CCR
Center for Computing Research

Lessons (I) Learned at NICE'16

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From my opening presentation …

- **We need better theoretical models of neural-inspired computing approaches**
  - Which neural-inspired concepts are most important and why?
    - Spike trains? Asynchrony? Co-local computing and memory? Connectivity? Approximate computing?

Key Question: What is Intrinsic and What is an Evolutionary Biproduct?

- **Neural systems were honed by evolution working in a highly constrained physio/biochemical space**

- **Of the many properties of neural systems, which (few?) are pivotal to computational power and which (many) are just artifacts of the way they evolved?**
  - Spiking?
  - Connectivity?
  - Heterogeneity?
  - Co-mingled computing and memory?

Lesson 1: We Really Do Need Better Theoretical Models

- **We need the counterpart of a Turing Machine for neural computation**
  - Would clarify the essential strengths of neural computing
  - Would enable more formal algorithmic thinking
  - Would support hardware design and programming methodologies

- **But is this even possible?**
  - Perhaps a reductionist approach won't work
  - Maybe the power is an emergent property of a complex, stochastic dynamical system

Lesson 2: Spiking is Essential, or Maybe Not

- **Spiking seems to provide a "sparse coding in time"**
  - Very useful for energy efficiency
  - (Is this mathematically related to compressive sensing?)

- **But some models don't rely on spiking and seem to work just fine.**

- **Is spiking central or an artifact?**
  - Great for fast sensing and cognition evolved from technology created for sensing

Lesson 3: Brains Suggest Ideas for Energy Efficiency

- **Low precision is acceptable for many tasks**
  - Computers disproportionately used for tasks that *require* high precision
  - Could perhaps enhance with iterative refinement
- **Slow clocks are OK**
- **Analog hardware may be sufficient**
- **Spiking communication reduces data volume**
- **Processing-in-memory saves communication cost**

Lesson 4: Theory, Experiment, and Engineering are All Needed

- **Experimental neuroscience is continuing to reveal features and capabilities of brains**
- **Theories attempt to synthesize these observations**
- **Engineered systems allow us to explore, validate or disprove theoretical concepts.**
  - Powerful new tools for improving our understanding
  - Force us to make hard choices about what to include and what to leave out
  - Commercial potential drives interest in fundamental neuroscience