BindsNET: An ML-oriented spiking networks library built with PyTorch

https://github.com/Hananel-Hazan/bindsnet

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What is BindsNET?

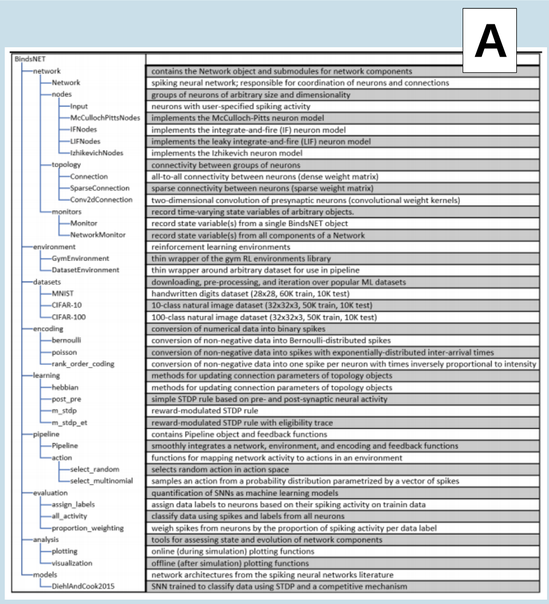
- Clock-driven *spiking neural networks* (SNN) simulation
- Oriented towards ML + RL
- User-friendly syntax + fast prototyping
- *Functional* (rather than *exact*) dynamics
- Run on CPUs, GPUs, or both
- Inherits performance + functionality of PyTorch

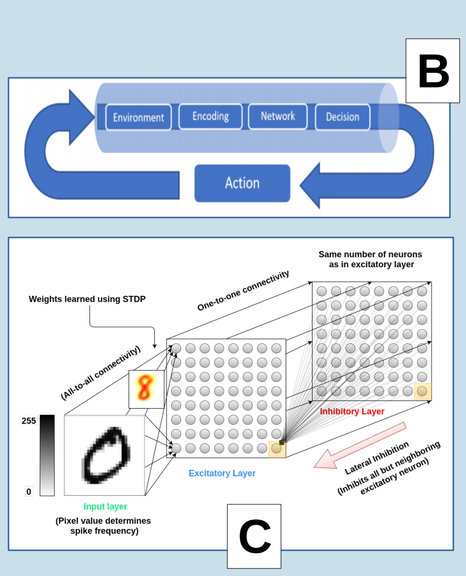
How is PyTorch used?

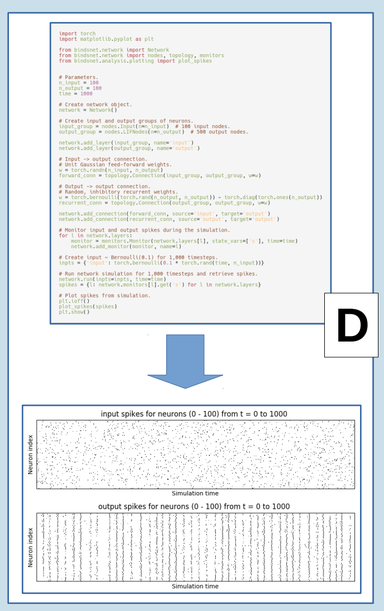
- **torch.Tensor** object: Linear algebra + tensor ops
- **torch.nn** module: Advanced network operations
- **torch.distributions** module: Generating spike data
- **torch.save, load**: Save / load params to / from disk
- **torchvision.datasets**: Planned integration!

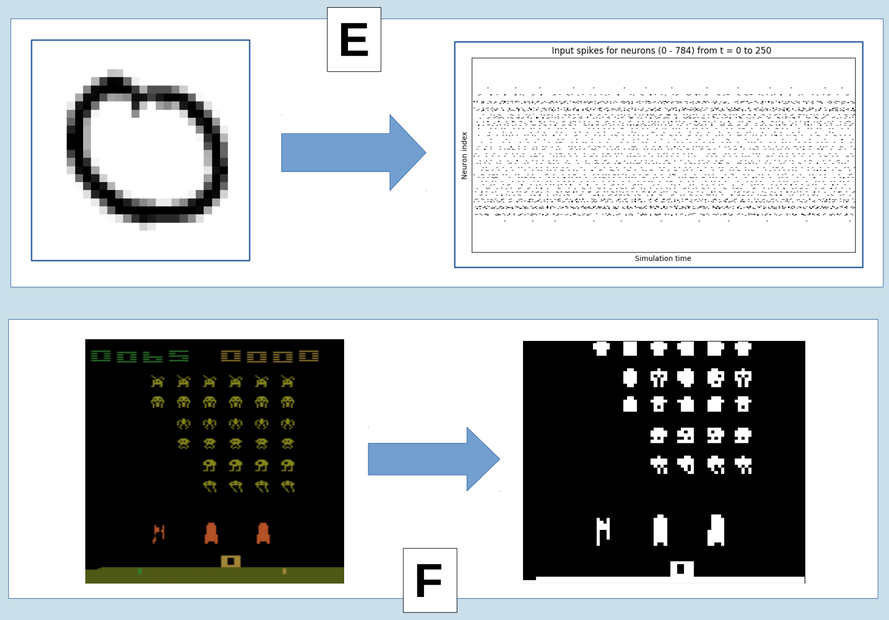
What's in the library?

- **Network**: Coordinates simulation of network components
- **Nodes / Connections**: Groups of neurons and connections between them
- **Learning rules**: Hebbian learning, STDP, reward-modulated STDP, back-prop (?)
- **Datasets**: Popular machine learning datasets
- **Encoding**: Converts real-valued data into spikes
- **OpenAI gym integration**: Converts gym environment outputs into spiking inputs
- **Pipeline**: Coordinates a network, dataset / environment, encoding, and action function
- **Plotting**: Interactive plots of state variables during network simulation
- **Models**: Experimental SNN architectures









A: BindsNET package structure; **B**: Schematic of Pipeline object; **C**: Example SNN architecture; **D**: Example network building + simulation script + spike outputs; **E**: Poisson encoding of MNIST digit for 250 timesteps; **F**: Pre-processed version of OpenAI gym's Space Invaders environment.

Why spiking neurons?

- More *biologically plausible* than ANN neurons
- Useful for modeling neuronal circuits + brains
- Speedup + power reduction on dedicated hardware
- Communicates with all-or-nothing *spikes*
- Naturally incorporates time by integrating input

ML + RL approach

- **Unsupervised**: Hebbian / associational rules
- **Supervised**: Force class-specific neurons to spike
- **RL**: Reward signal modulates learning rules
- *Competitive* inhibitory connections
- *Cooperative* excitatory connections

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