COGITOR: Colloidal Cybernetic Systems for Next-Generation Soft Robotics and Computing

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Aim

The COgITOR project aims to develop a novel liquid-state cybernetic system capable of sensing, computing, data storage, and energy harvesting. By leveraging colloidal (liquid-based) materials, the project seeks to create self-healing, adaptable, and fault-tolerant computing and sensing systems that operate efficiently in extreme environments.

Method

The research integrates multiple disciplines, including nanomaterials science, unconventional computing, electronics, and soft robotics. The project investigates the memory and computing properties of functionalized colloids, designs custom integrated circuits for state measurement, and develops self-healing polymer skins for system protection. Advanced techniques such as reservoir computing, memristor-based neuromorphic computing, and thermomagnetic energy harvesting are explored to enhance the capabilities of these liquid-state cybernetic systems.

Results

Significant breakthroughs have been achieved so far, including:

- **Memory and Computation**: Demonstration of in-memory computing in colloidal systems, achieving liquid analogue memory equivalent to 6 bits.
- **Neuromorphic Computing**: Implementation of memristor-like behavior in colloidal devices, enabling basic learning and logic operations.
- **Self-Healing Skins**: Development of smart materials capable of thermally activated healing, extending system durability.
- **Energy Harvesting**: Integration of photothermal and thermomagnetic energy conversion to power autonomous liquid systems.
- **Sensor Development**: Creation of liquid-state sensors and switches, supporting multi-functional cybernetic applications.

Conclusion

The COgITOR project has successfully demonstrated so far that colloidal systems can serve as the foundation for future cybernetic platforms, offering self-adaptive, resilient, and computationally efficient solutions. These findings pave the way for next-generation soft robotics, bio-inspired computing, and advanced sensing technologies, with potential applications in extreme environments, medical devices, and autonomous systems. Future research activities will focus on refining these technologies for broader practical deployment.