

PREFACE

Gagarin Readings — Unconventional Computing, Space Exploration and Origin of Life

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In Spring 2024, to celebrate the science and technology of space exploration, I organised a small but influential workshop "Gagarin Readings: Unconventional Computing, Space Exploration, and the Origin of Life" in Bristol. The workshop took place on April 11-12, 2024, in honor of the first-ever human spaceflight by Russian and Soviet cosmonaut Yuri Gagarin. Papers selected from the workshop presentations comprise the current special issue of the journal. Eminent researchers from the UK, Israel, Italy, Poland, Serbia, Canada, Japan, Russia, and Catalonia provide illustrative reports on their groundbreaking developments in chemical, biological, and astronomical computing.

This special issue presents a diverse collection of ten papers exploring innovative approaches in bio-inspired computing, materials science, and unconventional electronics. The first paper shows how to sense and compute using materials that are readily available in everyday life. This paper explores the potential of using commonly available biomaterials for low-energy, easy-to-use electronic devices and sensors, focusing on applications in healthcare, energy, and security. It includes a literature review of current biomaterial-based devices and presents a case study of a CdS-MWCNT system for detecting alkali metal cations in aqueous solutions. The second paper explores the complex relationship between cellular structure and function, focusing on the poorly understood electrical and electromagnetic interactions within and between cells. It discusses the potential to develop an integrated bioelectric

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model of cells, which could lead to advancements in hybrid technologies, novel bioelectric devices, and applications in nanotechnology and therapeutic modalities. The third study examines three key properties of neuromorphic systems: the beneficial role of noise in improving classification and forecasting, the importance of element cross-talk for bio-realistic learning and cognitive processes, and the critical need for energy efficiency. It emphasises the necessity of new hardware approaches to address these challenges effectively. Next paper explores the electrodynamic properties of dendrites, focusing on the cytoskeleton's role in neural computation. It proposes a model in which microtubules, actin filaments, and their interactions with ion channels and dendritic spines actively contribute to unconventional computing processes within neurons. The fifth paper presents chemically inspired cellular automata, demonstrating how noise can enhance computational power and break traditional efficiency trade-offs. Another intriguing work introduces a new computing model, "N-systems," based on molecular agents navigating a digraph to solve NP-complete problems, highlighting the potential of massively parallel processing in unconventional computing is presented in the sixth paper. The comparison between biological systems and digital AI is addressed in a subsequent paper, illustrating how life forms naturally optimise energy consumption, while modern AI systems fall short in this regard. The special issue is completed with three papers. One paper reports research on the integration of electrical signalling between mycelium and proteinoids in early Earth conditions offers insights into protocognition. Second paper explores the unique potential of kombucha mats as responsive materials and showcasing the promising future of fungi and kombucha mats as novel, sustainable platforms for intelligent biological systems and advanced materials for soft robotics and biosensors. This follows by the paper investigating the complexity and nonlinearity of several colloidal suspensions — when electrically stimulated with fractal, chaotic, and random binary signals. By analysing the responses using entropy, file compression, fractal dimension, and Fisher information measures, the study identifies TiO_2 as the most complex colloid and highlights the potential of these materials for reservoir computing due to their nonlinear behaviour, the work offers a rapid method for evaluating the suitability of colloids as computational substrates. The last and may be the most provocative paper explores the potential of liquid cybernetic systems in future space exploration, emphasising the advantages of liquid-based spacecraft over conventional designs. It discusses hypothetical missions involving these innovative systems, highlighting how they could improve the autonomous exploration of distant worlds.