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Space Resources, the Enabler of the Earth-Moon Econosphere (5)

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NEURAL COMPUTATIONAL ARCHITECTURE FROM IN-SITU RESOURCES FOR PLANETARY EXPLORATION

Abstract

We explore the prospect for leveraging active electronic circuitry from lunar resources. We find that solid-state transistor-based electronics cannot be feasibly manufactured in-situ rendering the prospect for in-situ maintenance and repair of avionics implausible for lunar assets. This represents a significant deficiency for in-situ self-sufficiency. However, there is a solution – the adoption of vacuum tube-based active electronics configured as neural network circuitry. Vacuum tubes are simple in construction using only a small number of materials, all of which can be sourced on the Moon. The bulkiness of vacuum tubes obviates the use of the central processing unit (CPU) for implementing sophisticated logic gate circuitry with software programmability. Analogue neural network circuits offer a different approach whose physical footprint is only logarithmically dependent on its functional complexity. Recurrent neural networks are Turing-complete and so capable of universal computing. Indeed, recent developments in Artificial Intelligence suggest an evolution of terrestrial computing towards special neural network hardware. We show that a wide range of algorithms can be implemented on analogue neural networks emphasising algorithms required to implement advanced robotics, especially bio-inspired approaches. We explore the Nakamura-Yamashita analogue neuron circuit and show that two cross-strapped neurons can implement obstacle avoidance behaviours in rovers. We explore the use of ratSLAM for rover navigation and neural fields for path planning that are uniquely suited to neural network implementation. We examine neural network algorithms for complex manipulator controllers. We also explore the problem of implementing learning algorithms in hardware circuitry. Our preliminary back propagation circuits suggest the plausibility of online learning circuitry though this increases circuit complexity considerably. Backpropagation is a simplification of the Kalman filter algorithm that has broad applications in optimal state estimation under stochastic conditions. It appears that neural network hardware is a plausible approach to indigenous electronics manufactured in-situ from lunar resources.