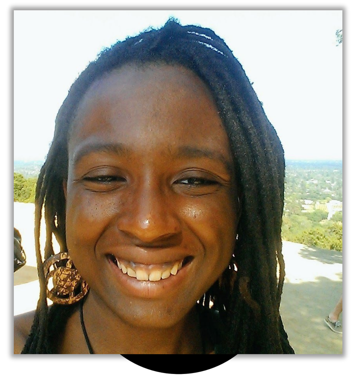
# Can single neurons solve MNIST?: The computational power of biological dendritic trees

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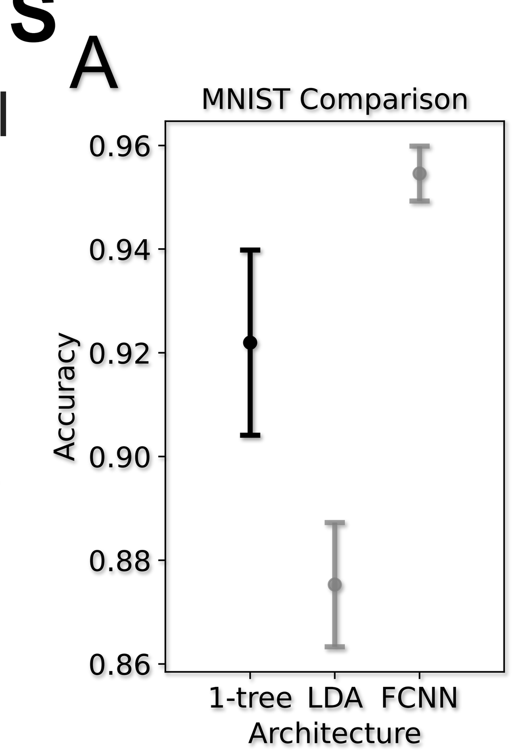
## BACKGROUND

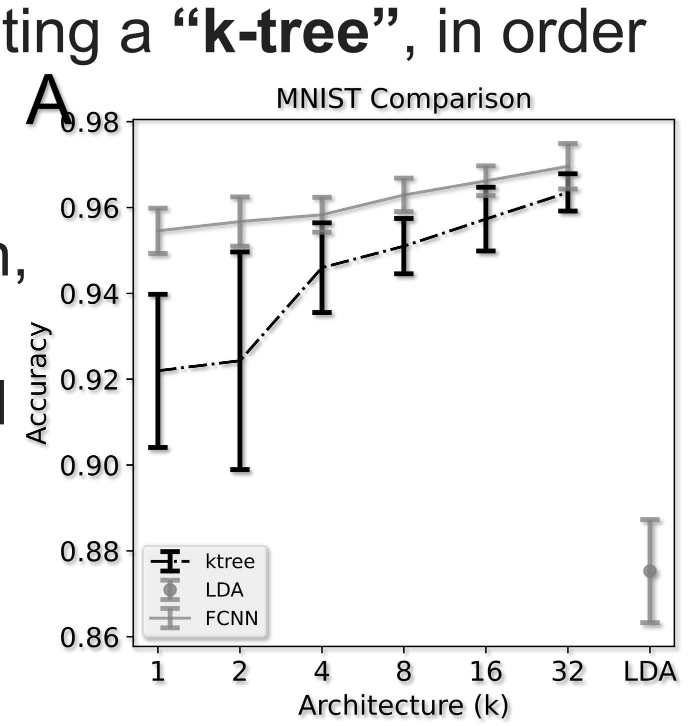
A classic line of inquiry of neuroscience is **“What are neurons computationally capable of?”.** Simplified models of neurons have been used to investigate this question, leaving out the potential for dendritic intricacies, nonlinearities, and synaptic repetitions to impact conclusions. This work uses a novel, computational-task-based method for determining the computational capability of **a dendrite-complete neuron model** by taking advantage of deep learning techniques.

## METHODS & RESULTS

We modified a deep artificial neural network, to have **dendritic sparsity constraints**, creating a **“1-tree”**, to see the impact of this biological property on computation:



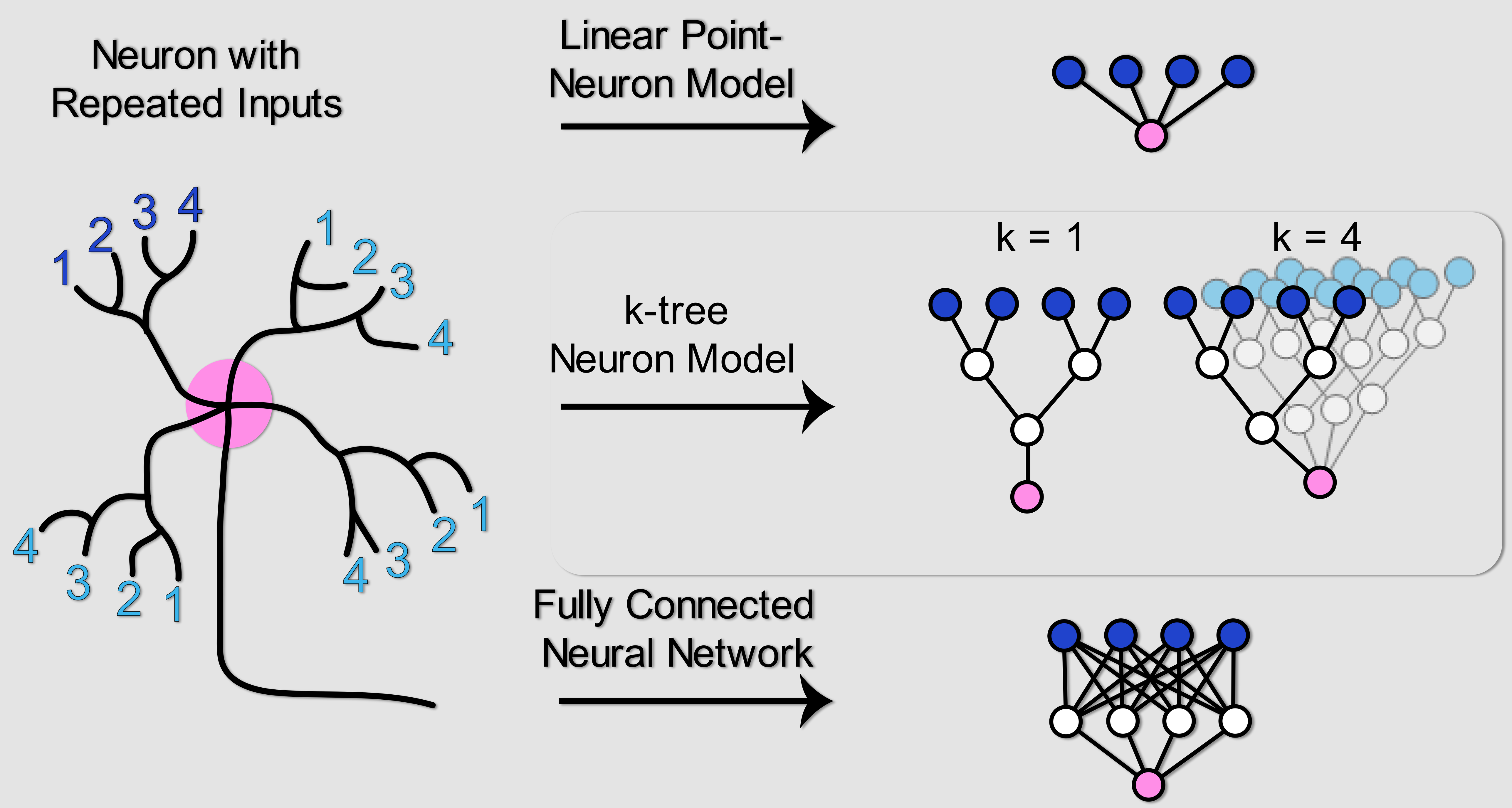

We then **repeated the inputs** to deep network, creating a **“k-tree”**, in order to see the impact of repeated synaptic inputs on computation, comparing that to a fully connected neural network:



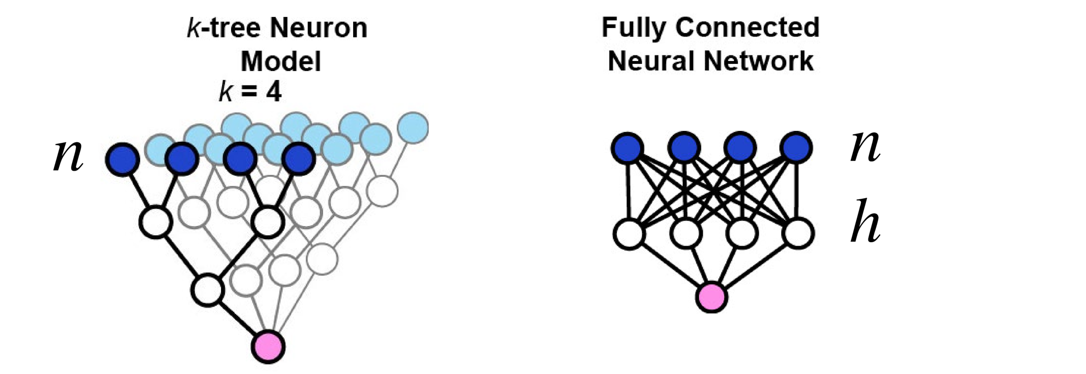

**Dendritic tree morphology** constraints could **limit** neuronal computational power,

*but*

**repeated inputs** to dendrites could **expand** neuronal computational power




### Parameter size matching k-tree and FCNN



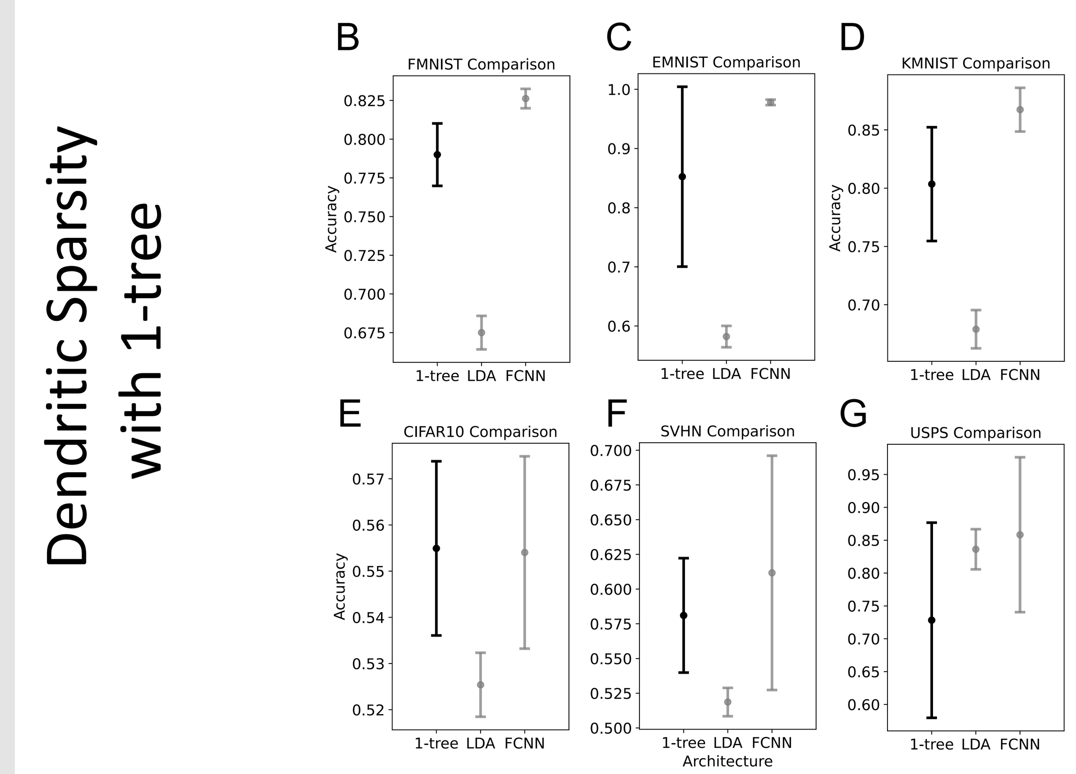

Parameter #: $2k(n-1)$ $h(n+1)$ $h = 2k$

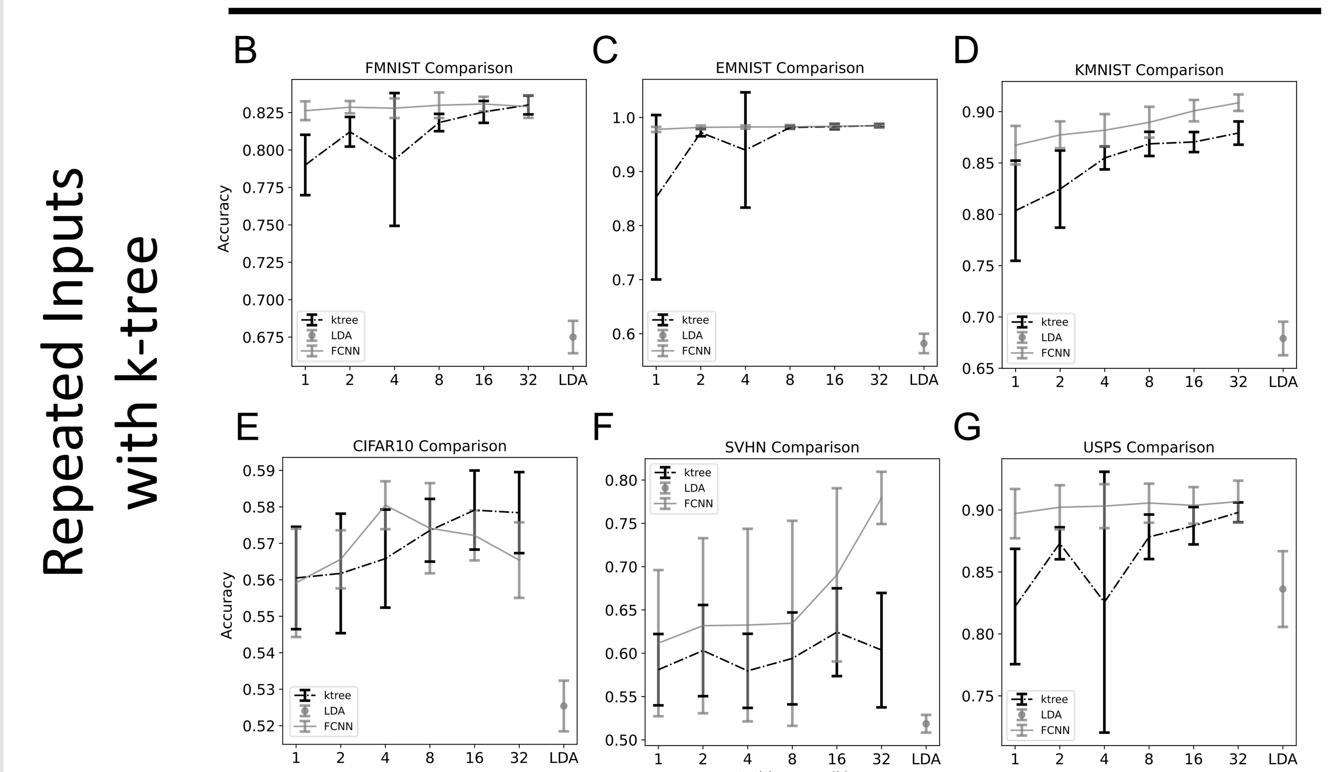
### Task-Based Modeling using Image Datasets

Binary Classification across tasks

| Dataset | Classes | Examples | 1-D Input Size |
|---|---|---|---|
| MNIST | 3, 5 | | 32x32 = 1024 |
| Fashion-MNIST (FMNIST) | 0, 6 | | 32x32 = 1024 |
| EMNIST | 14, 17 | | 32x32 = 1024 |
| Kuzushiji-MNIST (KMNIST) | 2, 6 | | 32x32 = 1024 |
| CIFAR-10 | 3, 5 | | 3x32x32 = 3072 |
| Street View House Numbers (SVHN) | 5, 6 | | 3x32x32 = 3072 |
| USPS | 3, 5 | | 16x16 =256 |

### Testing neuron model using multiple datasets





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