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Opportunities for Neural-Inspired Ideas in High Performance Computing

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We Live in Exciting Times

- **The BRAIN Initiative**
  - Improve understanding of neural processes and capabilities
- **The National Strategic Computing Initiative**
  - Multi-agency commitment to advanced computing
  - Includes research in non-traditional computing approaches
- **The DOE-led Exascale Initiative**
  - By mid-2020's deploy systems exhibiting 10^{18} ops/second

Exascale Challenges

- **From "Top 10 Exascale Research Challenges"**
  - **Power**
  - Resilience
  - Complex memory hierarchies
  - High performance networking

- **CMOS / von Neumann systems look to be unlikely to get us beyond a few exa-ops**

- **Can insights from neural systems provide ideas to address some of these challenges?**

Possible Concepts

- **Algorithms inspired by neural systems could**
  - Manage memory hierarchies
  - Monitor machine state to enhance resilience
  - Find features in large computational data sets

- **Perhaps as a co-processor, hardware inspired by neural systems could**
  - Provide very low power computing model
  - Enable very fast, efficient matrix-vector multiplication
  - Support very fast, efficient sorting
  - Maybe enable efficient solutions to integral equations

Next Steps

- **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?

- **We need neuroscientists working with computer architects and algorithm designers**
  - Challenging cultural issues
    - Communities have different vocabularies, scientific objectives, frames of reference