Supervised Learning of Neural Random-Access Machines with Differential Evolution

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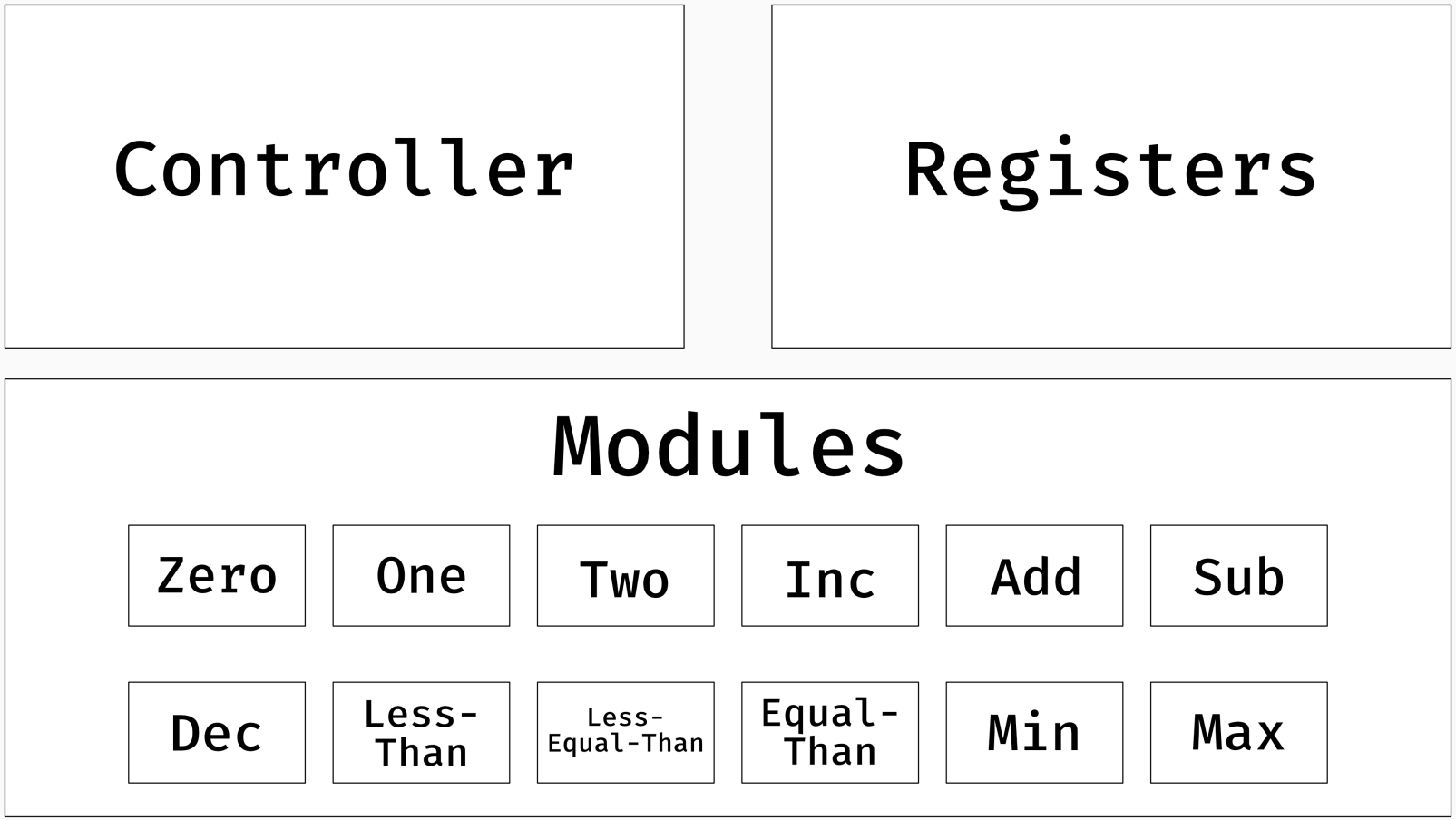
Neural Random-Access Machines

What is?

It is a machine introduced in [Kurach et al., 2015] based on a neural network which is capable of manipulating pointers and dereferencing them through a “logical” circuit. Its objective is to solve a task on which it has been trained creating and executing that circuit.

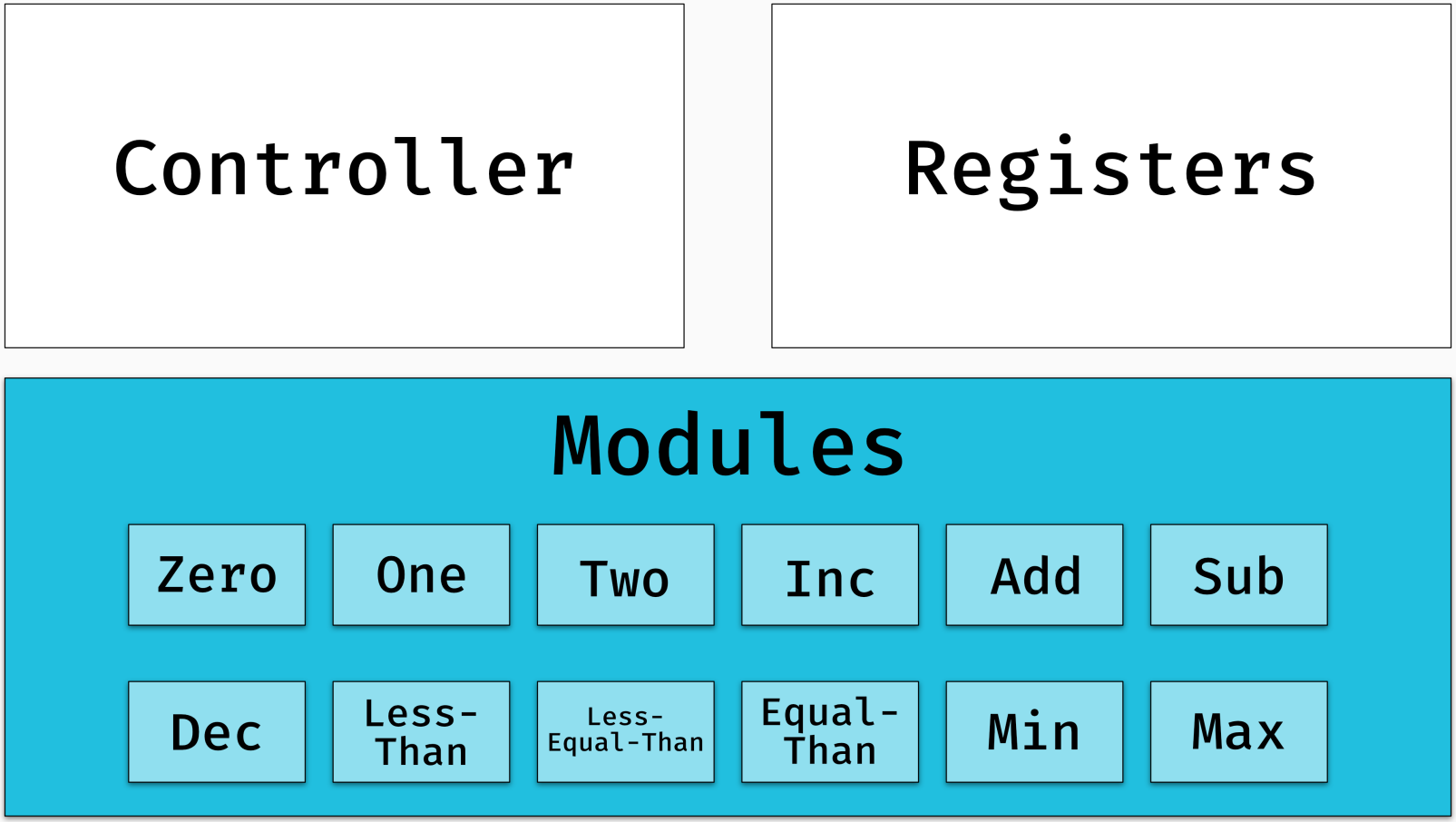
Registers only version



Introduction

Let $N = \{1, \ldots, I-1\}$, where I is an integer constant, the integers set over the NRAM should work. Since the training in [Kurach et al., 2015] is made through a gradient descent algorithm, the NRAM does not work directly over N but over stochastically independent probability distributions, defined as $p \in \mathbb{R}^I$ satisfying $0 \leq p_i \leq 1$ and $\sum_{i=0}^{I-1} p_i = 1$.

Modules


Controller
Registers
Modules
Zero
One
Two
Inc
Add
Sub
Dec
Less-Than
Less-Equal-Than
Equal-Than
Min
Max

Modules

The modules (or gates) are components through which the controller, connecting them, manipulates values and pointers. In the NRAM exist three types of modules, defined as follows:

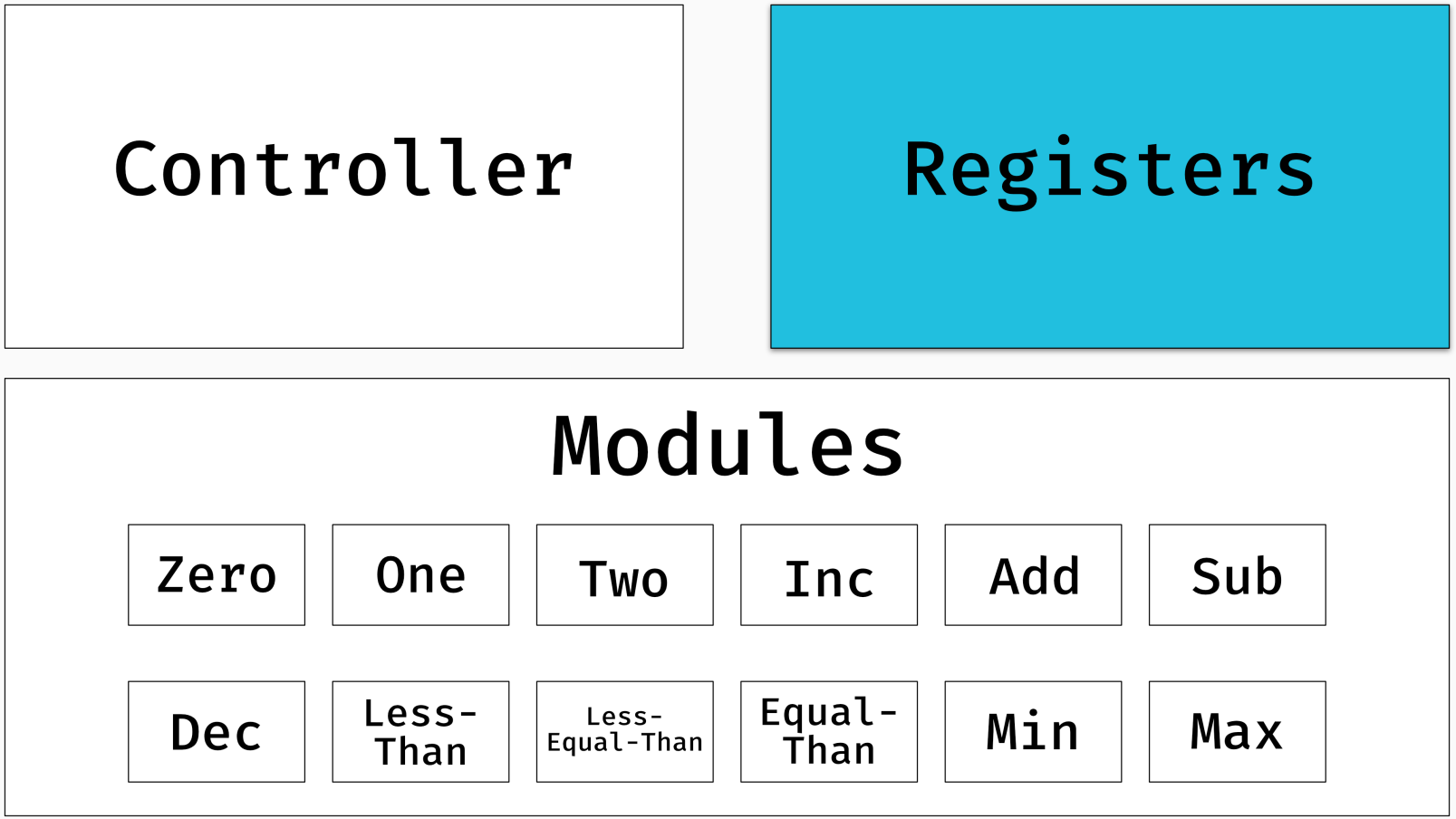
$$m_i \in N \ (\text{Constant modules}) \tag{1}$$

$$m_i : p \to p \ (\text{Unary modules}) \tag{2}$$

$$m_i : p \times p \to p \ (\text{Binary modules}) \tag{3}$$

Each of them take as input, except the constant modules, and emit probability distributions.

Registers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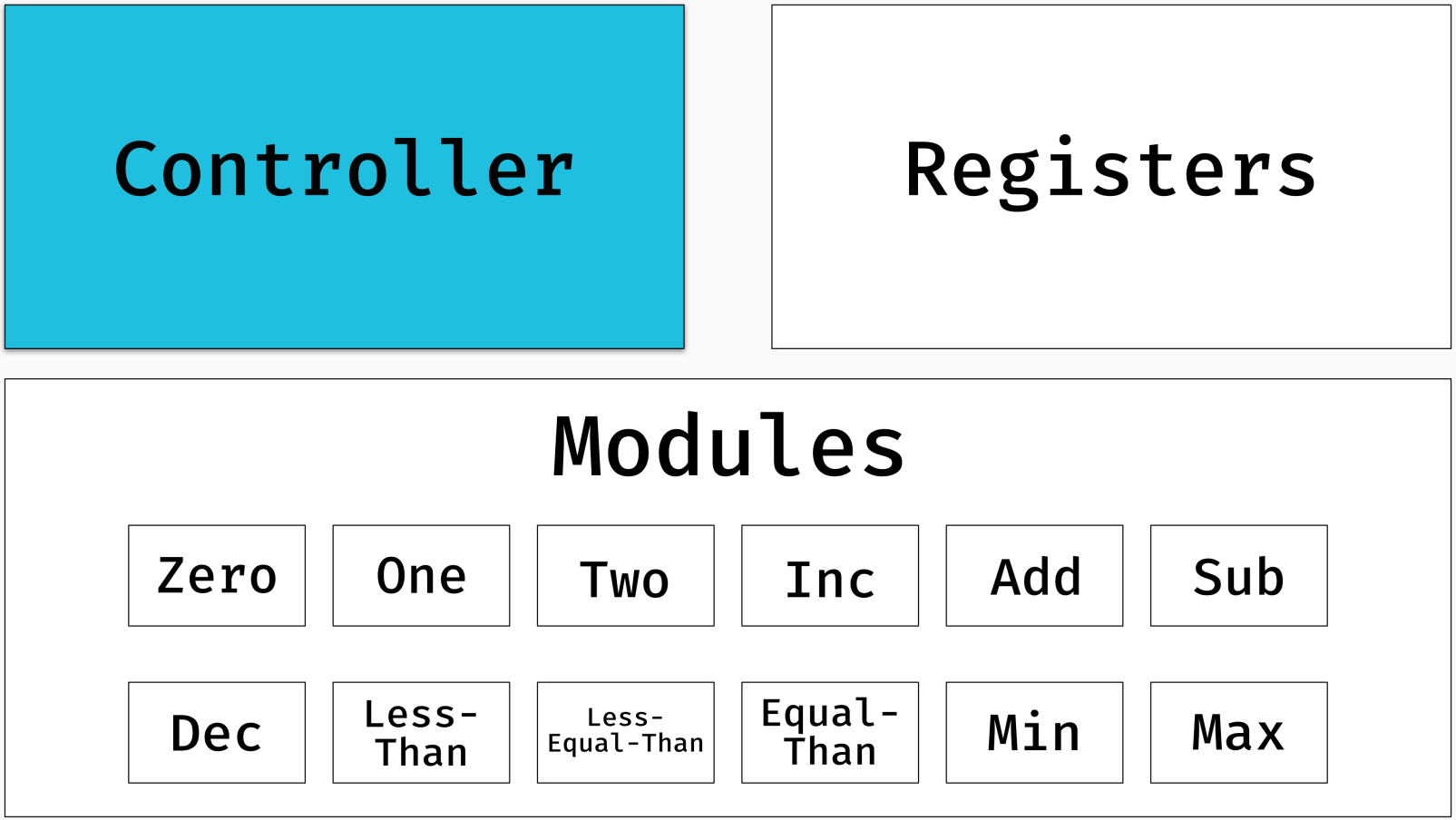
Registers

The registers are a set of memory cells, where each of them contains a probability distribution. Hence, in other words, every register play the role of a random variable.

Controller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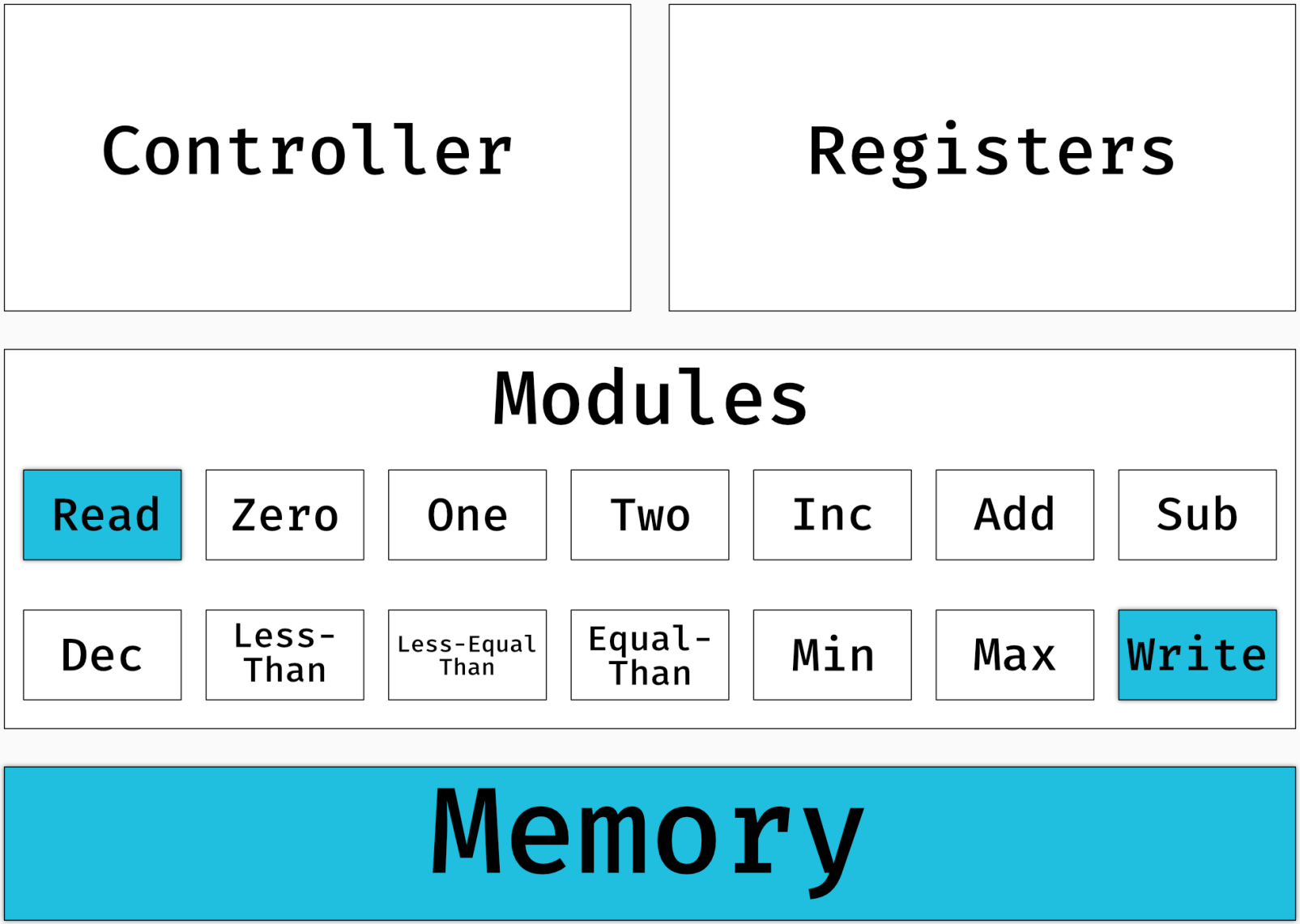
Controller

The controller is a neural network (MLP or LSTM) whose objective is to emit a circuit configuration through which the registers values are manipulated. To do this the controller takes as input the $\mathcal{P}(r_i = 0)$ of each register.

Timestep execution

Memory augmented version



Read & Write modules

Circuit example

Artificial Neural Network

Description

Perceptron

Multi Layer Perceptron (MLP)

Differential Evolution

Description

Differential Evolution variants

Mutation variants

Crossover variants

DENN (Differential Evolution for Neural Network)

Implementation and results

Implementation

Results

References

Kurach, K., Andrychowicz, M., and Sutskever, I. (2015).
Neural random-access machines.
CoRR, abs/1511.06392.