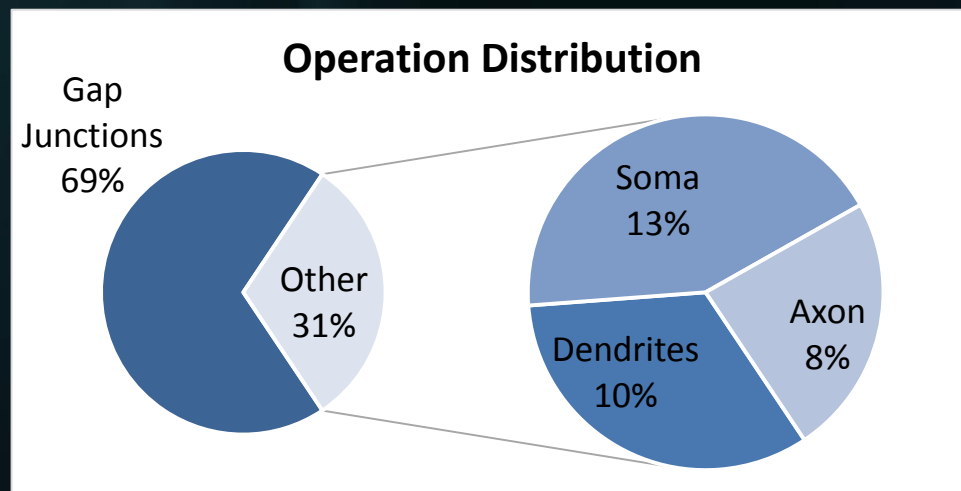
$$\frac{1}{1 + e^{(ax+b)/c}}$$

$$\frac{x - y}{z}$$

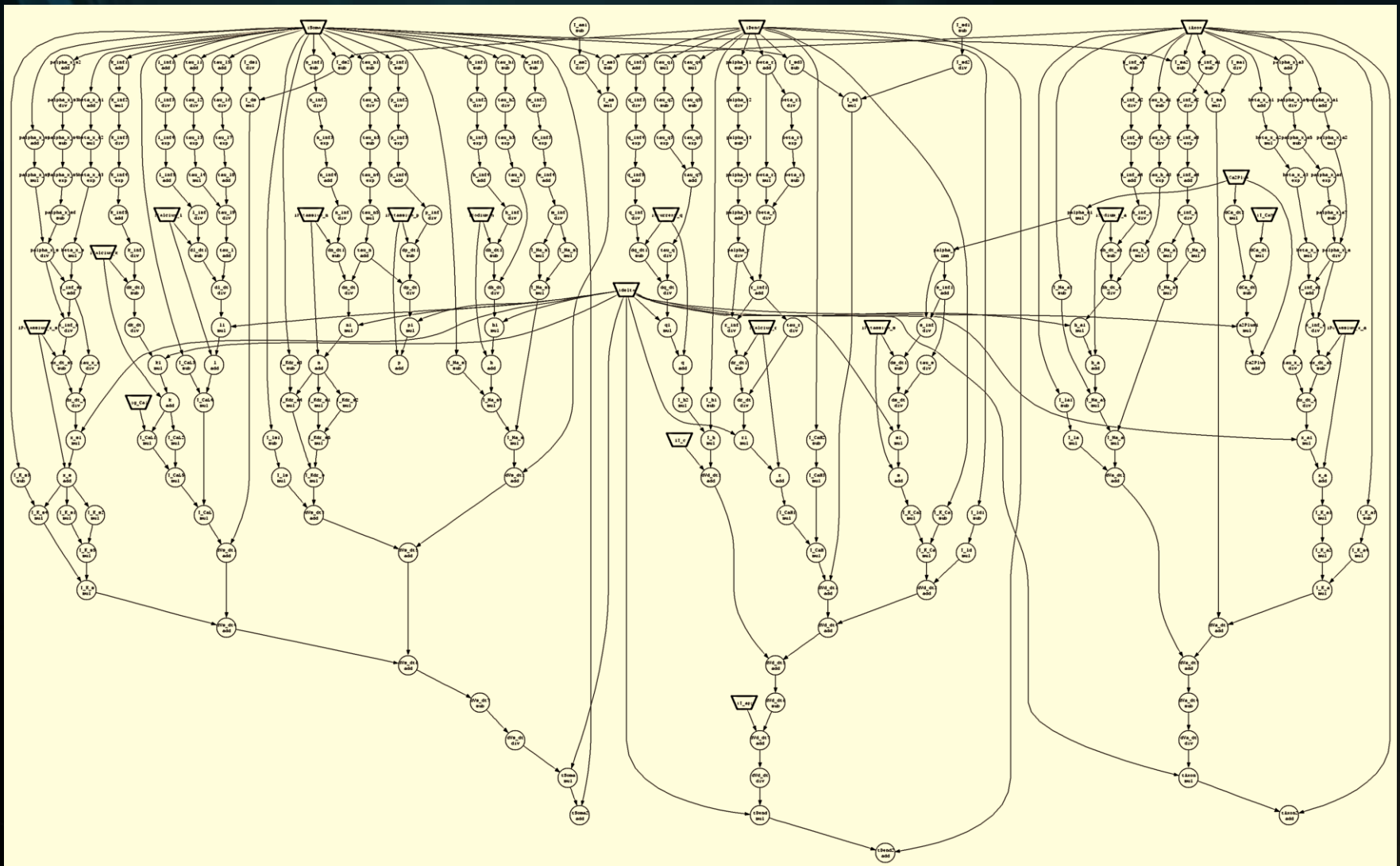
$$a \cdot x + b \cdot y$$

Application Characterization (II)

- All-to-all interconnected network:
Quadratic increase of GJ operations
- E.g. 96-cell network:
70% of total operations



Naïve IO-network (C)DFG



Inferior olive simulations

