Unleashing the Power of Cerebrospinal System for a Better Computer Architecture

Authors : Lakshmi N. Reddi, Akanksha Varma Sagi

Abstract : Studies on biomimetics are largely developed, deriving inspiration from natural processes in our objective world to develop novel technologies. Recent studies are diverse in nature, making their categorization quite challenging. Based on an exhaustive survey, we developed categorizations based on either the essential elements of nature - air, water, land, fire, and space, or on form/shape, functionality, and process. Such diverse studies as aircraft wings inspired by bird wings, a self-cleaning coating inspired by a lotus petal, wetsuits inspired by beaver fur, and search algorithms inspired by arboreal ant path networks lend themselves to these categorizations. Our categorizations of biomimetic studies allowed us to define a different dimension of biomimetics. This new dimension is not restricted to inspiration from the objective world. It is based on the premise that the biological processes observed in the objective world find their reflections in our human bodies in a variety of ways. For example, the lungs provide the most efficient example for liquid-gas phase exchange, the heart exemplifies a very efficient pumping and circulatory system, and the kidneys epitomize the most effective cleaning system. The main focus of this paper is to bring out the magnificence of the cerebro-spinal system (CSS) insofar as it relates to our current computer architecture. In particular, the paper uses four key measures to analyze the differences between CSS and human- engineered computational systems. These are adaptability, sustainability, energy efficiency, and resilience. We found that the cerebrospinal system reveals some important challenges in the development and evolution of our current computer architectures. In particular, the myriad ways in which the CSS is integrated with other systems/processes (circulatory, respiration, etc) offer useful insights on how the human-engineered computational systems could be made more sustainable, energy-efficient, resilient, and adaptable. In our paper, we highlight the energy consumption differences between CSS and our current computational designs. Apart from the obvious differences in materials used between the two, the systemic nature of how CSS functions provides clues to enhance life-cycles of our current computational systems. The rapid formation and changes in the physiology of dendritic spines and their synaptic plasticity causing memory changes (ex., long-term potentiation and long-term depression) allowed us to formulate differences in the adaptability and resilience of CSS. In addition, the CSS is sustained by integrative functions of various organs, and its robustness comes from its interdependence with the circulatory system. The paper documents and analyzes quantifiable differences between the two in terms of the four measures. Our analyses point out the possibilities in the development of computational systems that are more adaptable, sustainable, energy efficient, and resilient. It concludes with the potential approaches for technological advancement through creation of more interconnected and interdependent systems to replicate the effective operation of cerebro-spinal system.

Keywords : cerebrospinal system, computer architecture, adaptability, sustainability, resilience, energy efficiency
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