Weightless Neural Networks

Felipe M. G. França
Systems Engineering and Computer Science Program
Universidade Federal do Rio de Janeiro

felipe@cos.ufrj.br
felipe@ieee.org
The McCulloch and Pitts neuron model

\[ x_1w_1 + x_2w_2 + \ldots + x_nw_n > \sigma \]

\[ y = 1 \]
The weighless neuron model

*N*-tuple sampling machine
*Bledsoe and Browning, 1959*

Universal logic circuit
*Aleksander, 1966*

*Koch et al. 1982*
The RAM-node
Training phase

Mapping

Modified RAM discriminator

\[ \sum \]

0 if \( i = 0 \)

1 otherwise

Retina

Training set

Wi.S.A.R.D.

Wilkie Stonham and Aleksander's Recognition Device

Modified RAM discriminator

\[ \sum \]

0 if \( i = 0 \)

1 otherwise

Retina

Training set
Classification phase

Modified RAM discriminator

\[
\sum \begin{cases} 
1 & \text{if } b > 1 \\
0 & \text{otherwise}
\end{cases}
\]

Discriminator

Wi.S.A.R.D.
Wilkie Stonham and Aleksander's Recognition Device
WiSARD in action 1: HIV-1 subtypes – antiretroviral drug resistance

Recognition of HIV-1 subtypes and antiretroviral drug resistance using weightless neural networks

Caio R. Souza¹, Flavio F. Nobre¹, Priscila V.M. Lima², Robson M. Silva², Rodrigo M. Brindeiro³, Felipe M. G. França³

¹ COPPE, Universidade Federal do Rio de Janeiro – Brazil
² DEMAT/ICE, Universidade Federal Rural do Rio de Janeiro – Brazil
³ Laboratory of Molecular Virology, Universidade Federal do Rio de Janeiro – Brazil

Abstract. This work presents an application of an improved version of the WiSARD weightless neural network in the recognition of different mutation types of HIV-1 and in the determination of antiretroviral drugs resistance. The data set used consists of 1205 gene sequence of the HIV-1 protease of subtypes B, C and F from patients under treatment failure. Experiments performed with the bleaching technique over the WiSARD model under different data representation strategies have shown promising results, both in terms of accuracy and standard deviation.

- 94% accuracy;
- 1.3% SD;

Next:
- Specific resistance drug recognition;
- Other viral enzymes.
WiSARD in action 2: early detection of Epilepsy seizures

Early Detection of Epilepsy Seizures based on a Weightless Neural Network*

Kleber de Aguiar¹, Felipe M. G. França¹, Valmir C. Barbosa¹ and César A. D. Teixeira²

Abstract—This work introduces a new methodology for the early detection of epileptic seizure based on the WiSARD weightless neural network model and a new approach in terms of preprocessing the electroencephalogram (EEG) data. WiSARD has, among other advantages, the capacity of perform the training phase in a very fast way. This speed in training is due to the fact that WiSARD’s neurons work like Random Access Memories (RAM) addressed by input patterns. Promising results were obtained in the anticipation of seizure onsets in four representative patients from the European Database on Epilepsy (EPILEPSIAE). The proposed seizure early detection WNN architecture was explored by varying the detection anticipation (δ) in the 2 to 30 seconds interval, and by adopting 2 and 3 seconds as the width of the Sliding Observation Window (SOW) input. While in the most challenging patient (A) one obtained accuracies from 99.57% (δ=2s; SOW=3s) to 72.56% (δ=30s; SOW=2s), patient D seizures could be detected in the 99.77% (δ=2s; SOW=2s) to 99.93% (δ=30s; SOW=3s) accuracy interval.

*This work was financially supported by CNPq, CAPES and FAPEMIG, Brazilian research councils, and the Portuguese national project ICIS (CENTRO-07-0224-FEDER-002003)
¹Kleber de Aguiar, Felipe Maia Galvão França and Valmir C. Barbosa are with Systems Engineering and Computer Science Program, Federal University of Rio de Janeiro, Caixa Postal 68511, 21941-972, Rio de Janeiro RJ, Brazil kaguiar@cos.ufrj.br, felipe@cos.ufrj.br, valmir@cos.ufrj.br
²César Alexandre Domingues Teixeira is with Centre for Informatics and Systems (CISUC), Faculty of Sciences and Technology, University of Coimbra, Coimbra, Portugal 3030-290 cteixeir@dei.uc.pt

To achieve this particular goal, i.e., seizure detection, the WiSARD weightless neural network [4] was explored.

The paper is structured as follows: Section 2 describes the dataset used in this work and the methodology developed to performs an early detection of a seizure; Section 3 presents the results obtained; and the conclusion is in the Section 4.

The EEG data used in the experiments made contain only records with clinic seizures annotated. Information about the seizures developed during the data recordings and additional details about the patients data used in this paper are listed in Table I.

1Simple Partial
2Complex Partial
3Secondarily Generalized
4Unclassified

TABLE I: Data Recording - Patients Personal Details

<table>
<thead>
<tr>
<th>Patient (ID-Gender)</th>
<th>Onset Electrodes</th>
<th>Seizure Type</th>
<th>SP¹</th>
<th>CP²</th>
<th>SG³</th>
<th>UC⁴</th>
<th>Seizure Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>A-Male 15 29 0</td>
<td>8 1</td>
<td>2</td>
<td>11</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B-Male 21 29 2</td>
<td>4 0</td>
<td>2 8</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C-Female 1 29 6</td>
<td>0 1</td>
<td>1 8</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D-Female 23 27 0</td>
<td>4 0</td>
<td>1 5</td>
<td></td>
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</tr>
</tbody>
</table>
WiSARD in action 3:

WIPS: the WiSARD Indoor Positioning System

D. O. Cardoso¹, J. Gama², M. De Gregorio³, F. M. G. França¹,
M. Giordano³ and P. M. V. Lima¹

1 - Universidade Federal do Rio de Janeiro, PESC-COPPE
Rio de Janeiro - Brazil

2 - University of Porto, LIAAD-INESC
Porto - Portugal

3 - Istituto di Cibernetica “E. Caianiello” - CNR
Pozzuoli (NA) - Italy

4 - Universidade Federal Rural do Rio de Janeiro, DEMAT-ICE
Seropédica - Brazil

Abstract. In this paper, we present a WiSARD-based system facing the problem of Indoor Positioning (IP) by taking advantage of pervasively available infrastructures (WiFi Access Points – AP). The goal is to develop a system to be used to position users in indoor environments, such as: museums, malls, factories, offshore platforms etc. Based on the fingerprint approach, we show how the proposed weightless neural system provides very good results in terms of performance and positioning resolution. Both the approach to the problem and the system will be presented through two correlated experiments.
WiSARD in action 3:

Scenario

Walking paths for collecting MSN data

Discrete sampling during the walk

WiFi Access Point

Building 70 - Level 0

fingerprint

Building 70 - Level 0

MSN pattern

M - Mac address
S - Signal strength
N - signal Noise
WiSARD in action 4:

**BRICS-CCI & CBIC 2013**

**NeuroTech**

- **Dates & Updates**
- **Registration & Submissions**
- **Leaderboard**

**Results**

You are here: Home / Results

**Ranking (Task 1)**

1st: DMLAB DMLAB and Budapest University of Technology and Economics - Hungary
   - Team Name - Institution
   - Team Members: Gabor Nagy (Leader & contact person); Istvan Nagy-Sandor Kazi-Gergo Barta

1st: FEP - LIAAD - Finance Faculty of Economics and LIAAD-INESC Port, University of Porto - Portugal
   - Team Name - Institution
   - Team Members: João Gama (Leader); Maria R. Sousa (Contact person); Manuel J. Silva Gonçalves

2nd: Team Sandvik StatSoft Norway AS - Norway
   - Team Name - Institution
   - Team Members: Knut Opdal (Leader & contact person); Rikard Bohm

3rd: LabIA-PESC-UFRJ Universidade Federal do Rio de Janeiro - Brazil
   - Team Name - Institution
   - Team Members: Douglas Cardoso (Leader & contact person); Danilo Carvalho; Daniel Alves; Hugo Carneiro; Diego Souza

**Ranking (Task 2)**

1st: Team Sandvik StatSoft Norway AS - Norway
   - Team Name - Institution
   - Team Members: Knut Opdal (Leader & contact person); Rikard Bohm

2nd: FEP - LIAAD - Finance Faculty of Economics and LIAAD-INESC Port, University of Porto - Portugal
   - Team Name - Institution
   - Team Members: João Gama (Leader); Maria R. Sousa (Contact person); Manuel J. Silva Gonçalves

3rd: LabIA-PESC-UFRJ Universidade Federal do Rio de Janeiro - Brazil
   - Team Name - Institution
   - Team Members: Douglas Cardoso (Leader & contact person); Danilo Carvalho; Daniel Alves; Hugo Carneiro; Diego Souza
WiSARD-based Multi-target tracker
Conclusions, Ongoing and Future Work

17th European Symposium On Artificial Neural Networks
Advances in Computational Intelligence and Learning
Bruges (Belgium), 22-23-24 April 2009

14h25 Weightless Neural Systems
Organized by Massimo De Gregorio (Istituto di Cibernetica-CNR, Italy), Priscila M. V. Lima, Felipe M. G. França (Universidade Federal do Rio de Janeiro, Brazil)

14h25 A brief introduction to Weightless Neural Systems

- Igor Aleksander, Imperial College (United Kingdom)
- Massimo De Gregorio, Istituto di Cibernetica "Eduardo Caianiello" - CNR (Italy)
- Felipe França, Systems Engineering and Computer Science Program, COPPE - Universidade Federal do Rio de Janeiro (Brazil)
- Priscila Lima, Systems Engineering and Computer Science Program, COPPE - Universidade Federal do Rio de Janeiro (Brazil)
- Helen Morton, Brunel University (UK)
Conclusions, Ongoing and Future Work

BRICS7 – Weightless Networks and Stochastic Learning [Session Chair: Felipe França]

WEDNESDAY (9/11) – 09:00-10:00h

Room “E” – “Room Prof. Igor Aleksander” [Honorary Chair: Igor Aleksander]

#309 – “Tracking Targets in Sea Surface with the WiSARD Weightless Neural Network”, R. S. Moreira, N. F. Ebecken, A. S. Alves

#123 – “A WiSARD–based approach to Cdnet”, M. Gregorio, M. Giordano

#101 – “Rock-paper-scissors WiSARD”, D. F. P. de Souza, H. C. C. Carneiro, F. M. G. França, P. M. V. Lima

#227 – “Using Survey and Weighted Functions to Generate Node Probability Tables for Bayesian Networks”, M. Perkusich, A. Perkusich, H. Almeida
Conclusions, Ongoing and Future Work

CBIC7 – (Special session) Weightless Neural Networks [Session Chair: Felipe França]

WEDNESDAY (9/11) – 08:00-09:00h

Room “E” – “Room Prof. Igor Aleksander”, Honorary Chair of this Session


## Conclusions, Ongoing and Future Work

**22nd European Symposium On Artificial Neural Networks, Computational Intelligence and Machine Learning**
**Bruges (Belgium), 23-24-25 April 2014**

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### Friday April 25, 2014

| 09h00  | Advances on Weightless Neural Systems  
**Organized by Massimo De Gregorio, Priscila M.V. Lima, Wilson R. de Oliveira (Italy & Brazil)** |
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<tbody>
<tr>
<td>09h00</td>
<td>Advances on Weightless Neural Systems</td>
</tr>
</tbody>
</table>
- Massimo De Gregorio, Istituto di Cibernetica (Italy)  
- Felipe M. G. França, Universidade Federal do Rio de Janeiro - COPPE/PESC/UFRJ (Brazil)  
- Priscila M. V. Lima, Universidade Federal Rural do Rio de Janeiro - Instituto de Ciências Exatas - Departamento de Matemática (Brazil)  
- Wilson R. de Oliveira, Universidade Federal Rural de Pernambuco - Departamento de Estatística e Informática (Brazil)  |
# Conclusions, Ongoing and Future Work

**European Symposium on Artificial Neural Networks, Computational Intelligence and Machine Learning**

Bruges (Belgium), 22 - 24 April 2015

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**Wednesday 22 April 2015**

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<th>Event</th>
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<tbody>
<tr>
<td>09h00</td>
<td><strong>Opening</strong></td>
</tr>
<tr>
<td>09h10</td>
<td><strong>Prototype-based and weightless models</strong></td>
</tr>
</tbody>
</table>

**10h10**  
A WiSARD-based multi-term memory framework for online tracking of objects

- Daniel Nascimento, Federal University of Rio de Janeiro (Brazil)
- Rafael Carvalho, Federal University of Tocantins (Brazil)
- Felix Mora-Camino, École Nationale de l'Aviation Civile (France)
- Priscila Lima, Federal University of Rio de Janeiro (Brazil)
- Felipe Franca, Federal University of Rio de Janeiro (Brazil)

**10h30**  
Memory Transfer in DRASiW–like Systems

- De gregorio Massimo, Istituto di Cibernetica (Italy)
- Giordano Maurizio, Istituto di Calcolo e Reti ad Alte Prestazioni - CNR (Italy)

**10h50**  
**Prototype-based and weightless models**

*Poster spotlights*
Conclusions, Ongoing and Future Work

Special Issue on Weightless Neural Systems

Description:
Mimicking biological neurons by focusing on the excitatory/inhibitory decoding, which is naturally performed by the dendritic trees, is a different and attractive alternative to the integrate-and-fire neuron stylization. In such alternative analogy, neurons can be seen as a set of Random Access Memory (RAM) nodes addressed by Boolean inputs and producing Boolean outputs. The shortening of the semantic gap between...
Conclusions, Ongoing and Future Work

JOURNALS


GRIECO, B. P. A.; LIMA, P. M. V.; DE GREGORIO, M.; FRANÇA, F. M. G. . Producing pattern examples from mental images?. Neurocomputing (Amsterdam), v. 73, p. 1057-1064, 2010.

LNCS

Conclusions, Ongoing and Future Work

PROCEEDINGS (1/5)


Conclusions, Ongoing and Future Work

PROCEEDINGS (2/5)


Conclusions, Ongoing and Future Work

PROCEEDINGS (3/5)


Conclusions, Ongoing and Future Work

PROCEEDINGS (4/5)


Conclusions, Ongoing and Future Work

PROCEEDINGS (5/5)


http://labia.cos.ufrj.br/publicacoes/artigos/weightless-hierarchy-memory-tracker

Thank you, Obrigado!

felipe@ieee.org