The Weightless Neural Model WiSARD and Applications

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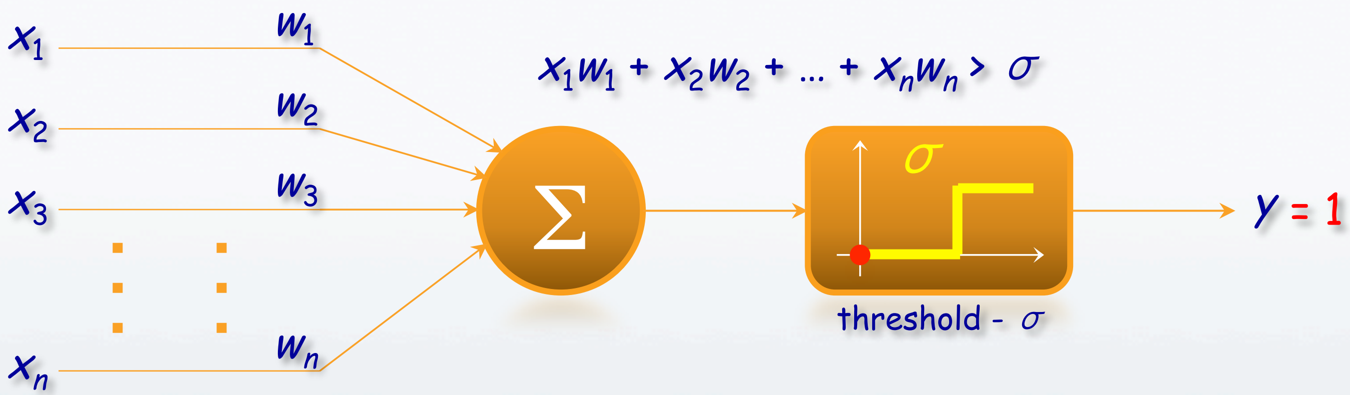
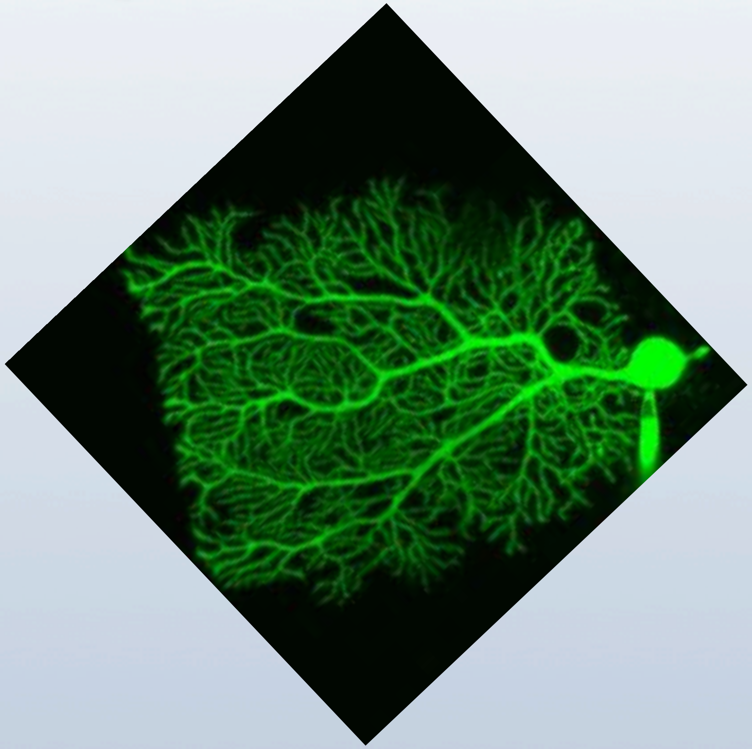
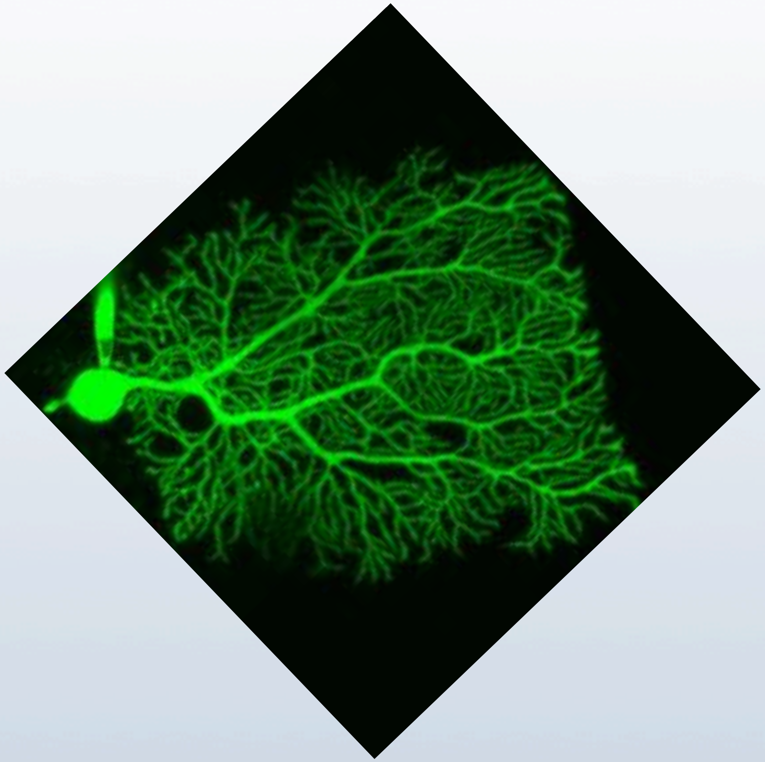
The McCulloch and Pitts neuron model



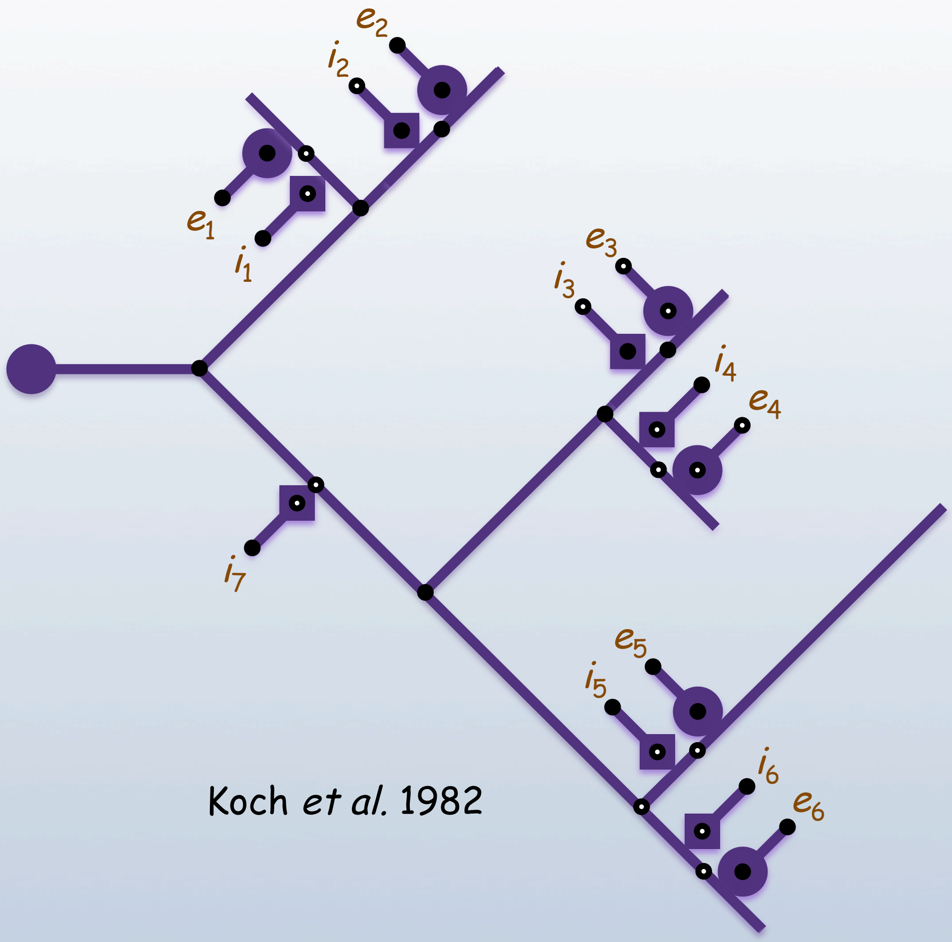


The weighless neuron model

N-tuple sampling machine
Bledsoe and Browning, 1959

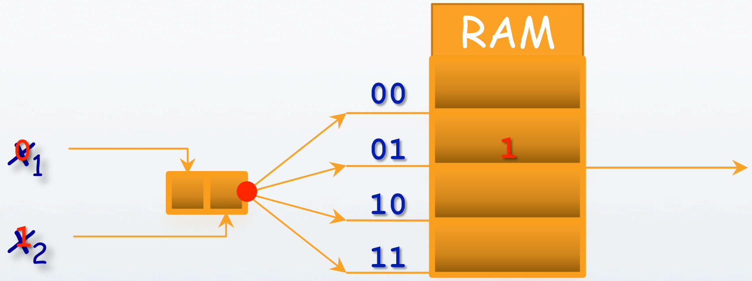


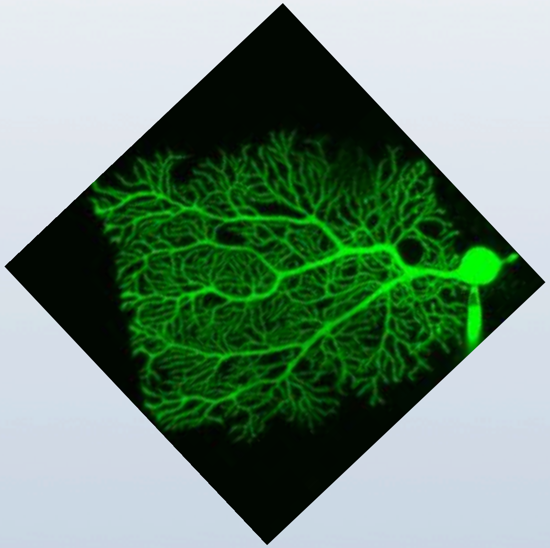
Universal logic circuit
Aleksander, 1966

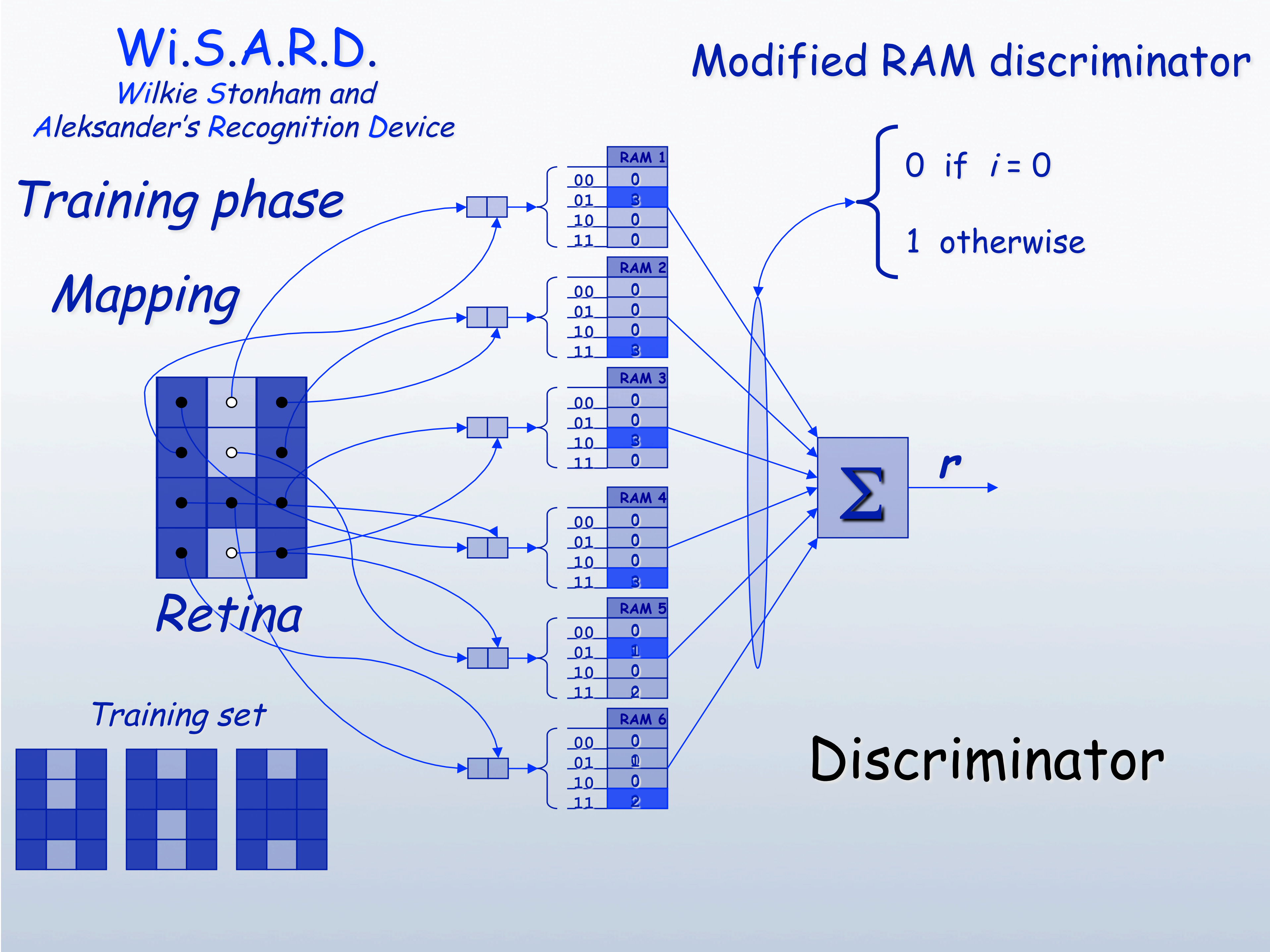


Koch *et al.* 1982

The RAM-node







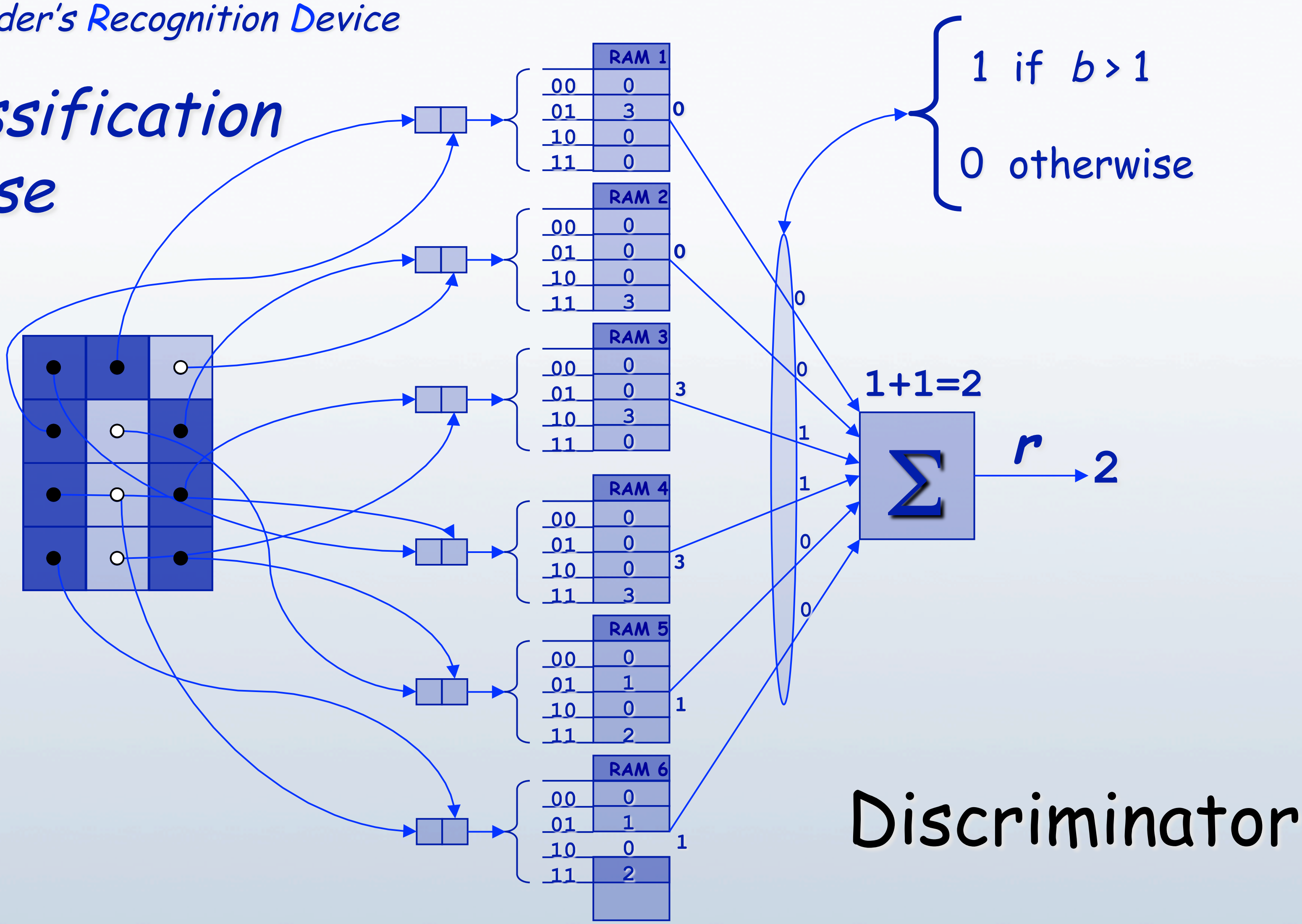
Wi.S.A.R.D.
Wilkie Stonham and
Aleksander's Recognition Device
Modified RAM discriminator
Training phase
Mapping
Retina
Training set
RAM 1
00 0
01 3
10 0
11 0
RAM 2
00 0
01 0
10 0
11 3
RAM 3
00 0
01 0
10 3
11 0
RAM 4
00 0
01 0
10 0
11 3
RAM 5
00 0
01 1
10 0
11 2
RAM 6
00 0
01 1
10 0
11 2
0 if i = 0
1 otherwise
Σ
r
Discriminator

Wi.S.A.R.D.

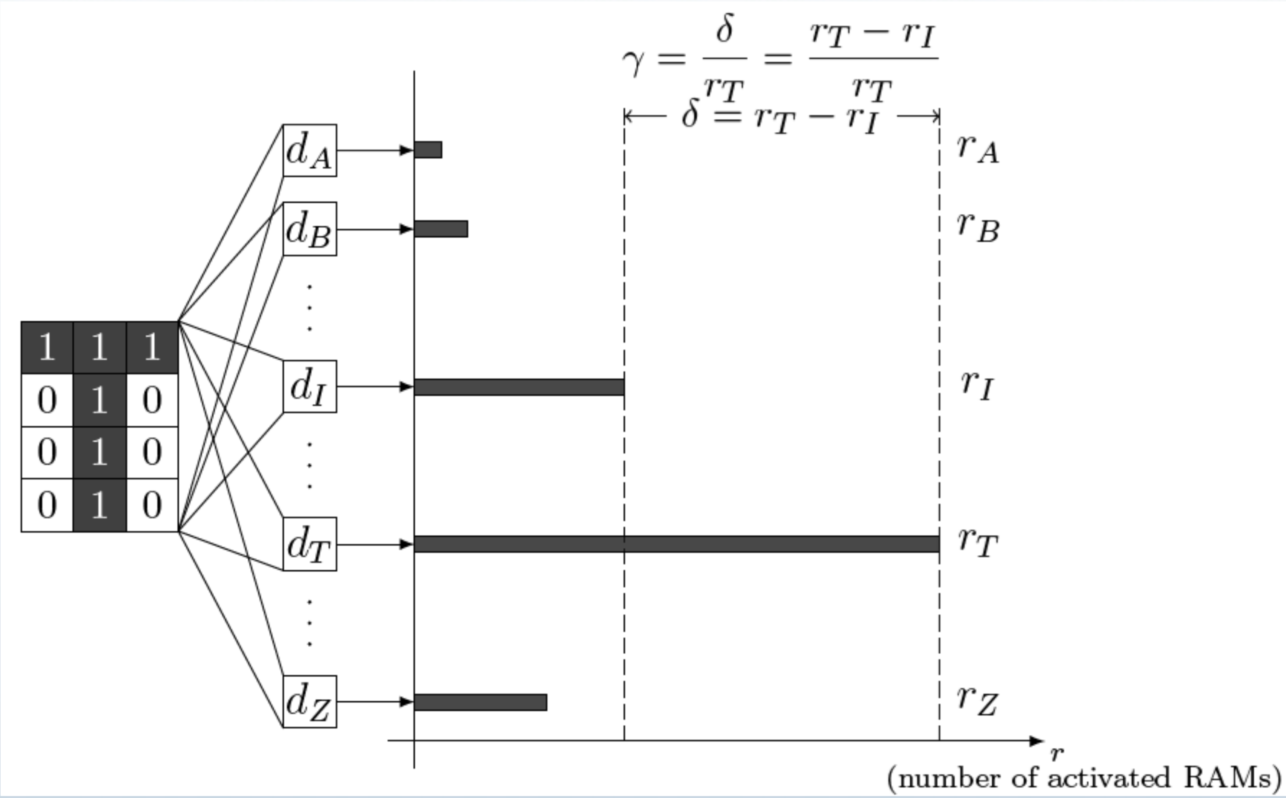
Wilkie Stonham and Aleksander's Recognition Device

Modified RAM discriminator

Classification phase



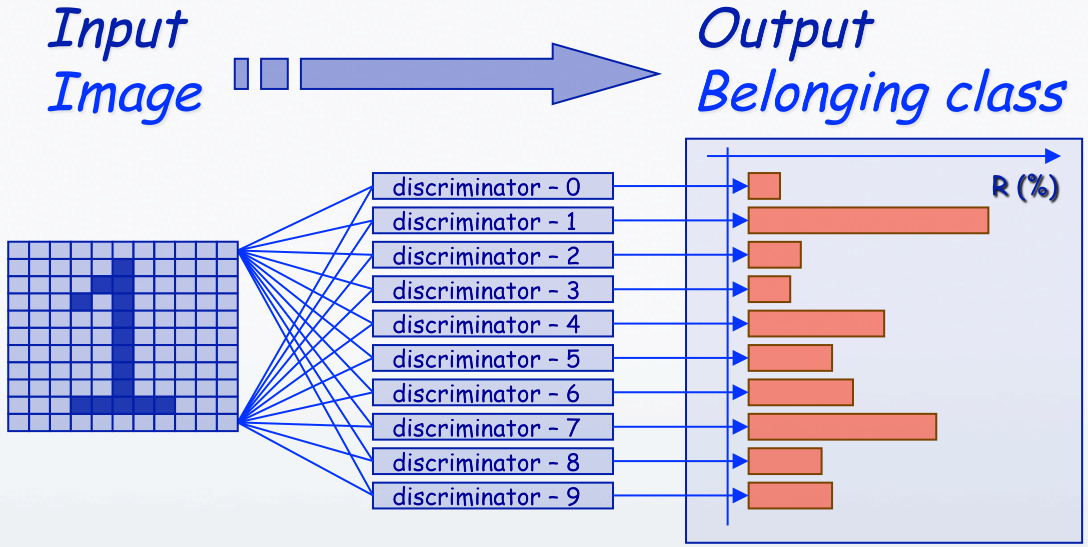
WiSARD — Wilkes, Stoham and Aleksander Recognition Device (1984)



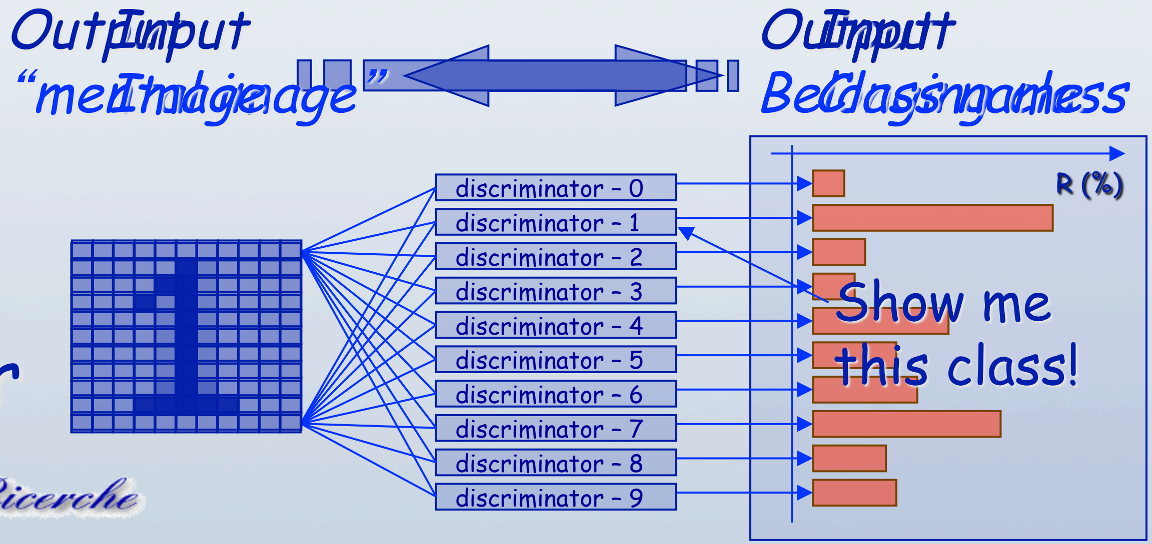
Wi.S.A.R.D.

Wilkie Stonham and Aleksander's Recognition Device

Multidiscriminator



Modified Multidiscriminator



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WiSARD in action 1: Globo's *Eva Byte*

A New Intelligent Systems Approach to 3D Animation in Television

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CIVR'07, July 9–11, 2007, Amsterdam, The Netherlands.
ACM 978-1-59593-733-9/07/0007.

WiSARD in action 1: Globo's *Eva Byte*

WiSARD in action 2: HIV-1 subtypes – antiretroviral drug resistance

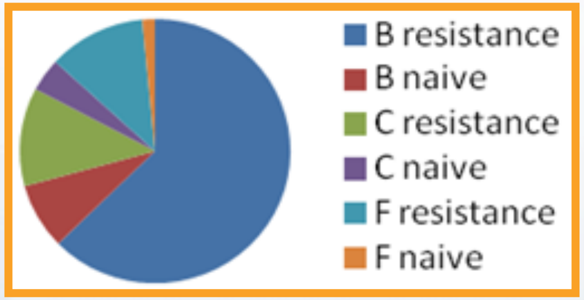
ESANN 2012 proceedings, European Symposium on Artificial Neural Networks, Computational Intelligence and Machine Learning. Bruges (Belgium), 25-27 April 2012, i6doc.com publ., ISBN 978-2-87419-049-0. Available from http://www.i6doc.com/en/livre/?GCOI=28001100967420.

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

Caio R. Souza[1], Flavio F. Nobre[1], Priscila V.M. Lima[2], Robson M. Silva[2], Rodrigo M. Brindeiro[3], Felipe M. G. França[1]

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 resistence. 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 enzimes.

WiSARD in action 3: early detection of Epilepsy seizures

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

Kleber de Aguiar[1], Felipe M. G. França[1], Valmir C. Barbosa[1] and César A. D. Teixeira[2]

***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.**

TABLE I: Data Recording - Patients Personal Details

Patient (ID-Gender)	Onset Age	Electrodes	Seizure Type SP[1]	CP[2]	SG[3]	UC[4]	Seizure Total
A-Male	13	29	0	8	1	2	11
B-Male	21	29	2	4	0	2	8
C-Female	1	29	6	0	1	1	8
D-Female	23	27	0	4	0	1	5

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.

*This work was financially supported by CNPq, CAPES and FAPERJ, Brazilian research councils, and the Portuguese national project iCIS (CENTRO-07-0224-FEDER-002003)

[1]Kleber 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

[2]César Alexandre Domingues Teixeira is with Centre for Informatics and Systems (CISUC), Faculty of Sciences and Technology, University of Coimbra, Coimbra, Portugal 3030-290 cteixei@dei.uc.pt

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.

[1]Simple Partial
[2]Complex Partial
[3]Secondarily Generalized
[4]Unclassified

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WiSARD in action 4: Localização *indoor*

WIPS: the WiSARD Indoor Positioning System

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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

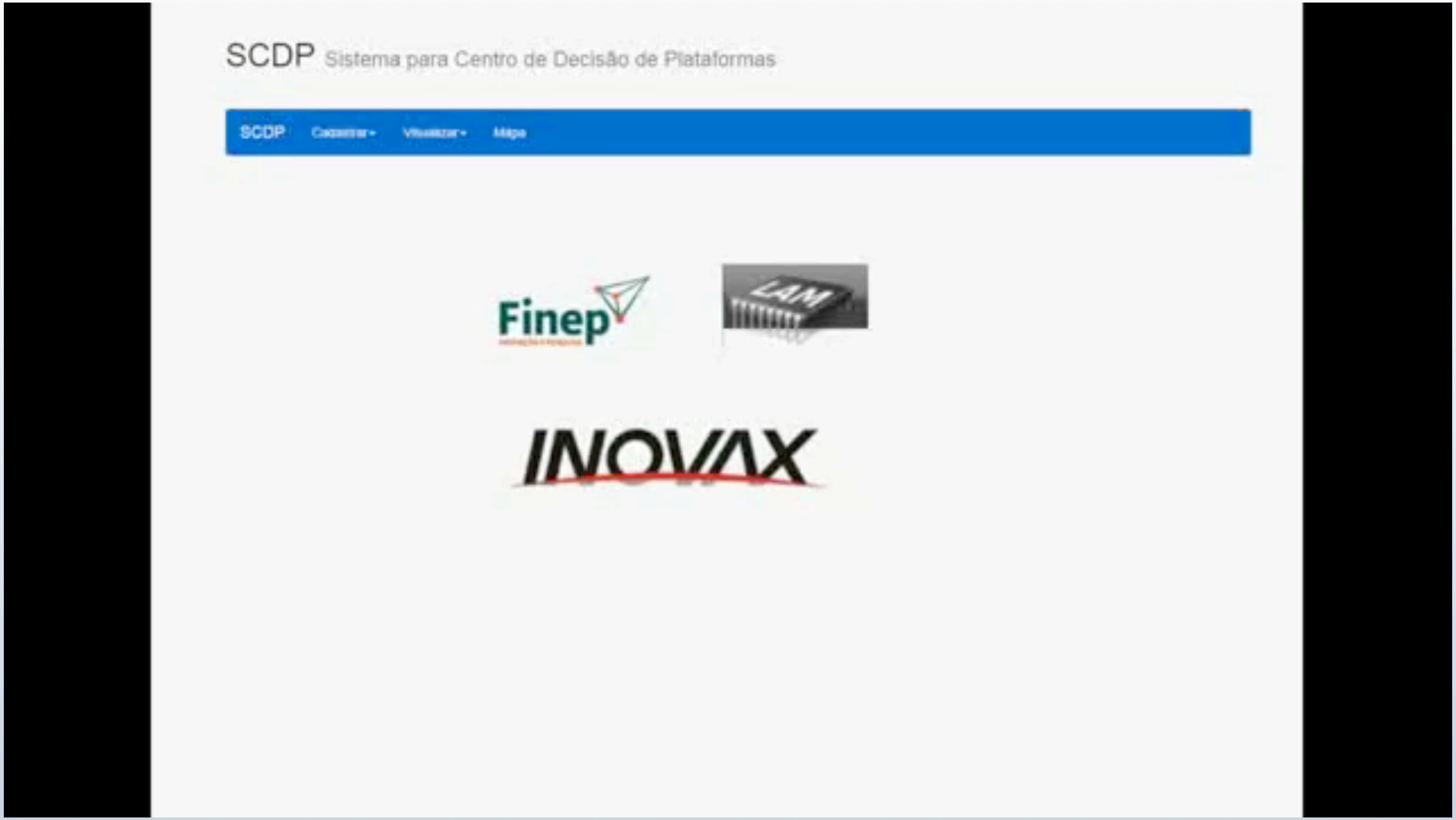
4 - Universidade Federal Rural do Rio de Janeiro, DEMAT-ICE
Seropédica - Brazil

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.

FINEP – Pré-sal,
INOVAX
Parque tecnológico

WiSARD in action 4: Localização *indoor*

WiSARD in action 4: Localização *indoor*



WiSARD in action 5: credit assignment

- brics2013@neurotech.com.br

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BRICS-CCI & CBIC 2013

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Results

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Ranking (Task 1)	Team Name – Institution	Team Members
1st	DMLAB DMLAB and Budapest University of Technology and Economics - Hungary	-Gabor Nagy (Leader & contact person)-Istvan Nagy-Sandor Kazi-Gergo Barta
1st	FEP – LIAAD – Finance Faculty of Economics and LIAAD-INESC Porto, University of Porto - Portugal	-João Gama (Leader)-Maria R. Sousa (Contact person)-Manuel J. Silva Gonçalves
2nd	Team Sandvika StatSoft Norway AS - Norway	-Knut Opdal (Leader & contact person)-Rikard Bohm
3rd	LabIA-PESC-UFRJ Universidade Federal do Rio de Janeiro - Brazil	-Douglas Cardoso (Leader & contact person)-Danilo Carvalho-Daniel Alves-Hugo Carneiro-Diego Souza

Ranking (Task 2)		
1st	Team Sandvika StatSoft Norway AS - Norway	-Knut Opdal (Leader & contact person)-Rikard Bohm
2nd	FEP – LIAAD – Finance Faculty of Economics and LIAAD-INESC Porto, University of Porto - Portugal	-João Gama (Leader)-Maria R. Sousa (Contact person)-Manuel J. Silva Gonçalves
3rd	LabIA-PESC-UFRJ Universidade Federal do Rio de Janeiro - Brazil	-Douglas Cardoso (Leader & contact person)-Danilo Carvalho-Daniel Alves-Hugo Carneiro-Diego Souza

WiSARD in action 5: credit assignment

Neurocomputing 183 (2016) 70–78

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ELSEVIER

Financial credit analysis via a clustering weightless neural classifier

CrossMark

Douglas O. Cardoso [a], Danilo S. Carvalho [a], Daniel S.F. Alves [a], Diego F.P. Souza [a,*], Hugo C.C. Carneiro [a], Carlos E. Pedreira [a], Priscila M.V. Lima [b], Felipe M.G. França [a]

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A R T I C L E   I N F O

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Keywords:
Bleaching
ClusWiSARD
Clustering
Concept drifting
Credit assignment
Online learning

A B S T R A C T

Credit analysis is a real-world classification problem where it is quite common to find datasets with a large amount of noisy data. State-of-the-art classifiers that employ error minimisation techniques, on the other hand, require a long time to converge, in order to achieve robustness. This paper explores Clus-WiSARD, a clustering customisation of the WiSARD weightless neural network model, applied to two different credit analysis real-world problems. Experimental evidence shows that ClusWiSARD is very competitive with Support Vector Machine (SVM) w.r.t. accuracy, with the advantage of being capable of online learning. ClusWiSARD outperforms SVM in training time, by two orders of magnitude, and is slightly faster in test time.

WiSARD in action 5: credit assignment

D.O. Cardoso et al. / Neurocomputing 183 (2016) 70–78

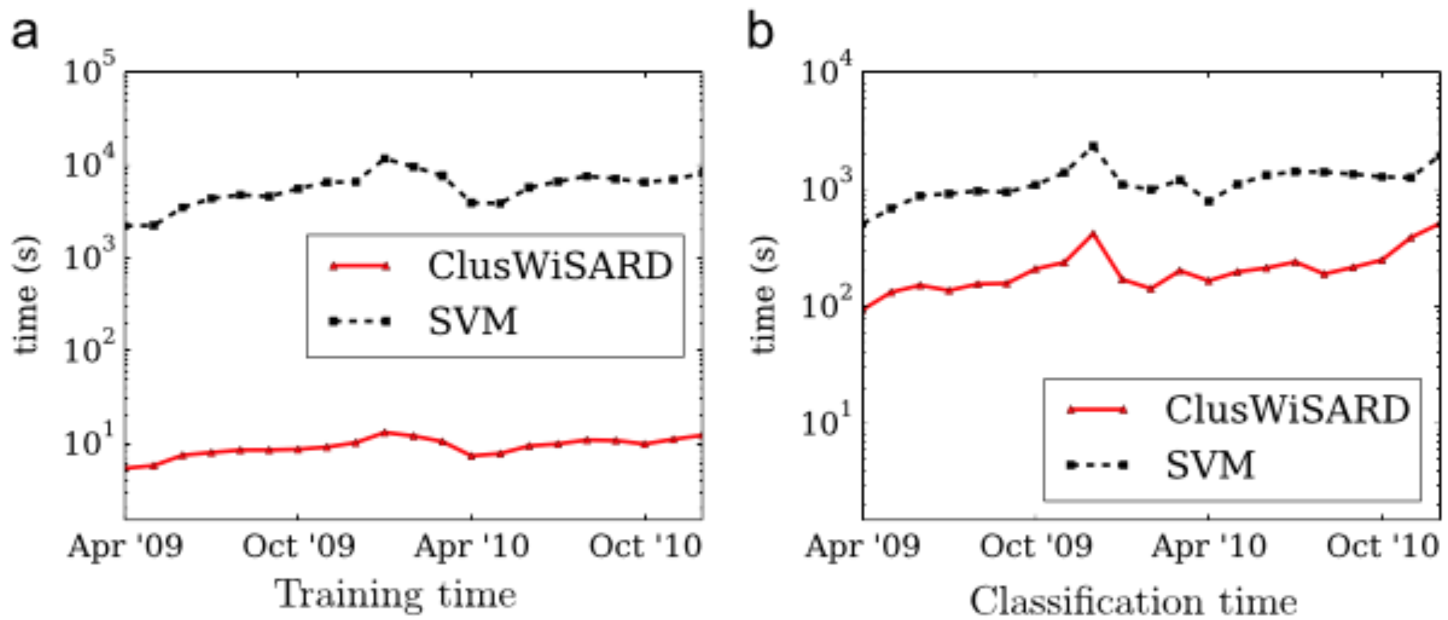

Fig. 9. Time spent: SVM and ClusWiSARD over the BRICS-CCI dataset. (a) Training time. (b) Classification time.

WiSARD in action 6:

Janken-pon = じゃんけんぽん

Rock-paper-scissors WiSARD

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***Abstract*—This paper presents some strategies used for creating intelligent players of rock-paper-scissors using WiSARD weightless neural networks and results obtained therewith. These strategies included: (*i*) a new approach for encoding of the input data; (*ii*) three new training algorithms that allow the reclassification of the input patterns over time; (*iii*) a method**

adaptiveness and an extremely simple architecture [10], [11], [12], the WiSARD neural network has been chosen as the basic paradigm in the proposal of rock-paper-scissors players/agents. The network shall receive as input the game history of last H rounds and thus try to predict the next move of its opponent.

WiSARD in action 7: : biased news

ICNSC 2017

Evaluating Weightless Neural Networks for Bias Identification on News

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*Universidade Federal do Rio de Janeiro - PPGI
Rio de Janeiro - Brazil
†Istituto di Scienze Applicate e Sistemi Intelligenti - CNR
Pozzuoli (NA) - Italy

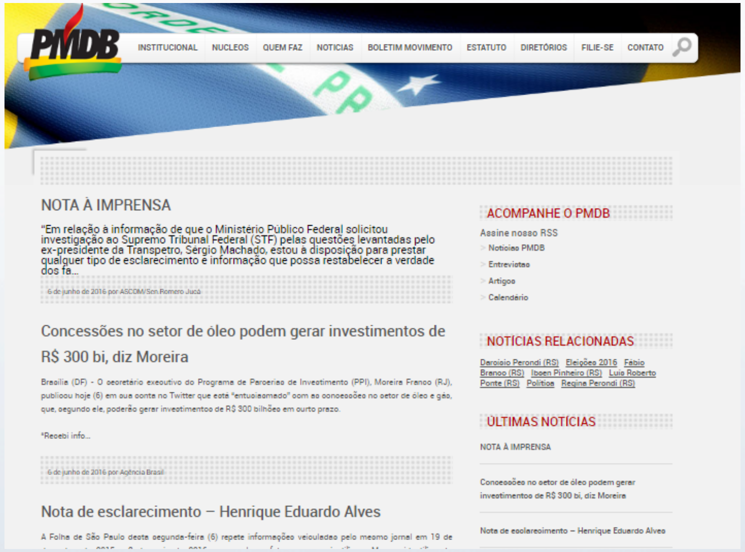
***Abstract*—Identifying biases in articles published in the news media is one of the most fundamental problems in the realm of journalism and communication, and automatic mechanisms for detecting that a piece of news is biased have been studied for decades. In this paper, we compare the WiSARD classifier, a lightweight efficient weightless neural network architecture, against Logistic Regression, Gradient Tree Boosting, SVM and Naive Bayes for identification of polarity in news. Motivated by the fast pace at which news feeds are published, we envision the increasing need for efficient and accurate mechanisms for bias detection. WiSARD presented itself as a good candidate for the task of bias identification, specially in dynamic contexts, due to its online learning ability and comparable accuracy when contrasted against the considered alternatives.**

Our problem consists of identifying, for each of the articles in the selected database, whether it appeared in the website of PMDB or PT. We address the following two questions:

- is it feasible to automatically classify the sources of articles on politics?
- what are the advantages and disadvantages of the classification tools, with respect to accuracy and efficiency/performance?

We provide an affirmative answer to the first question, and identify weightless neural networks (WNN) as simple and efficient tools to perform the classification. Note that not all the articles published in the websites of the major Brazilian

WiSARD in action 7: : biased news



- Selected sources: the Brazilian Democratic Movement Party (PMDB) and the Workers Party (PT);
- These two parties are currently two of the major players in Brazilian politics;
- Assuming that the two sources considered in this paper generate two "biased" news feeds.

WiSARD in action 8: social media

ESANN 2016

ESANN 2016 proceedings, European Symposium on Artificial Neural Networks, Computational Intelligence and Machine Learning. Bruges (Belgium), 27-29 April 2016, i6doc.com publl., ISBN 978-287587027-8. Available from http://www.i6doc.com/en/.

Semi-Supervised Classification of Social Textual Data Using WiSARD

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Abstract.
Text categorization is a problem which can be addressed by a semi-supervised learning classifier, since the annotation process is costly and ponderous. The semi-supervised approach is also adequate in the context of social network text categorization, due to its adaptation to class distribution changes. This article presents a novel approach for semi-supervised learning based on WiSARD classifier (SSW), and compares it to other already established mechanisms (S3VM and NB-EM), over three different datasets. The novel approach showed to be up to fifty times faster than S3VM and EM-NB with competitive accuracies.

WiSARD in action 9: *disque denúncia/crime stoppers*

ESANN 2017

ESANN 2017 proceedings, European Symposium on Artificial Neural Networks, Computational Intelligence and Machine Learning. Bruges (Belgium), 26-28 April 2017, i6doc.com publ., ISBN 978-287587039-1. Available from http://www.i6doc.com/en/.

Automatic Crime Report Classification through a Weightless Neural Network

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Abstract. Anonymous crime reporting is a tool that helps to reduce and prevent crime occurrences. The classification of the crime reports received by the call center is necessary for the data organization and also to stipulate the importance of a particular report and its relation to others. The objective of this work is to develop a system that assists the call center's operator by recommending classification to new reports. The system uses a weightless neural network that automatically attribute a class to a report. At the end of this work it was possible to observe that automatic classifications of crime reports with high accuracy are possible using a weightless neural network.

WiSARD in action 10: ontology alignment

ICANN 2017

Ontology Alignment with Weightless Neural Networks

Thais Viana[1*], Carla Delgado[1,2], João C. P. da Silva[2], and Priscila Lima[1]

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Abstract. In this paper, we present an ontology matching process based on the usage of Weightless Neural Networks (WNN). The alignment of ontologies for specific domains provides several benefits, such as interoperability among different systems and the improvement of the domain knowledge derived from the insights inferred from the combined information contained in the various ontologies. A WiSARD classifier is built to estimate a distribution-based similarity measure among the concepts of the several ontologies being matched. To validate our approach, we apply the proposed matching process to the knowledge domain of algorithms, software and computational problems, having some promising results.

Keywords: Weithtless Neural Network, WiSARD, Ontology Alignment, Ontology Matching

WiSARD in action 11: *emotions classification*

ESANN 2018

ESANN 2018 proceedings, European Symposium on Artificial Neural Networks, Computational Intelligence and Machine Learning. Bruges (Belgium), 25-27 April 2018, i6doc.com publ., ISBN 978-287587047-6. Available from http://www.i6doc.com/en/.

Near-optimal facial emotion classification using a WiSARD-based weightless system

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1- PESC/COPPE 2- NCE
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Abstract. The recognition of facial expressions through the use of a WiSARD-based n-tuple classifier is explored in this work. The competitiveness of this weightless neural network is tested in the specific challenge of identifying emotions from photos of faces, limited to the six basic emotions described in the seminal work of Ekman and Friesen (1977) on identification of facial expressions. Current state-of-the-art for this problem uses a convolutional neural network (CNN), with accuracy of 100% and 99.6% in the Cohn-Kanade and MMI datasets, respectively, with the proposed WiSARD-based architecture reaching accuracy of 100% and 99.4% in the same datasets.

WiSARD in action 12: *high frequency trading*

IJCNN 2018

Weightless Neural Network for High Frequency Trading

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***Abstract*—High frequency trading depends on quick reactions to meaningful information. In order to identify opportunities in intraday negotiation in the stock markets, we propose a weightless neural network autonomous trader agent composed by forecasting and decision modules. The forecasting module uses ridge regression, which compared favorably against recursive least squares with exponential forgetting. The decision model applies the predicted prices to compute technical indicators based on a set of relative strength indicators evaluated by back-testing, which are then used to train the weightless neural network WiSARD in deciding whether to buy or sell stocks. Experimental results on a real dataset from the Brazilian stock market showed that it is feasible encode the back-testing in WiSARD in order to improve trading rules in a way that is compatible with the reaction time required by online market updates.**

***Index Terms*—WiSARD, high frequency trading, relative strength indicator, ridge regression.**

I. Introduction

A typical algorithm in high frequency trading operates at the millisecond time scale. In this kind of trade, the success of investors is based not only on the quality of the information they use to support decision making but also on how fast

Página 1 / 7

overfitting problems, we opted to predict the future price of stocks by ridge regression.

To validate our trader agent, we have tested it on PETR4, one of the most negotiated stocks in the Brazilian market, BM&FBovespa. The BM&FBovespa exchange uses the PUMA system to trade stocks. This system is comprised of a financial information exchange protocol, which is composed by specific messages that enable the online electronic communication between market makers and the BM&FBovespa in a standardized way. We compare the forecasting accuracy on PETR4 to recursive least squares with exponential forgetting and evaluated trading strategies by back-testing, using the methodology described in [5].

Although high frequency trading still faces questions about governmental regulations, the major financial markets have established their own. Several papers have addressed the impact of these practices on market quality [6]. Nevertheless, according to the Securities and Exchange Commission (SEC) this practice currently dominates the majority of trading in the U.S. market [7]. In the Brazilian case, BM&FBovespa has allowed this type of trading since 2009.

The remainder of this paper is organized as follows. Section

WiSARD in action 13: Multi-target tracker

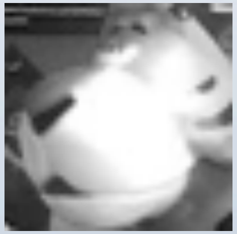
WESPA!!

Goal

Follow an object identified in the first frame

Hierarchic Memory Tracker

- Inspired by the human short, medium, long term memories
- Object changes its shape
- Different patterns stored for different shapes of the object

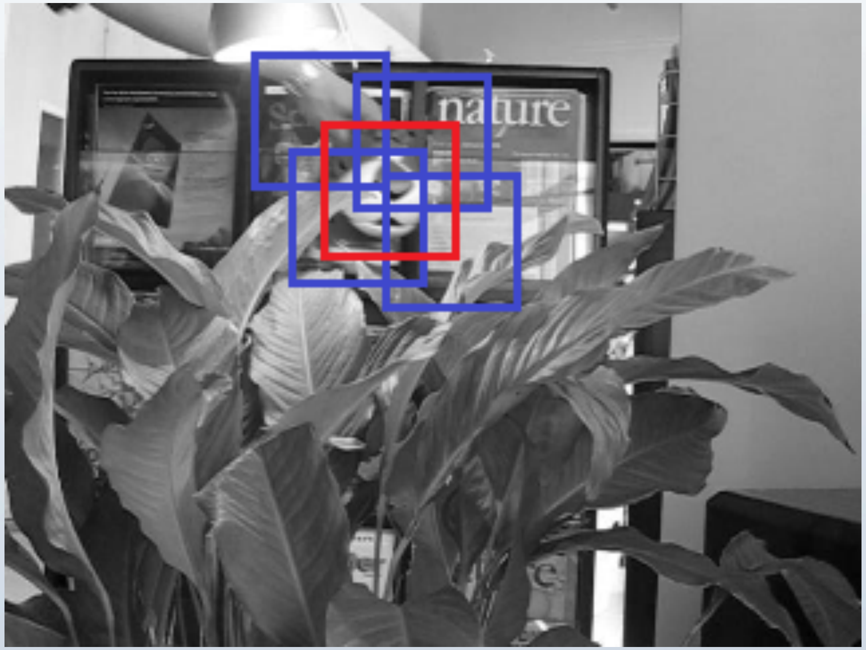
   

Hierarchic Memory Tracker

- The location is passed as input to the tracker in the first frame.
- First discriminator D1 is trained and stored in a queue.

Hierarchic Memory Tracker

- The search is done locally at each frame.



Hierarchic Memory Tracker

- After some frames, D1 returns 0.85 of RAMS activated

Hierarchic Memory Tracker

- D1 continues tracking leader until the score falls below a recognition threshold 0.5

- D1 returns 0.45 of activated RAMS
- D2 is trained and assumes tracking

Hierarchic Memory Tracker

- Best discriminator response is chosen and it goes to the first place of the queue.

- D1 = 0.7
- D2 = 0.4

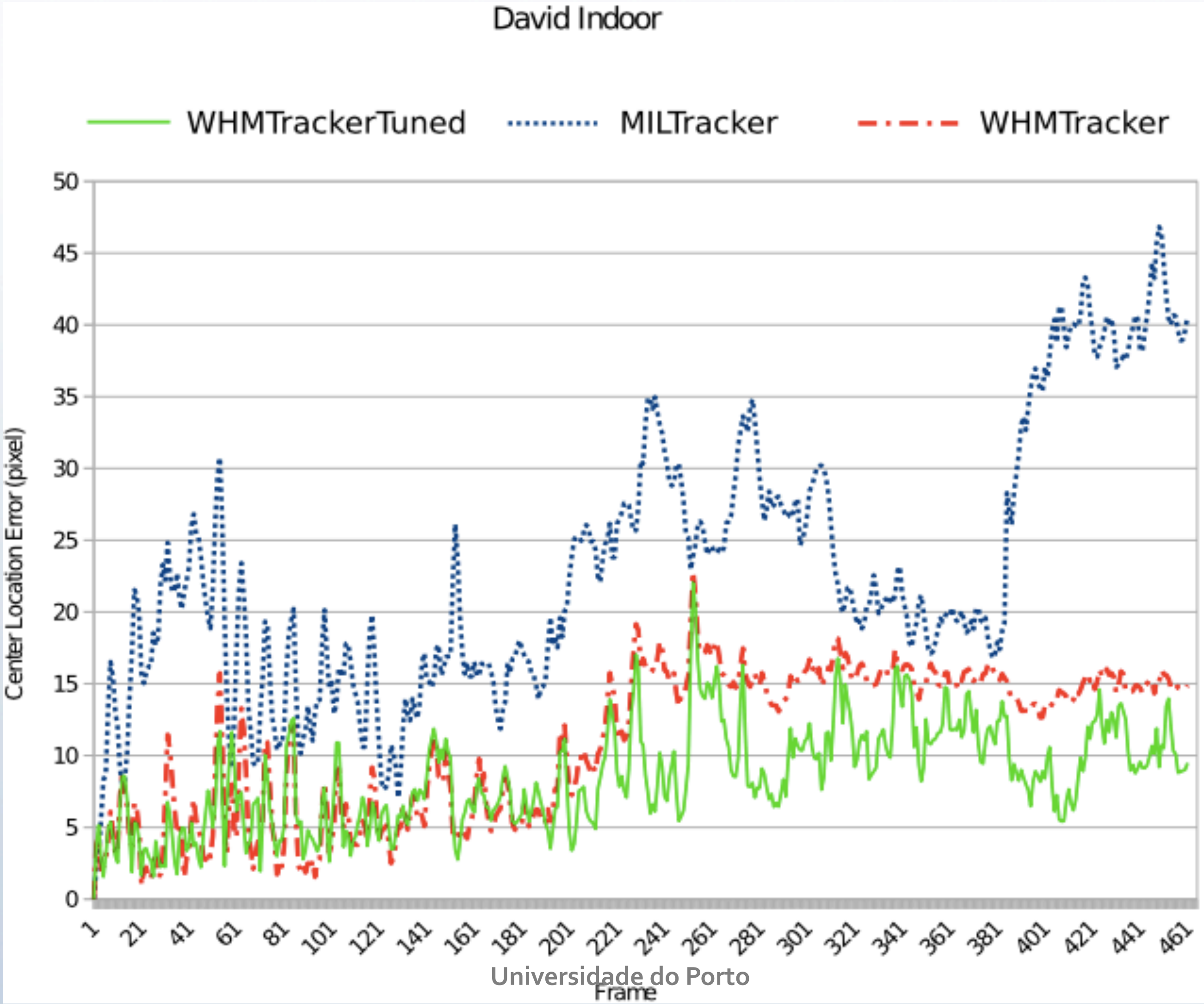
Hierarchic Memory Tracker

- If all the discriminators return scores below the threshold, a new one is trained (D3 = 1.0) .

- D1 = 0.45
- D2 = 0.3

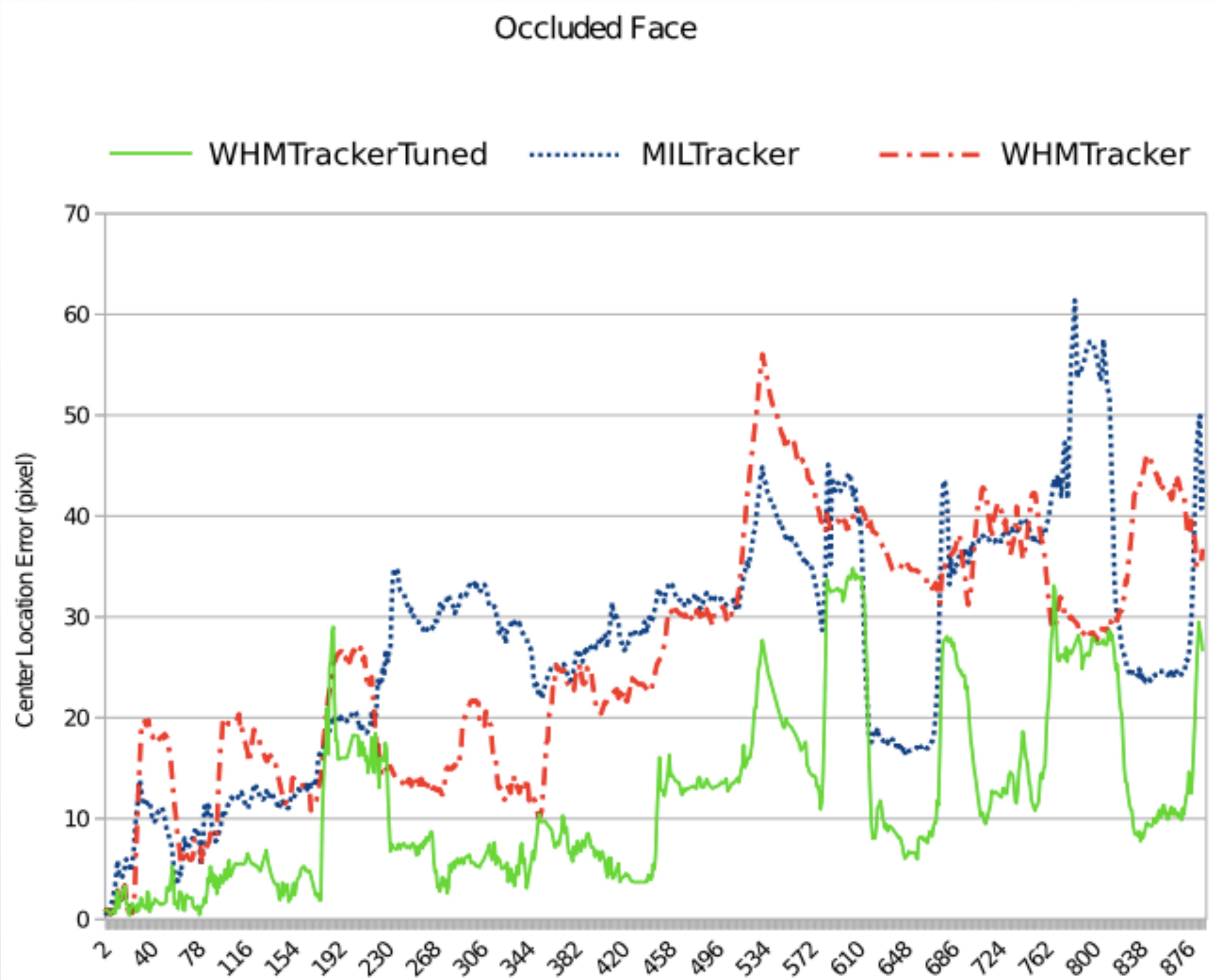
Follow an object identified in the first frame

Results – Average Center Location Errors

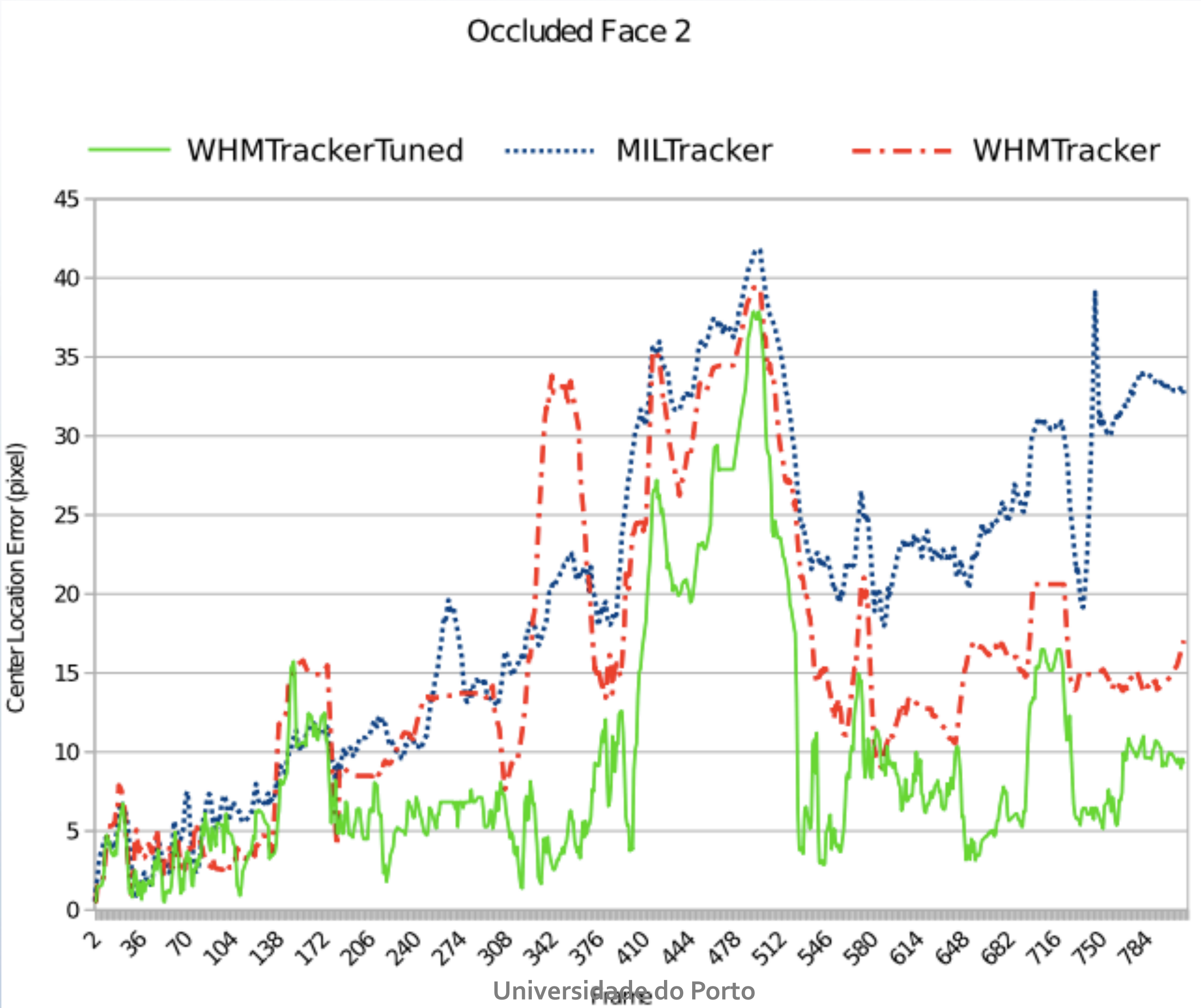


Follow an object identified in the first frame

Results - Average Center Location Errors

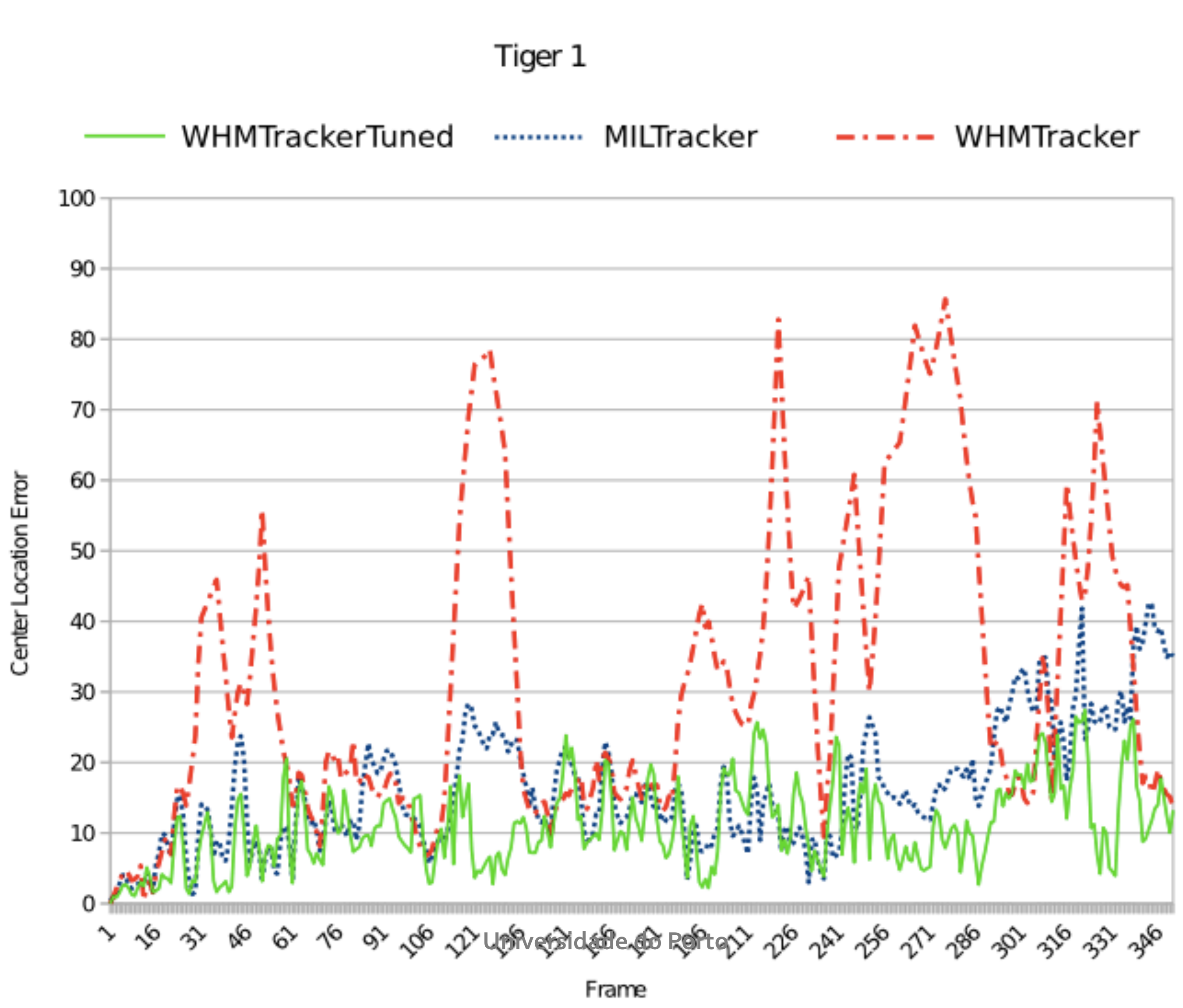


Results – Average Center Location Errors

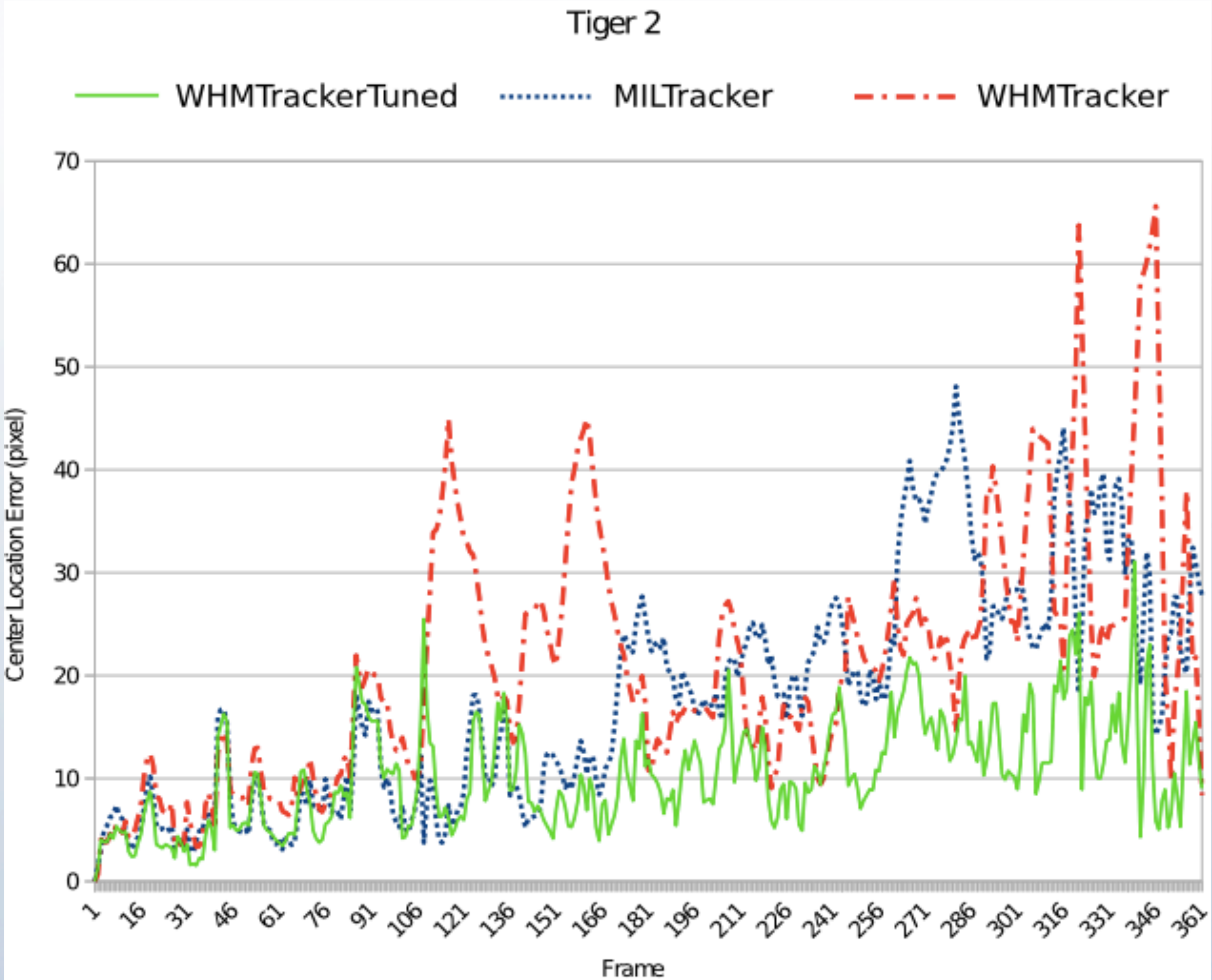


Follow an object identified in the first frame

Results – Average Center Location Errors



Results – Average Center Location Errors



WiSARD in action 13: Multi-target tracker

Multi-target & Pose estimation

WiSARD in action 14: computational linguistics

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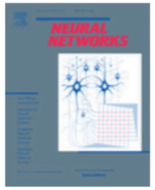

Multilingual part-of-speech tagging with weightless neural networks

CrossMark

Hugo C.C. Carneiro [a,*], Felipe M.G. França [a], Priscila M.V. Lima [b]

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ABSTRACT

Training part-of-speech taggers (POS-taggers) requires iterative time-consuming convergence-dependable steps, which involve either expectation maximization or weight balancing processes, depending on whether the tagger uses stochastic or neural approaches, respectively. Due to the complexity of these steps, multilingual part-of-speech tagging can be an intractable task, where as the number of languages increases so does the time demanded by these steps. WiSARD (**Wi**lkie, **S**tonham and **A**leksander's **R**ecognition **D**evice), a weightless artificial neural network architecture that proved to be both robust and efficient in classification tasks, has been previously used in order to turn the training phase faster. WiSARD is a RAM-based system that requires only one memory writing operation to train each sentence. Additionally, the mechanism is capable of learning new tagged sentences during the classification phase, on an incremental basis. Nevertheless, parameters such as RAM size, context window, and probability bit mapping, make the multilingual part-of-speech tagging task hard. This article proposes mWANN-Tagger (**m**ultilingual **W**eightless **A**rtificial **N**eural **N**etwork **tagger**), a WiSARD POS-tagger. This tagger is proposed due to its one-pass learning capability. It allows language-specific parameter configurations to be thoroughly searched in quite an agile fashion. Experimental evaluation indicates that mWANN-Tagger either outperforms or matches state-of-art methods in accuracy with very low standard deviation, i.e., lower than 0.25%. Experimental results also suggest that the vast majority of the languages can benefit from this architecture.

WiSARD in action 15: computational linguistics

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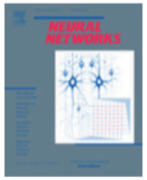
journal homepage: www.elsevier.com/locate/neunet



A universal multilingual weightless neural network tagger via quantitative linguistics

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Part-of-speech tagging
Weightless neural networks
Zipf's law
Lexical diversity

ABSTRACT

In the last decade, given the availability of corpora in several distinct languages, research on multilingual part-of-speech tagging started to grow. Amongst the novelties there is mWANN-Tagger (**m**ultilingual **w**eightless **a**rtificial **n**eural **n**etwork **tagger**), a weightless neural part-of-speech tagger capable of being used for mostly-suffix-oriented languages. The tagger was subjected to corpora in eight languages of quite distinct natures and had a remarkable accuracy with very low sample deviation in every one of them, indicating the robustness of weightless neural systems for part-of-speech tagging tasks. However, mWANN-Tagger needed to be tuned for every new corpus, since each one required a different parameter configuration. For mWANN-Tagger to be truly multilingual, it should be usable for any new language with no need of parameter tuning. This article proposes a study that aims to find a relation between the lexical diversity of a language and the parameter configuration that would produce the best performing mWANN-Tagger instance. Preliminary analyses suggested that a single parameter configuration may be applied to the eight aforementioned languages. The mWANN-Tagger instance produced by this configuration was as accurate as the language-dependent ones obtained through tuning. Afterwards, the weightless neural tagger was further subjected to new corpora in languages that range from very isolating to polysynthetic ones. The best performing instances of mWANN-Tagger are again the ones produced by the universal parameter configuration. Hence, mWANN-Tagger can be applied to new corpora with no need of parameter tuning, making it a universal multilingual part-of-speech tagger. Further experiments with Universal Dependencies treebanks reveal that mWANN-Tagger may be extended and that it has potential to outperform most state-of-the-art part-of-speech taggers if better word representations are provided.

WiSARD : recent theoretical results

Home | Neural Computation | List of Issues | Early Access | The Exact VC Dimension of the WiSARD *n*-Tuple Classifier

Monthly
288pp. per issue
6 x 9, illustrated
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The Exact VC Dimension of the WiSARD *n*-Tuple Classifier

Hugo C. C. Carneiro, Carlos E. Pedreira, Felipe M. G. França and Priscila M. V. Lima

Posted Online November 21, 2018
https://doi.org/10.1162/neco_a_01149

Neural Computation
Early Access
p.1-32

Abstract

The Wilkie, Stoneham, and Aleksander recognition device (WiSARD) n-tuple classifier is a multiclass weightless neural network capable of learning a given pattern in a single step. Its architecture is determined by the number of classes it should discriminate. A target class is represented by a structure called a discriminator, which is composed of N RAM nodes, each of them addressed by an n-tuple. Previous studies were carried out in order to mitigate an important problem of the WiSARD n-tuple classifier: having its RAM nodes saturated when trained by a large data set. Finding the VC dimension of the WiSARD n-tuple classifier was one of those studies. Although no exact value was found, tight bounds were discovered. Later, the bleaching technique was proposed as a means to avoid saturation. Recent empirical results with the bleaching extension showed that the WiSARD n-tuple classifier can achieve high accuracies with low variance in a great range of tasks. Theoretical studies had not been conducted with that extension previously. This work presents the exact VC dimension of the basic two-class WiSARD n-tuple classifier, which is linearly proportional to the number of RAM nodes belonging to a discriminator, and exponentially to their addressing tuple length, precisely $N(2^n - 1) + 1$. The exact VC dimension of the bleaching extension to the WiSARD n-tuple classifier, whose value is the same as that of the basic model, is also produced. Such a result confirms that the bleaching technique is indeed an enhancement to the basic WiSARD n-tuple classifier as it does no harm to the generalization capability of the original paradigm.

Vapnik–Chervonenkis dimension – measures the capacity (complexity, expressive power, richness, or flexibility) of a space of functions that can be learned by a classification algorithm.

Conclusions, Ongoing and Future Work

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NGD Systems announces availability of industry's first Computational Storage

"Bringing Intelligence to Storage"

NEWS PROVIDED
NGD Systems →
Jul 25, 2017, 07:5

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SSD. Capable of
available in PCIe

"Orange, like m
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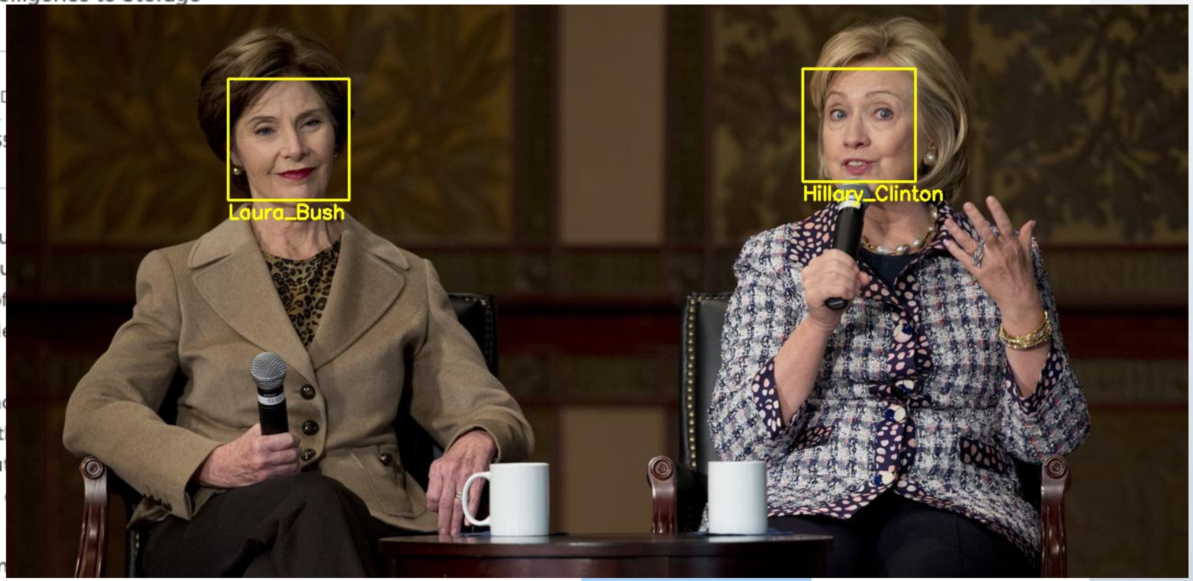
computational

In a recent dem
wholly owned subsidiary of Orange SA, a facial recognition application utilizing a weightless neural network algorithm ran directly on an NGD Systems SSD including the training phase, without needing to transfer data to the host. "NGD Systems' vision of bringing intelligence to storage is now a reality. Advanced applications like embedded Artifical Intelligence (AI) and machine learning, which are by nature IO intensive, can run within the storage device," said Nader Salessi, Founder & CEO at NGD Systems.



In situ processing!

Conclusions, Ongoing and Future Work

ESANN'2009

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

1[st] BRICS Countries Congress (BRICS-CCI) and 11[th] Brazilian Congress (CBIC) on Computational Intelligence

BRICS-CCI & CBIC 2013

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

International Supporting Societies

IEEE Computational Intelligence Society

Association for Computing Machinery

The International Neural Network Society (INNS)

National Supporting Societies

Brazilian Russian Indian Chinese

Conclusions, Ongoing and Future Work

ESANN 2014

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

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)

09h00 Advances on Weightless Neural Systems

- 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

Wednesday 22 April 2015

09h00 ***Opening***

09h10 **Prototype-based and weightless models**

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

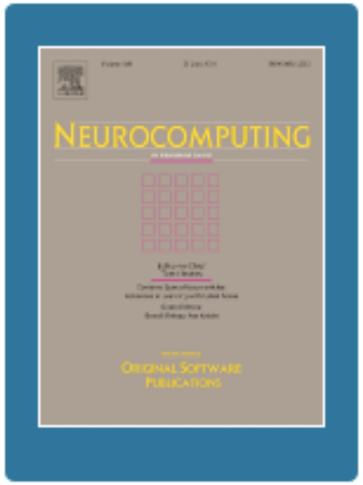
- Daniel Nascimento, Federal University of Rio de Janeiro (Brazil)
- Rafael Carvalho, Federal University of Tocantins (Brazil)
- Felix Mora-Camino, École Nationale de l'Aviation Civile (France)
- Priscila Lima, Federal University of Rio de Janeiro (Brazil)
- Felipe França, Federal University of Rio de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



Neurocomputing

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

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

Bruges (Belgium), 24 - 26 April 2019

Special sessions

Special sessions are organized by renowned scientists in their respective fields. Papers submitted to these sessions are reviewed according to the same rules as any other submission. Authors who submit papers to one of these sessions are invited to mention it on the author submission form; submissions to the special sessions must follow the same format, instructions and deadlines as any other submission, and must be sent according to the same procedure.

The following special sessions will be organized at ESANN2019:

- **60 Years of Weightless Neural Systems**
  Organized by Priscila M. V. Lima (Universidade Federal do Rio de Janeiro, Brazil), Felipe M. G. França (Universidade Federal do Rio de Janeiro, Brazil), Massimo De Gregorio (Ist. di Sci. Appl. e Sistemi Intelligenti, Italy), Wilson R. de Oliveira (Univ. Fed. Rural Pernambuco, Brazil)
- **Statistical physics of learning and inference**
  Organized by Michael Biehl (University of Groningen, The Netherlands), Nestor Caticha (Univ. Sao Paulo, Brazil), Manfred Opper (TU Berlin, Germany), Thomas Villmann (HU Mittweida, Germany)
- **Streaming data analysis, concept drift and analysis of dynamic data sets**
  Organized by Albert Bifet (Télécom ParisTech, France), Barbara Hammer (Bielefeld University, Germany), Frank-Michael Schleif (University of Applied Sciences Würzburg-Schweinfurt, Germany)

60 Years of Weightless Neural Systems
Organized by Priscila M. V. Lima (Universidade Federal do Rio de Janeiro, Brazil), Felipe M. G. França (Universidade Federal do Rio de Janeiro, Brazil), Massimo De Gregorio (Ist. di Sci. Appl. e Sistemi Intelligenti, Italy), Wilson R. de Oliveira (Univ. Fed. Rural Pernambuco, Brazil)

Mimicking biological neurons by focusing on the decoding performed by the dendritic trees is an attractive alternative to the integrate-and-fire McCullogh-Pitts neuron stylisation. RAM-based, or Boolean neurons, and weightless neural systems have been studied and applied in a broad spectrum of situations, resulting in theoretical findings and the development of exciting applications to an ample set of domains, ranging from natural language processing to game playing, including memory transfer mechanisms, biomedical applications, computational vision, hardware security, and quantum learning.

The year of 2019 marks the 60-years anniversary of the seminal paper on n-tuple classifiers by Bledsoe and Browning, as well as the 35-years of the WiSARD model, and the tenth anniversary of the first special session on weightless neural systems at ESANN. This session invites original contributions on theoretical and practical aspects of weightless neural systems at all levels of abstraction, as well as their relationship to themes of current interest such as: deep learning, convolutional neural models, adversarial learning, etc.

Thank you, Obrigada!

priscilamvl@gmail.com

UNIVERSIDADE FEDERAL DO RIO DE JANEIRO

Results – Average Center Location Errors

Video Clip	*MILTrack*	*WHMTrack*	*WHMTrackTuned*	*FPS*
Sylvester	**11**	22	8*	87
David Indoor	23	**11**	8*	22
Occluded Face	**27**	**27**	12*	17
Occluded Face 2	20	**16**	9*	28
Tiger 1	**16**	33	11*	45
Tiger 2	**18**	21	10*	43
Coupon Book	**15**	4*	4*	21

[1] The set of videos is available in: `http://vision.ucsd.edu/~bbabenko/project_miltrack.html`

* = BEST results
bold = 2° best

Default and tunned parameters

Video	*Bits*	*New disc.*	*Memory Size*	*Search area*
Default params.	*5*	*0.7*	*6*	*14*
Tiger1	default	0.35	20	14
Tiger2	default	0.35	20	16
Occluded Face	3	0.5	10	10
Occluded Face 2	3	0.5	10	10
David Indoor	6	default	default	10
Sylvester	3	0.8	default	10

Conclusions, Ongoing and Future Work

Video Clip	*TLD*	*MILTrack*	*WHMTrack*	*WHMTrackTuned*	*FPS*
Sylvester	6*	11	22	**8**	87
David Indoor	4*	23	11	**8**	22
Occluded Face	**15**	27	27	12*	17
Occluded Face 2	**13**	20	16	9*	28
Tiger 1	6*	**16**	33	**11**	45
Tiger 2	-	**18**	21	10*	43
Coupon Book	-	**15**	4*	4*	21

[1] The set of videos is available in: `http://vision.ucsd.edu/~bbabenko/project_miltrack.html`

* = BEST results
bold = 2° best

Z. Kalal, K. Mikolajczyk, and J. Matas, Tracking-Learning-Detection, *IEEE Trans. on Pattern Analysis and Machine Intelligence*, 60(1), Jan 2010.