Photonic Artificial Neural Networks

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January 2, 2018

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Introduction

WHAT and WHY? BACKUP project, why silicon photonics (CMOS compatibility)

The formalization of the von Neumann architecture (1945) and the development of modern computers in the second half the 20th century allowed a great improvement in many scientific and technological areas. The technological progress led to [...]

Now, on the verge of the era of artificial intelligence (AI), many breakthroughs in complex of AIs are happening. This is mainly due to the immense amount of data fed to AI algorithms. For this reason however, the algebraic calculus which is carried out so efficiently by computers is not enough anymore.

Chapter 1

Artificial Neural Networks

THEORY ON ANNs Artificial Neural Networks (ANNs) are computing devices which operate in way that mimics biological neural networks.

1.1 Types of ANNs

1.1.1 Feed Forward NN

FF NN node

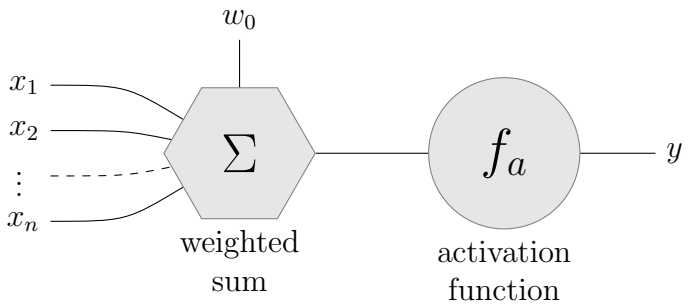

Figure 1.1: Feed Forward node

$$y = f_a\left(w_0 + \sum_i^n w_i x_i\right) \tag{1.1}$$

1.1.2 Other Types of ANNs

Chapter 2

Photonics applied to ANNs

How do I intend to create a hardware photonic ANN node?

2.1 Weighted sum of inputs

This thing has already been demonstrated and integrated widely, so it will not be the focus of this work.

2.2 Nonlinear activation function

On the other hand, a photonic nonlinear activation function has not yet been found. This is where the focus of my work will be.

2.2.1 Simulations

Chapter 3

Samples, setup and measurements

3.1 The samples

I could say that in the time this work was done there would have not been enough time to design and produce an ad hoc device. The aim of this thesis is to produce a proof of concept, to answer the question of feasibility.

The samples on which this work is based have been provided by the IRIS project. Specifically I had a few different structures available: from single rings resonators to the full matrix, each accessible via grating couplers. My choice was a system of intermediate complexity: a simple waveguide, coupled to eight drop channels by a single or a couple of ring resonators each. Moreover, these samples were provided with thermo-electric pads to heat the rings and effectively tune their resonance. The final choice was to study the *mini-matrix* in which the coupling mechanism was provided by single ring resonators, because it was considered simpler.

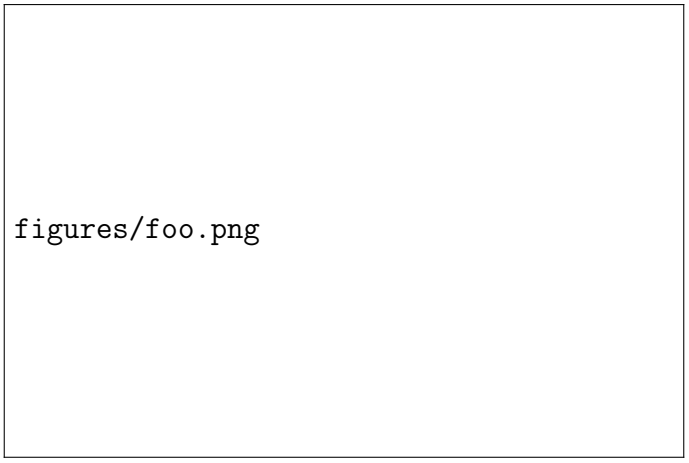

Figure 3.1: image/scheme of the minimatrix

3.2 The setup

3.3 Results

Conclusion