AAMAS 2021 ONLINE, MAY 3–7

P.PORTO

gecad Research Group on Intelligent Engineering and Computing for Advanced Innovation and Development

Agent-based machine learning

Tutorial

Cyber-physical multi-agent systems

Tiago Pinto

Polytechnic of Porto

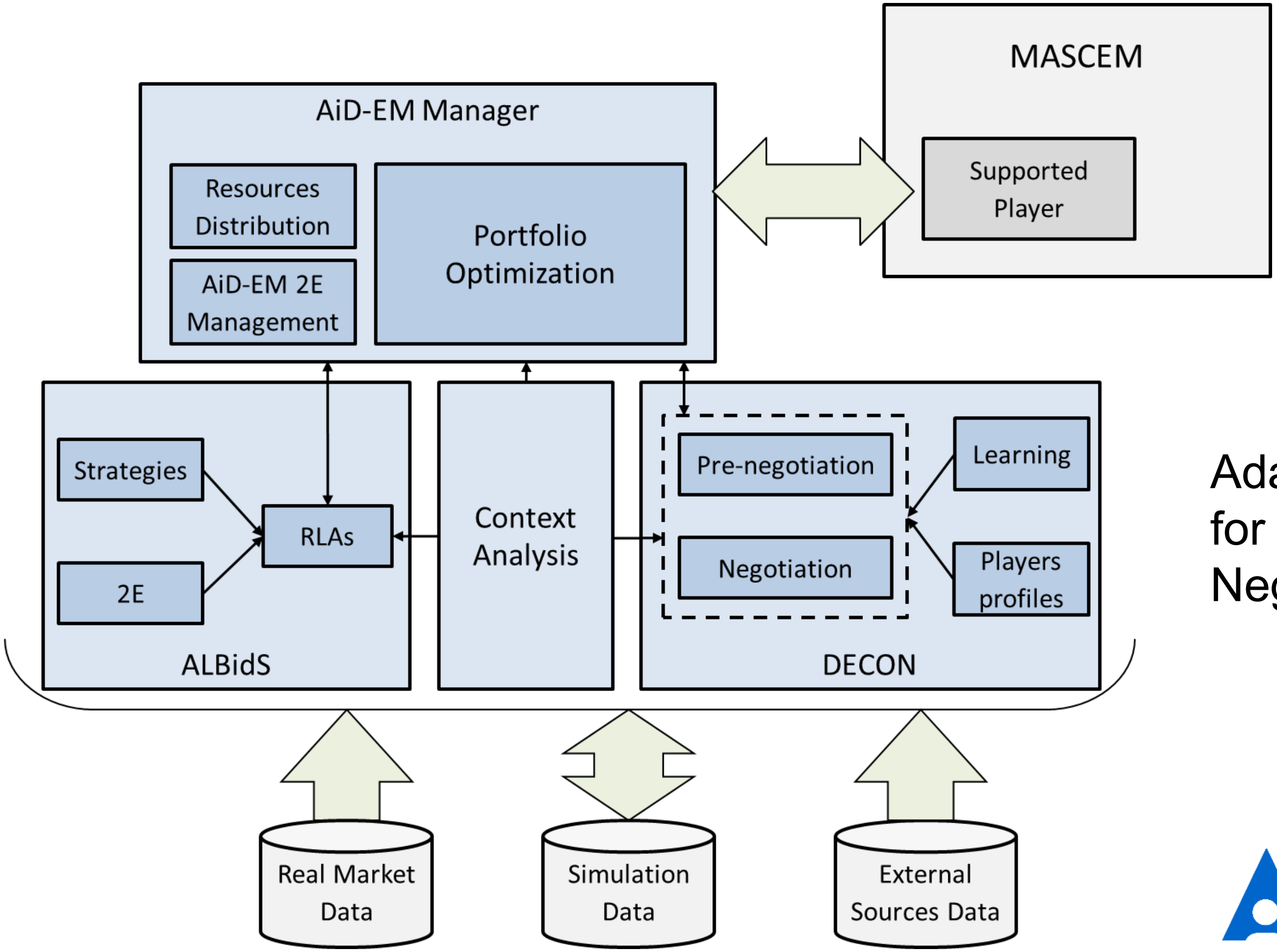
tcp@isep.ipp.pt

FCT Fundação para a Ciência e a Tecnologia

PORTUGAL 2020

EUROPEAN UNION
European Regional Development Fund

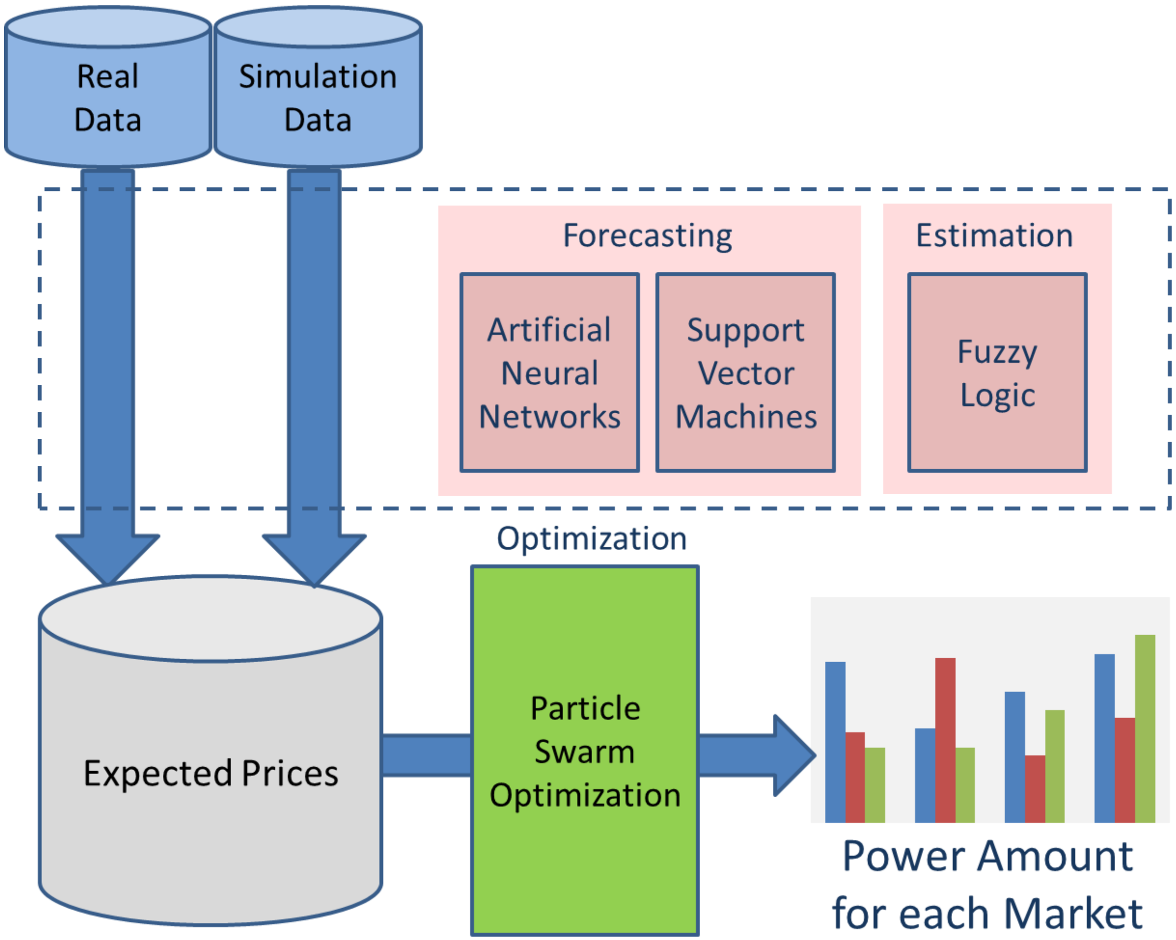
AiD-EM



Adaptive Decision Support for Electricity Market Negotiations

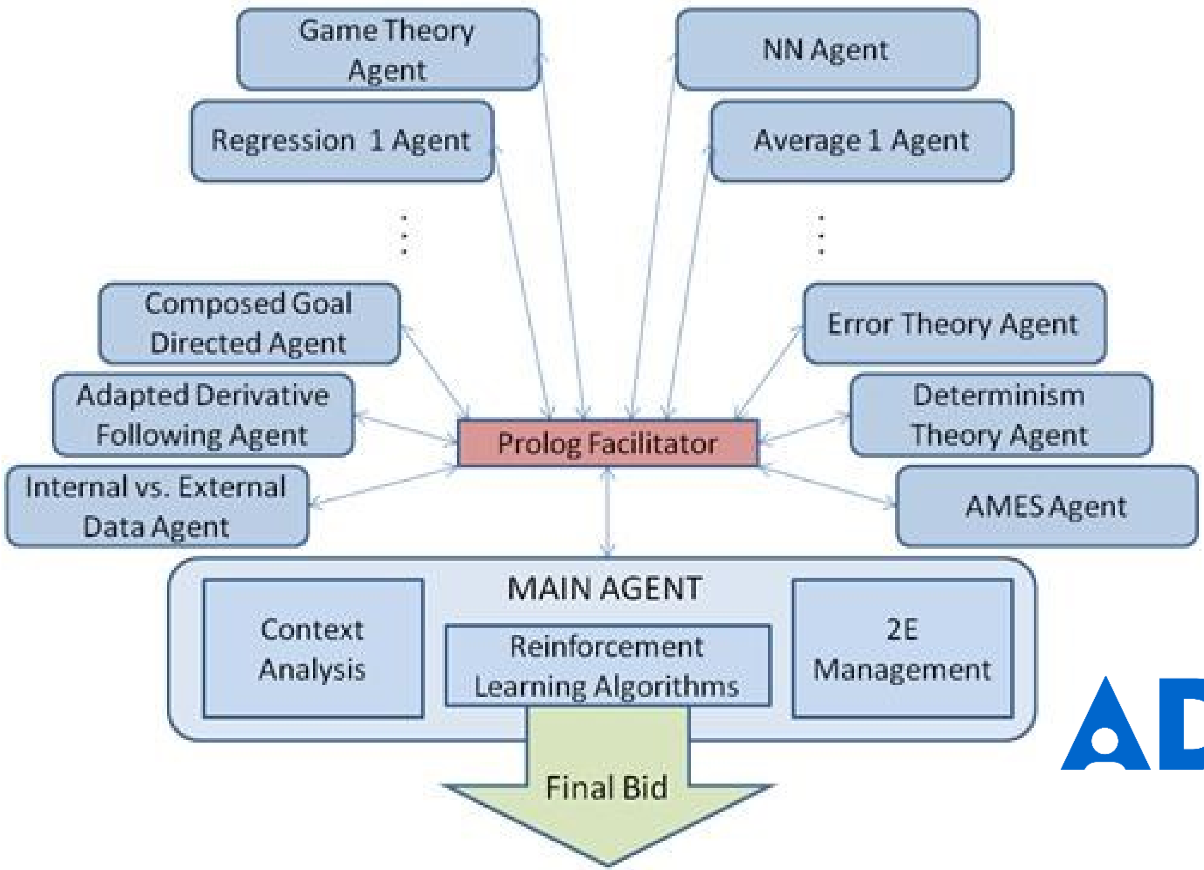
ADAPT

Portfolio Optimization



ALBidS

Adaptive Learning Strategic Bidding System



ADAPT

AAMAS2021 ONLINE, MAY 3–7

gecad

ALBidS

– Main Agent

– A simple reinforcement learning algorithm

$$C_{t+1} = C_t - \left|\left(R - P\right)\right|$$

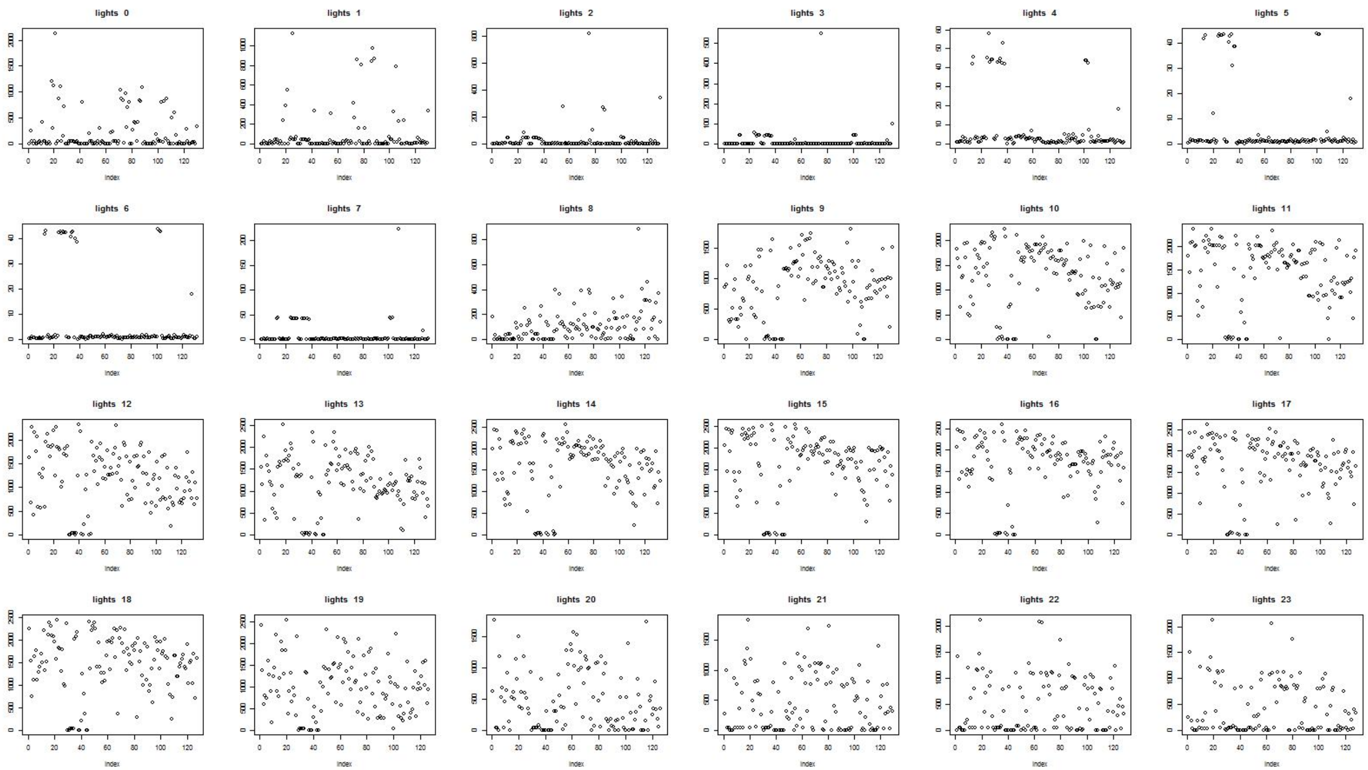
– The revised Roth-Erev reinforcement learning algorithm, including a weight value W for the definition of the importance of past experience

$$C_{t+1} = C_t \times W - \left|\left(R - P\right)\right| \times \left(1 - W\right)$$

– A learning algorithm based on the Bayes theorem of probability

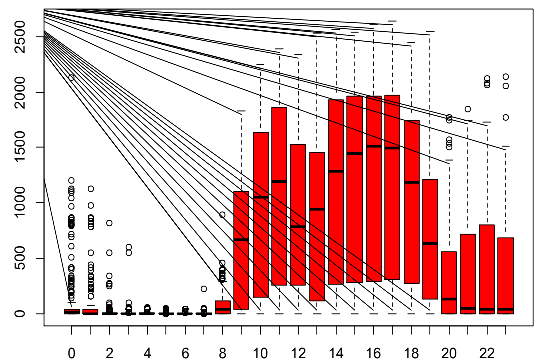
$$EU\left(A|E\right) = \sum_i P(O_i \mid E, A) \times U(O_i \mid A)$$

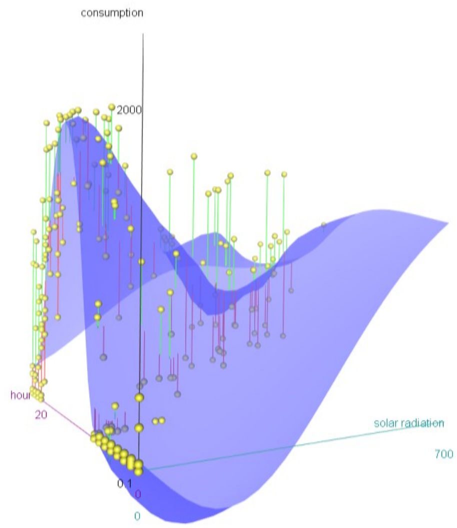
Energy consumption forecasting



Energy consumption forecasting

Boxplot shows that consumption between hours 9 and 23 is very variable

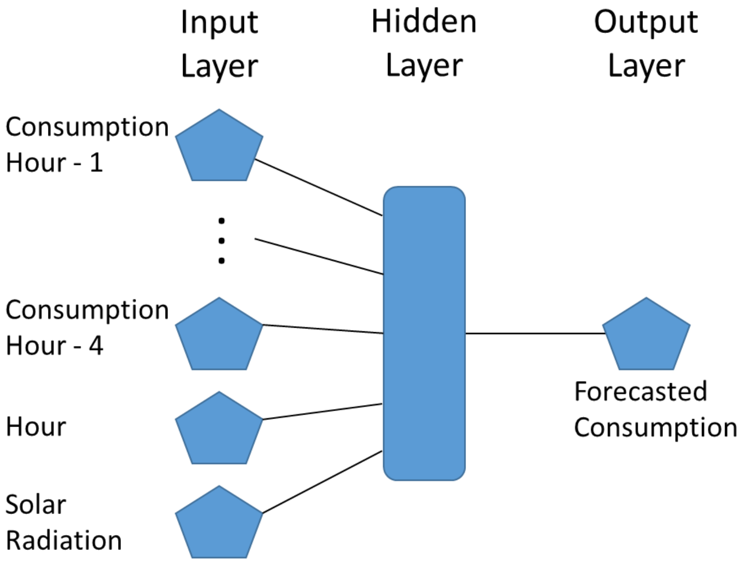




When the solar radiation is lower the consumption of lights is higher in most hours

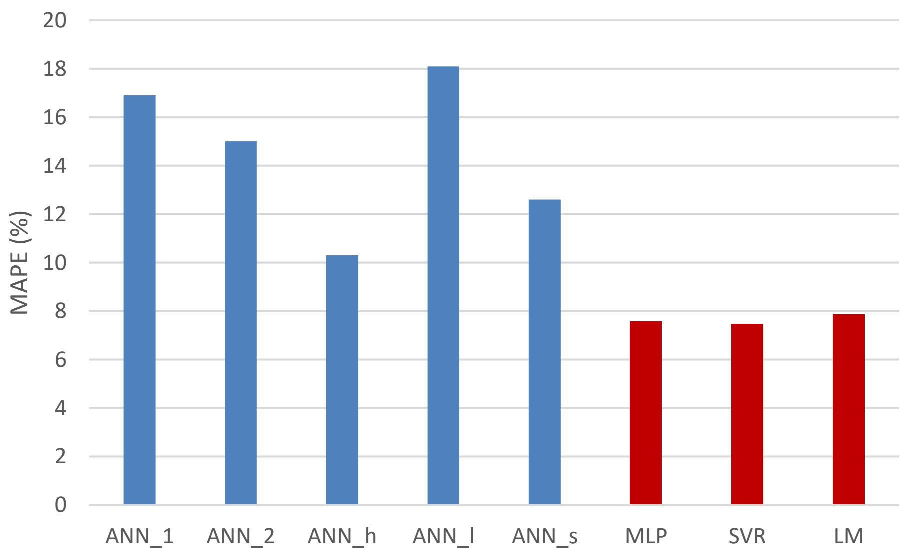
Energy consumption forecasting

- Feedforward ANN



Energy consumption forecasting

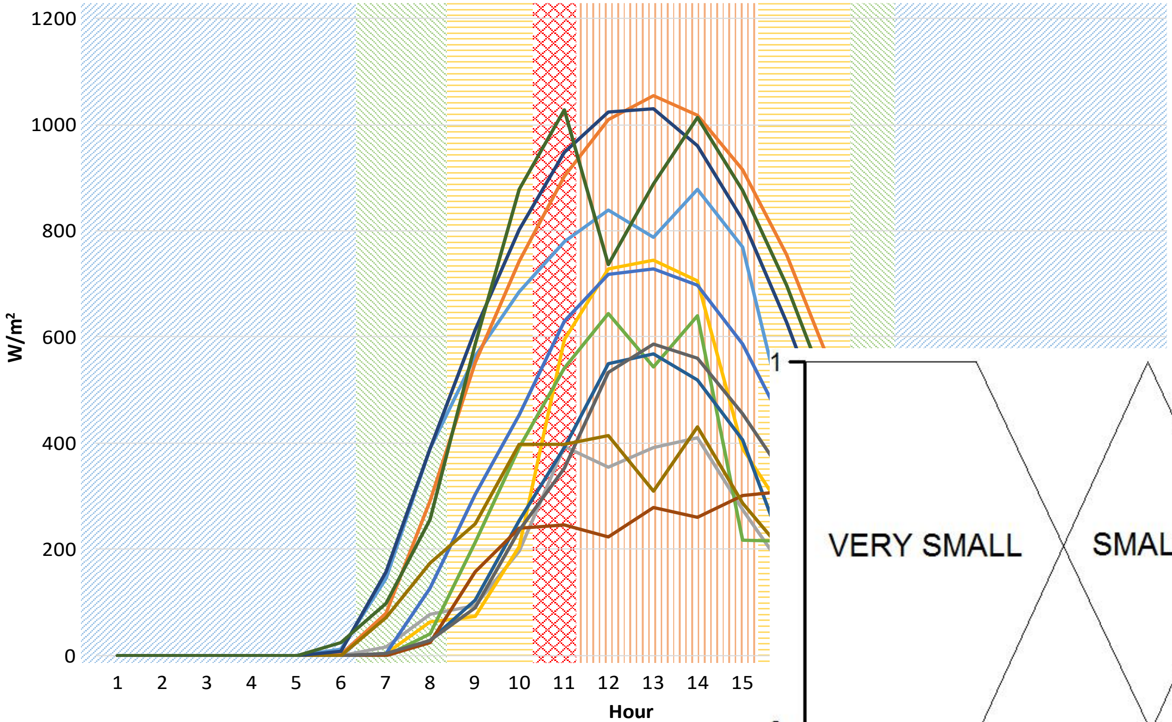
Method	MAPE(%)	Description
ANN_1	16.9	Input: Contextual data Output (1): Total consumption
ANN_2	15.0	Input: Contextual data Outputs (3): Consumption of HVAC, lights, sockets
ANN_h	10.3	Input: Contextual data and external data Output: Consumption of HVAC
ANN_l	18.1	Input: Contextual data and external data Output: Consumption of lights
ANN_s	12.6	Input: Contextual data and external data Output: Consumption of sockets
MLP	**7.57**	**Input: Hour, solar radiation, consumption** **Output: Consumption of lights**
SVR	**7.48**	**Input: Hour, solar radiation, consumption** **Output: Consumption of lights**
LM	**7.87**	**Input: Hour, solar radiation, consumption** **Output: Consumption of lights**

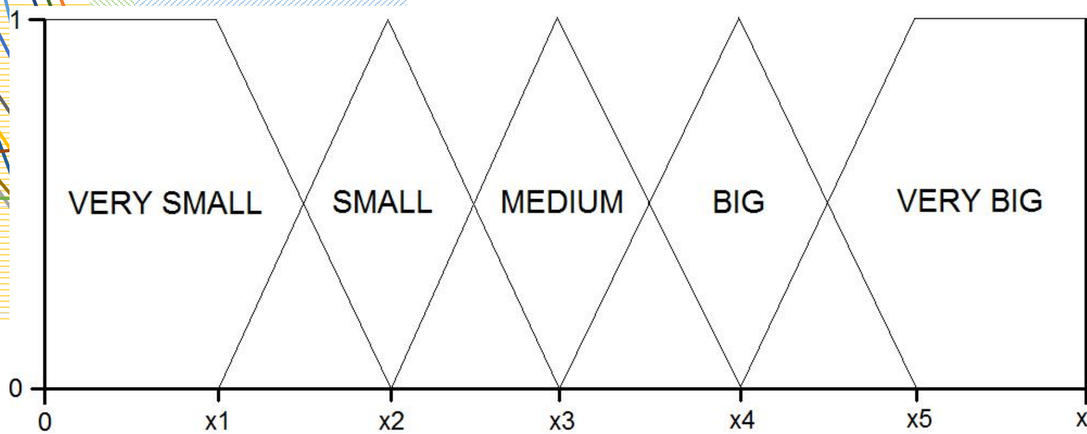


- The three methods present lower forecasting errors than previous approaches

Fuzzy Rule-Based Systems (FRBS)

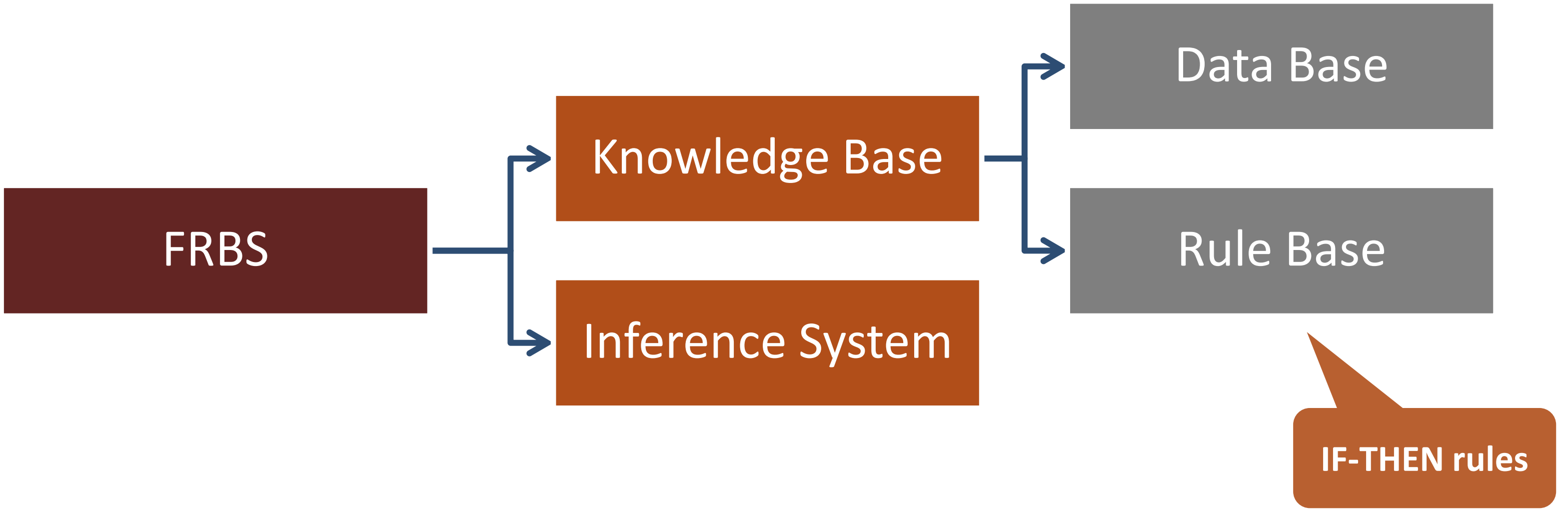
- Combines Fuzzy Logic with forecasting
- Generates fuzzy rules from numeric input data
- Decreases the time spent in the learning process





Fuzzy Rule-Based Systems (FRBS)

- The architecture is essentialy composed by knowledge base module and inference system module



Fuzzy Rule-Based Systems (FRBS)

1. FRBS based on space partition
2. FRBS based on neural networks
3. FRBS based on clustering approaches
4. FRBS based on genetic algorithms
5. FRBS based on gradient descent

Contextual Learning

Generic *F(x)*

Best solution for all situations?

Energy 85 (2015) 78–93

Contents lists available at ScienceDirect

Energy

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

Negotiation context analysis in electricity markets

Tiago Pinto*, Zita Vale [1], Tiago M. Sousa, Isabel Praça

GECAD - Knowledge Engineering and Decision Support Research Centre - Polytechnic of Porto (IPP), R. Dr. António Bernardino de Almeida, 431, 4200-072 Porto, Portugal

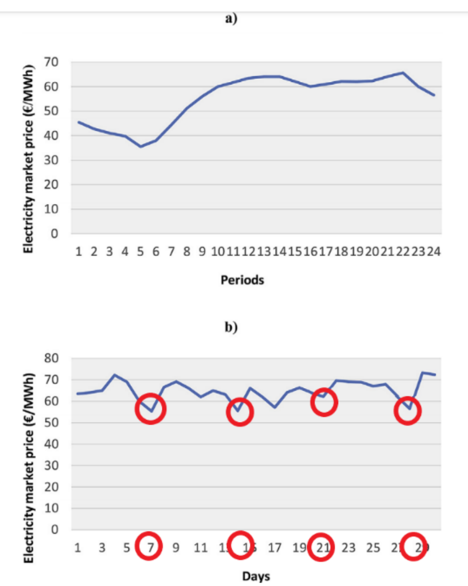


Fig. 2. Evolution of the market price throughout: a) the hourly periods of one day – September 1st 2014, b) the 30 days of September 2014, concerning only one period – period twelve. Adapted from Ref. [8].

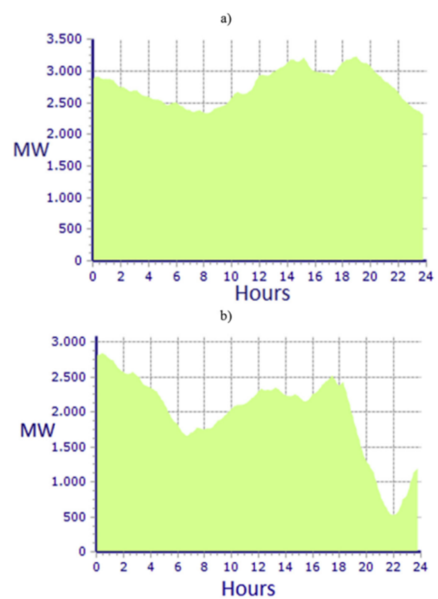


Fig. 3. Wind power generation in the Iberian Peninsula during the 24 h of: a) April, 15th 2012, b) October, 17th 2012. Adapted from Ref. [44].

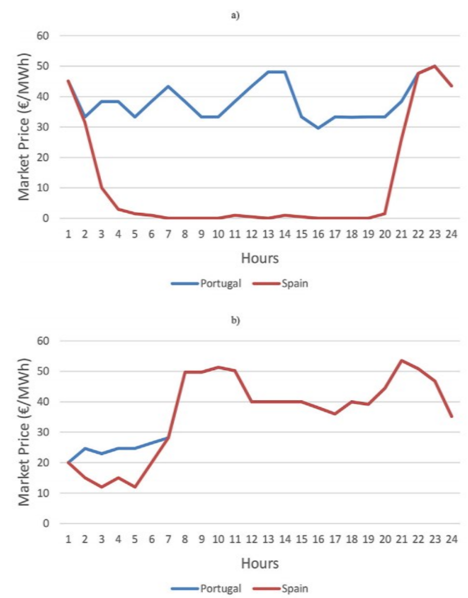
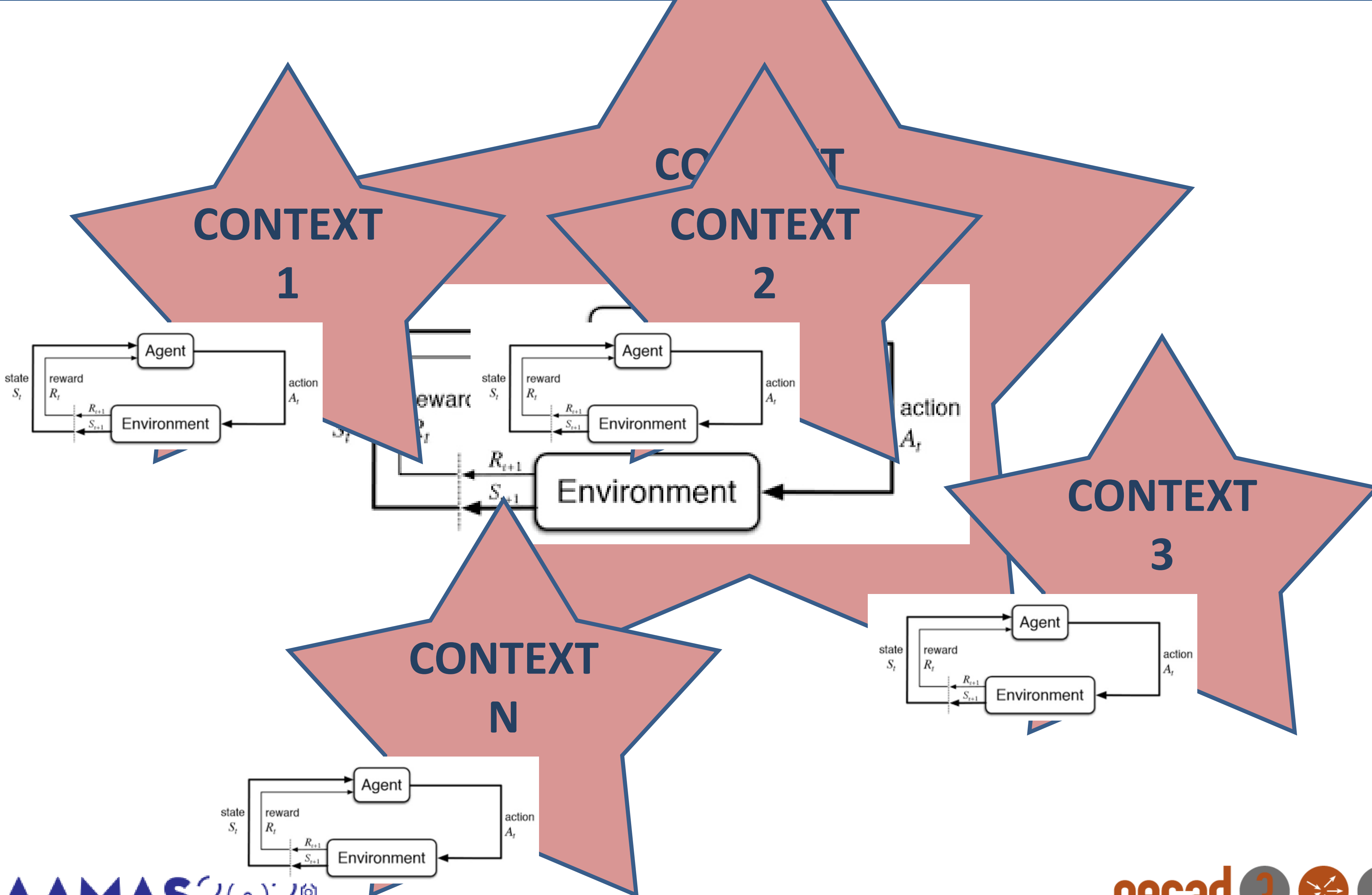


Fig. 4. Variation of the market price in Portugal and Spain throughout the 24 hourly of: a) April, 15th 2012, b) October, 17th 2012. Adapted from Ref. [8].

Contextual Learning



Contextual Learning

24th European Conference on Artificial Intelligence - ECAI 2020
Santiago de Compostela, Spain

Contextual Q-Learning

Tiago Pinto[1] and **Zita Vale**[2]

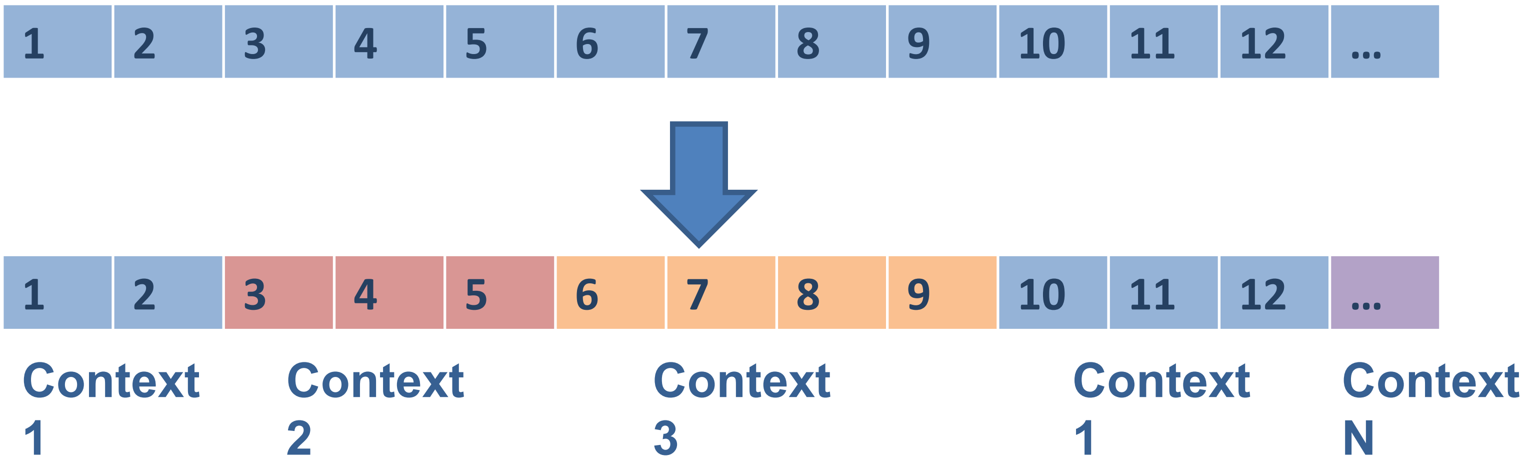
$$Q: c \, x \, s \, \text{x a} \rightarrow U$$

Context | State | Action

Learning rate | Discount factor

$$Q_{t+1}(c_{t,} s_t, a_t)$$
$$= Q_t(c_{t,} s_t, a_t) + \alpha(c_{t,} s_t, a_t)[r_{c,s,at} + \gamma \cdot U_t(s_{t+1}) - Q_t(c_{t,} s_t, a_t)]$$

Contextual Learning

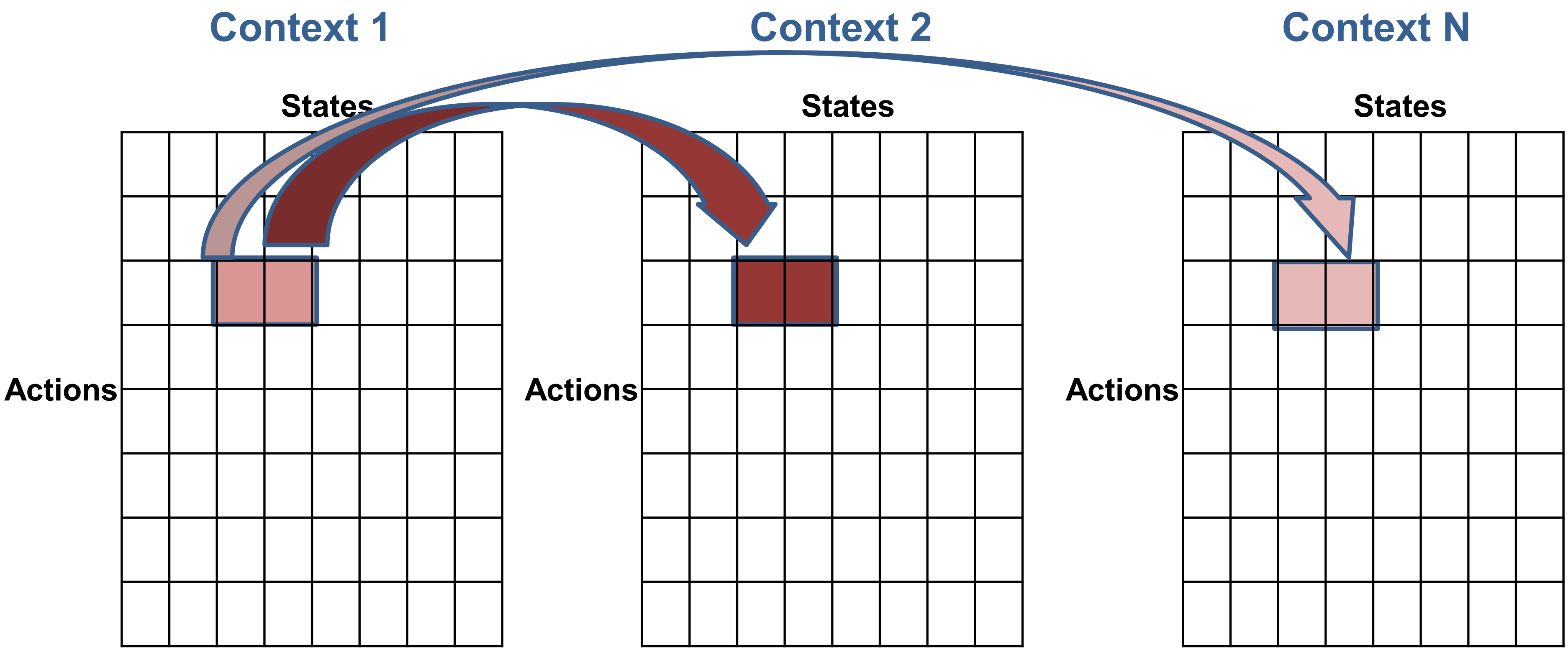


Leads to a smaller number of observations (per context)

Slower learning convergence

Contextual Learning

Transfer learning



Contextual Learning

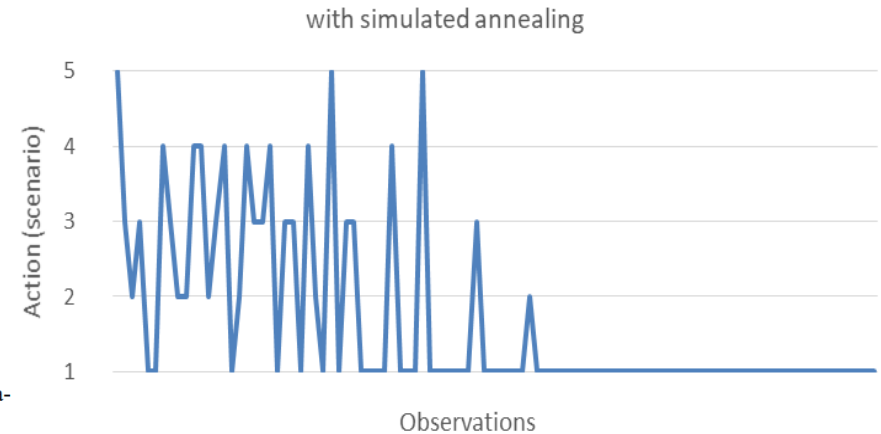
Contextual simulated annealing Q-learning for pre-negotiation of agent-based bilateral negotiations

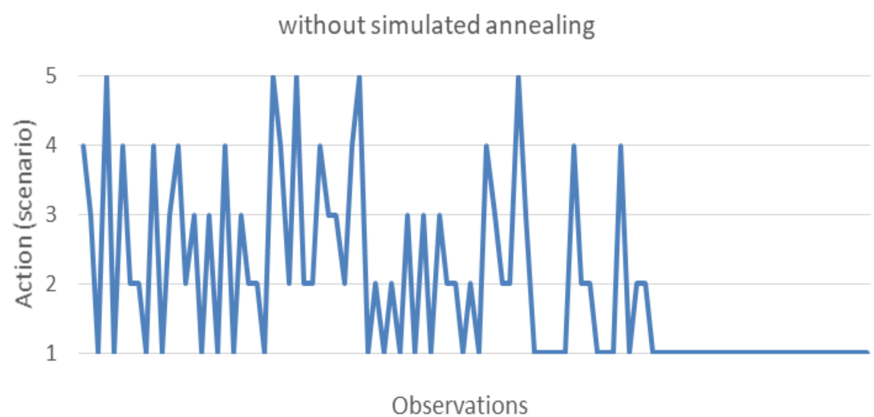
Tiago Pinto[1,2], Zita Vale[2]

[1] GECAD – Research Group on Intelligent Engineering and Computing for Advanced Innovation and Development
[2] Institute of Engineering, Polytechnic of Porto (ISEP/IPP), Portugal
{tcp, zav}@isep.ipp.pt

Abstract. Electricity markets are complex environments, which have been suffering continuous transformations due to the increase of renewable based gen-

Faster convergence with simulated annealing





Efficiency/Effectiveness (2E)

Case-based reasoning for dynamic application of optimization algorithms

Ricardo Faia[1,2], Tiago Pinto[1], Tiago Sousa[3], Zita Vale[4] and Juan Manuel Corchado[2]
[1]GECAD research group, Polytechnic of Porto, Porto, Portugal
[2]BISITE research center, University of Salamanca, Spain
[3]Department of Electrical Engineering, Technical University of Denmark (DTU), Lyngby, Denmark
[4]Polytechnic of Porto, Porto, Portugal

1 Introduction

This paper is an extended abstract from [Faia *et al.*, 2017], presented at the International Conference on Case Based Reasoning (ICCBR) 2017.

With the increase of distributed renewable energy sources

Table 1. Case structure

Type of parameter		Designation
		ID
	A1	ORS problem
		ORS function

Multi-Agent-Based CBR Recommender System for Intelligent Energy Management in Buildings

Tiago Pinto, *Member, IEEE*, Ricardo Faia, Maria Navarro-Caceres, Gabriel Santos, Juan Manuel Corchado, and Zita Vale, *Senior Member, IEEE*

***Abstract*—This paper proposes a novel case-based reasoning (CBR) recommender system for intelligent energy management in buildings. The proposed approach recommends the amount of**

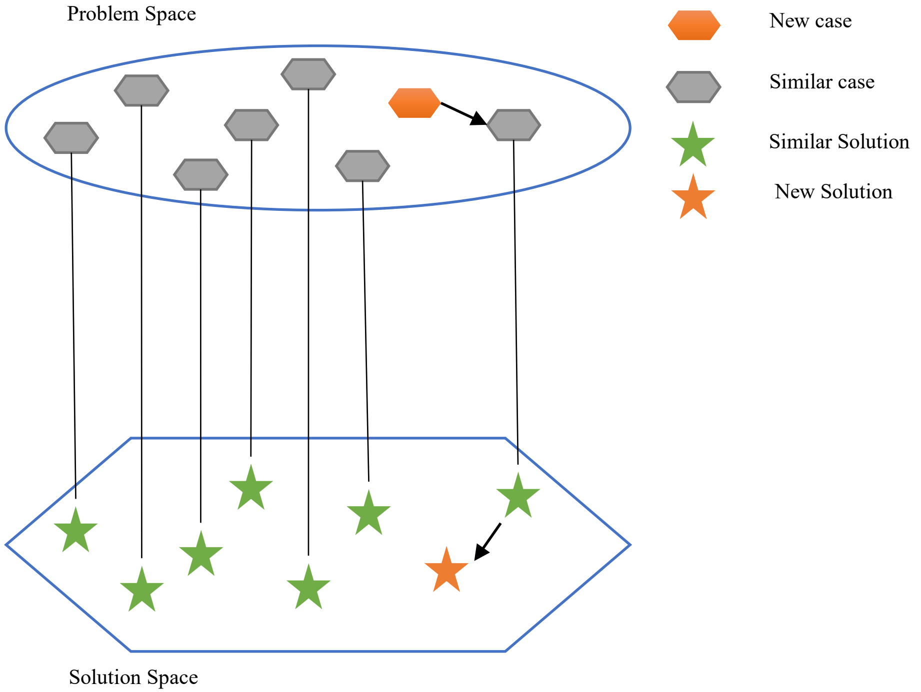
communication between all devices allowing the control, monitoring, and remote access of the management system [5]. Several works deal with the smart home as a house management system

AAMAS 2021 ONLINE, MAY 3–7

gecad

Efficiency/Effectiveness (2E)

- Retrieve — Clustering, K-NN, Decision Trees
- Reuse — SVM, PSO
- Revise — Expert Systems, Fuzzy logic
- Retain



Efficiency/Effectiveness (2E)

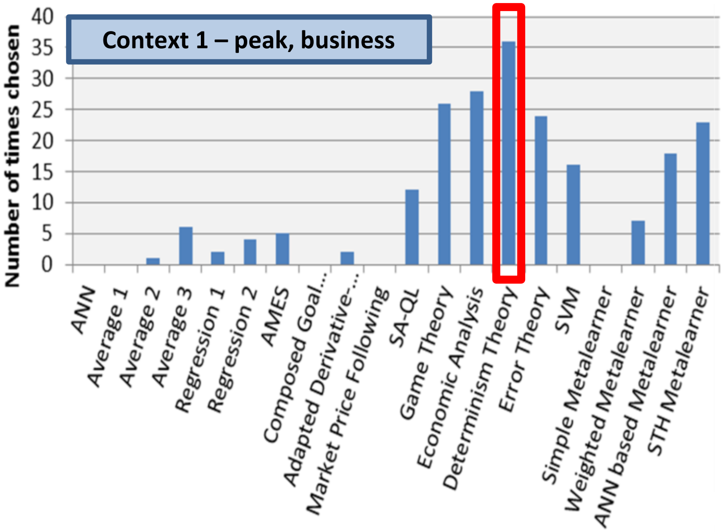
The methods with efficiency classification equal to NEG. automatically are selected to solve the case study

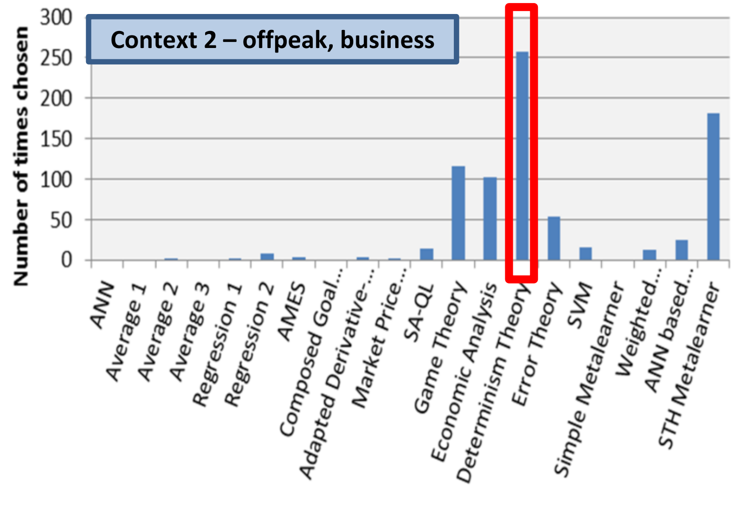
Method	Equation (8)	Confusion Matrix		Type of modification
		Efficiency	Effectiveness	
ERS²A	NEG.	-	-	-
RSA	NEG.	-	-	-
PERS²A	NEG.	-	-	-
SADT	NEG.	-	-	-
PRESPSO	-	VERY SMALL	VERY SMALL	Very small reduction
PSODT	-	VERY SMALL	VERY SMALL	Very small reduction
PSO	-	VERY SMALL	SMALL	Small reduction
HSA	-	VERY SMALL	VERY SMALL	Very small reduction
PERSGA	-	VERY SMALL	VERY SMALL	Very small reduction
GADT	-	VERY SMALL	VERY SMALL	Very small reduction

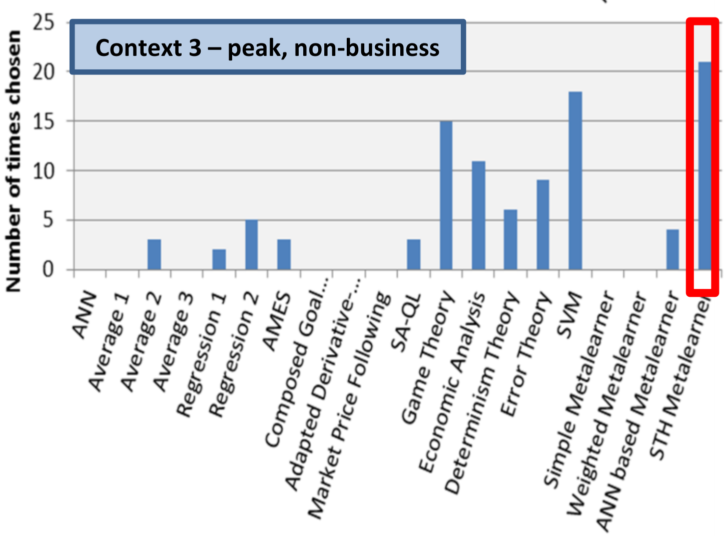
Other methods are subject to a Fuzzy confusion matrix

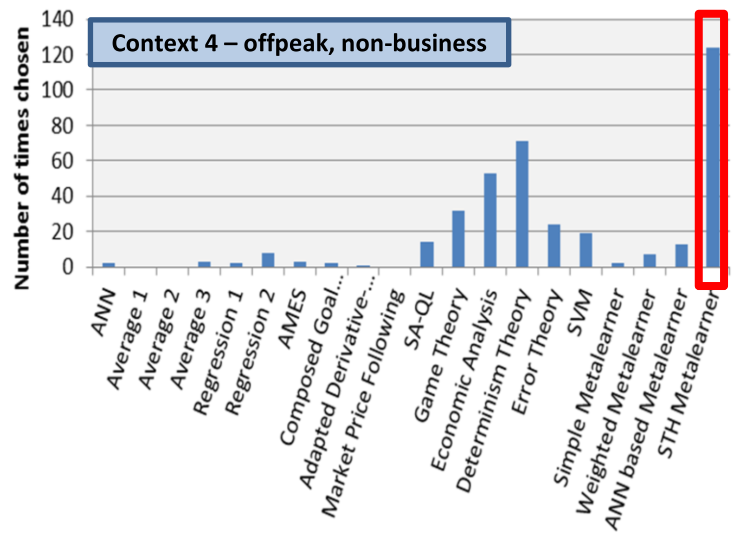
The modification type is applied in method parameters

Results



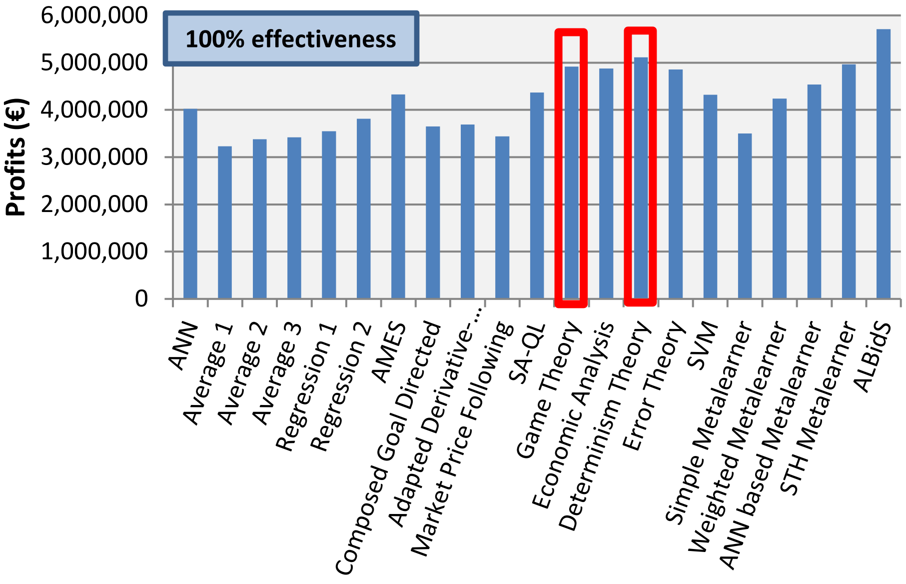


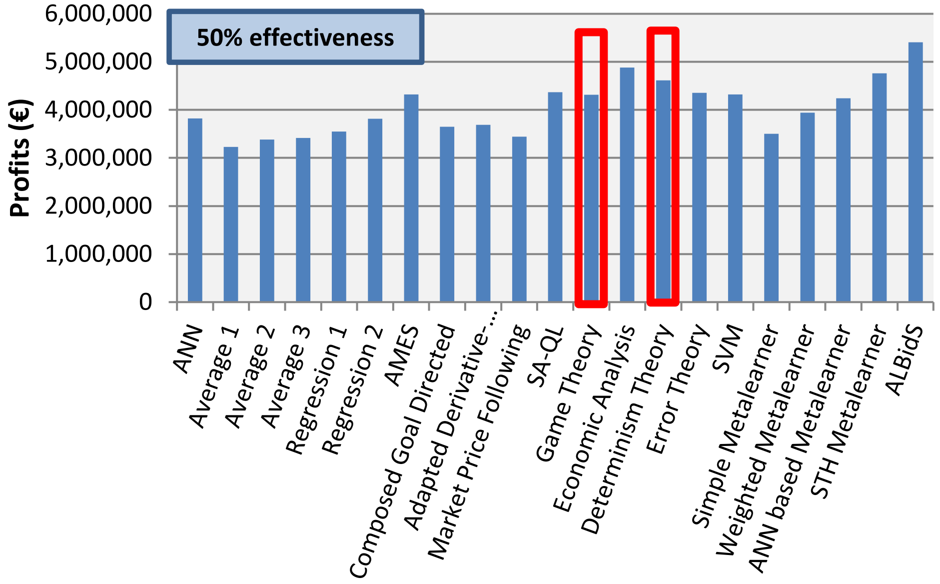


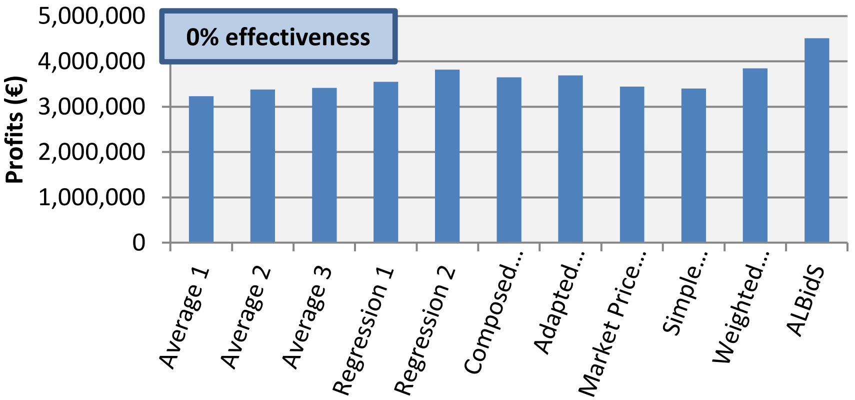


In **different contexts**, **different strategies** are chosen

Results

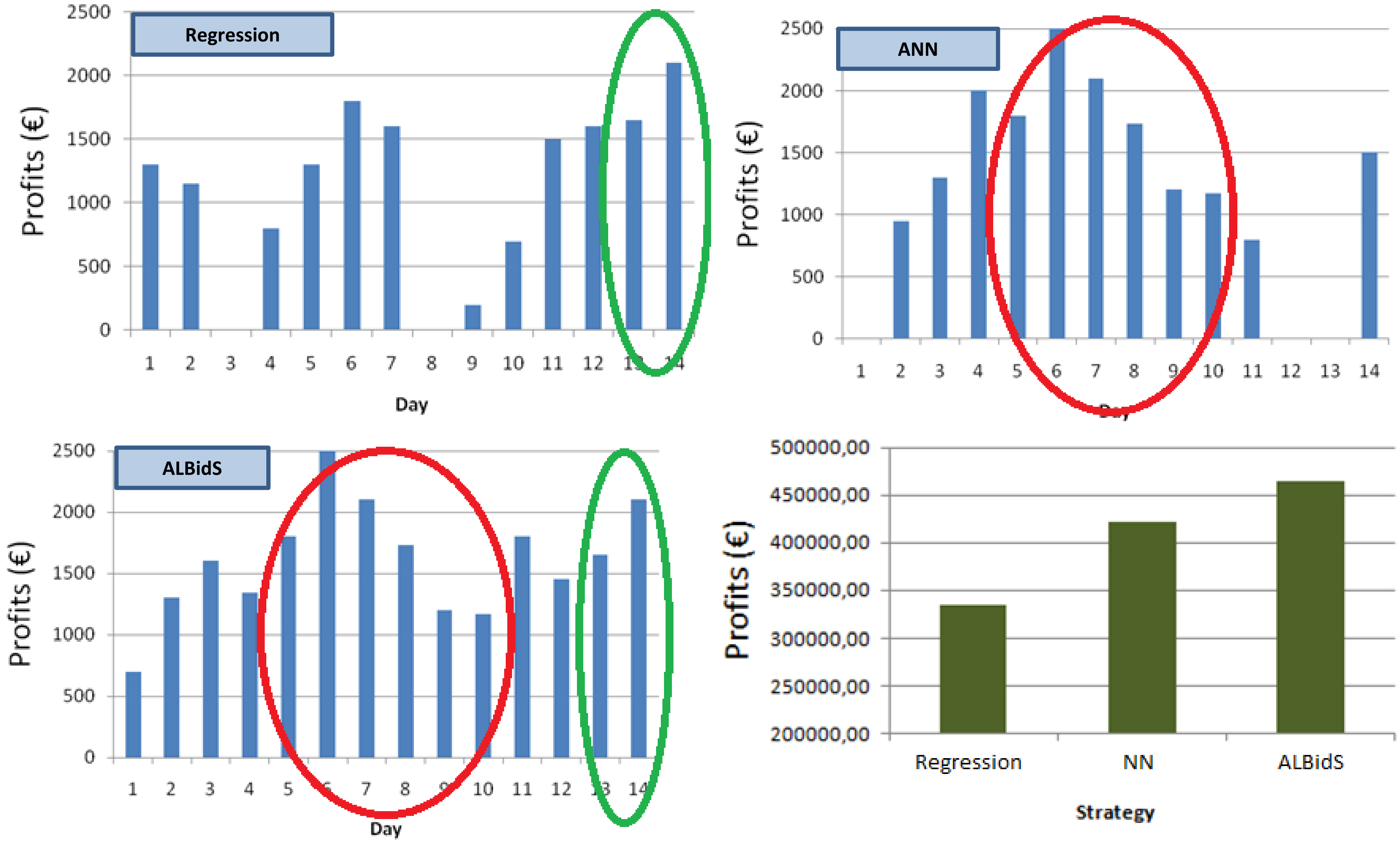






- **100% effectiveness:** all strategies are executed at their full potential
- **50% effectiveness:** all strategies are executed with a reduction in execution times – reflected in their performance (e.g. game theory and determinism theory)
- **0% effectiveness :** only the fastest strategies are executed

Results



www.MASCEM.com/casos.aspx

Thank you

Please contact me for any questions or comments

tcp@isep.ipp.pt

https://scholar.google.com/citations?user=RfV9O88AAAAJ&hl=pt-PT&oi=ao

P.PORTO

gecad

Research Group on Intelligent Engineering and Computing for Advanced Innovation and Development

AAMAS2021
ONLINE, MAY 3–7

P.PORTO

gecad
Research Group on Intelligent Engineering and Computing for Advanced Innovation and Development

Agent-based machine learning

Tutorial

Cyber-physical multi-agent systems

Tiago Pinto
Polytechnic of Porto
tcp@isep.ipp.pt

FCT Fundação para a Ciência e a Tecnologia
PORTUGAL 2020
EUROPEAN UNION
European Regional Development Fund