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FORWARD- AND BACK-PROPAGATION WITH AN ANALOG NEURAL NETWORK

Abstract

Establishing our presence on the moon, such as initially through a lunar village, will require timely access to locally manufactured parts and equipment. In-Situ Resource Utilization (ISRU), coupled with 3-D printers and the concept of a self-replicating machine can reduce the costs incurred compared to when material is transported from Earth. Autonomous rovers deployed for mining resources are an example of complex, intelligent structures that can be 3-D printed on the moon. These rovers should be equipped with advanced navigation capabilities, with obstacle avoidance representing a fundamental and indispensable functionality. Navigation demands employing control circuitry, but manufacturing semiconductor circuits on the lunar surface is not viable due to the need for approximately 30 physical and chemical processes and up to a thousand chemicals for an electronic product, which cannot be replicated or are not available on the moon. ISRU lends itself to extracting lunar materials for building simple 3-D printed electronic components like vacuum tubes, resistors, and capacitors. Vacuum tubes are a possible alternative to silicon-based diodes as they can potentially be manufactured on the moon. They are less susceptible to radiation and are highly reliable if buried under a stable environment like lunar regolith. The early op-amp, a versatile component found in electric circuits and electronic devices, used vacuum tubes in their construction. Op-amps can perform a vast range of sophisticated operations. Other than control circuitry, computing architecture and stored memory are necessary. A neuron network can exhibit these qualities and mimic a general-purpose computer.

This study showcases an artificial neural network (ANN) built from simple analog components that can potentially be manufactured on the moon. The ANN discovers a mapping between inputs and outputs via a feedback loop and trains a set of weights that produce a desired output for control. The methodology is broken into three parts: forward propagation, calculating new weights, and backpropagating the weights until trained. It is observed with the trained weights for a pair of inputs, a new pair of similar inputs can predict desired outputs. The results prove analog ANN circuits can learn obstacle avoidance, which is a fundamental autonomous rover behavior. Additionally, the findings indicate an ANN architecture constructed with elementary electronic components can be utilized for robotic control, but further work will be required toward building circuits for batch training data.