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THE APPLICATION OF DEEP LEARNING TO SPACE MISSIONS

Abstract

Deep learning has been shown to be effective for visual object identification, speech recognition, natural language understanding, predicting drug activity, and genomics. Many of these terrestrial applications have direct or indirect application to space missions. They may, for example, be used to support the operations of unmanned craft, facilitate human-robot interactions or aid in performing or understanding human space missions' biological impacts. This paper provides a survey of current research in deep learning and considers how each technique discussed could be beneficial to space missions.

Deep learning is a class of machine learning techniques that makes use of multiple layers of non-linear information processing. It can be used for supervised or unsupervised feature extraction and transformation as well as for pattern analysis and classification. It builds on a wealth of prior work that uses the neurons in the human brain as a model for decision-making. The number of virtual neurons, number of layers of neurons, the configuration of the neurons between layers and the data used for training determines how the neural network will work. A key distinction between deep learning and conventional neural networks is that these 'deep' networks have many hidden layers (layers that do not directly receive input or provide output). The addition of numerous hidden layers transforms the input representation of the data into a higher, more abstract representation.

As part of the review, numerous deep learning architectures are discussed. These include: deep neural networks (DNNs), convolutional neural networks (CNNs), recurrent neural networks (RNNs), long short term memory (LSTM), autoencoders (AEs), Boltzmann machines (BMs), restricted Boltzmann machines (RBMs), deep belief networks (DBNs), hidden Markov models (HMMs), and Gaussian mixture models (GMMs).

On the application side, several prospective areas of use are considered. The application of deep learning to process and analyze imagery from satellites or from vehicles on the surface of other planets is considered and several techniques well-suited to this challenge are identified. The use of deep learning to remove 'noise' from audio is also evaluated, both for audio communications and data processing. Its use for rover missions, to learn to recognize patterns that the system hadn't been specifically trained to perceive – thus increasing adaptability – is also considered.

The use of deep learning techniques, developed for terrestrial applications, for similar space applications (e.g., speech processing, drug prediction) is also reviewed. The paper concludes by discussing future directions of the deep learning field.