Dataflow Matrix Machines: an Overview

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A one-page overview of the recent results of our group related to **dataflow matrix machines**.

Dataflow matrix machines (DMMs) are generalized **recurrent neural networks**. The main feature of DMMs are **vector neurons**. While recurrent neural networks process streams of numbers, dataflow matrix machines process streams of representations of arbitrary vectors (**linear streams**).

Another important feature of DMMs is that neurons of arbitrary input and output arity are allowed, and a rich set of built-in transformations of linear streams is provided.

Recurrent neural networks are Turing-complete, but they are an esoteric programming language, and not a convenient general-purpose programming platform. DMMs provide a formalism friendly to handling sparse vectors, conditionals, and more, and there are indications that DMMs will grow to become a **powerful general-purpose programming platform**, in addition to being a convenient machine learning platform.

In this context, it is possible to represent large classes of programs by matrices of real numbers, which allows us to modify programs in continuous fashion and to synthesize programs by synthesizing matrices of real numbers.

Further details and preprints

Self-referential mechanism: Consider a linear stream of matrices describing the connectivity pattern and weights of a DMM. Select a dedicated neuron `Self` emitting such a stream on its output, and use the latest value of that stream as the current **network matrix** (matrix describing the connectivity pattern and weights of our DMM). A typical `Self` neuron would work as an accumulator taking additive updates from other neurons in the network. This mechanism enables reflection facilities and powerful **dynamic self-modification facilities**. In particular, the networks in question have facilities for dynamic expansion.

The recent DMM-related preprints by our group:

`https://arxiv.org/abs/1603.09002`
`https://arxiv.org/abs/1605.05296`
`https://arxiv.org/abs/1606.09470`
`https://arxiv.org/abs/1610.00831`

Modern recurrent neural networks with good machine learning properties such as LSTM and Gated Recurrent Unit networks are naturally understood in the DMM framework as networks having linear and bilinear neurons in addition to neurons with more traditional sigmoid activation functions.

Our new open source effort

The new open-source implementation of core DMM primitives in **Clojure**:

`https://github.com/jsa-aerial/DMM`

This open-source implementation features a new **vector space of recurrent maps**, which allows us to represent a large variety of linear streams as streams of recurrent maps. The vector space of recurrent maps also makes it possible to express **variadic neurons** as neurons having just one argument.

Therefore a **type of neuron** is simply a function transforming recurrent maps, which is a great simplification compared to the formalism presented in the preprints above. See the **design notes** within this open-source implementation for further details.