Photo-Z redshift reconstruction using a constructive multilayer perceptron

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Motivations : Photo-Z redshift reconstruction

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On the realistic validation of photometric redshifts, or why Teddy will never be Happy

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- *Challenge ?*
  - *Lack of spectroscopic coverage in feature space (e.g. colours and magnitudes)*
  - *Mismatch between photometric error distributions associated with the spectroscopic and photometric samples.*

Motivations : Photo-Z redshift reconstruction

- *Regression task*
  - Techniques :
    - Decision tree, IBL, Bayesian networks, Lattice-based,
    - SVM, Artificial Neural Networks (ANN), …
- Different models of ANN:
  - …
  - **Multilayer perceptron**
  - …
- *Choice of the ANN structure ?*
  - *Application to photo-Z redshift reconstruction*

Motivations

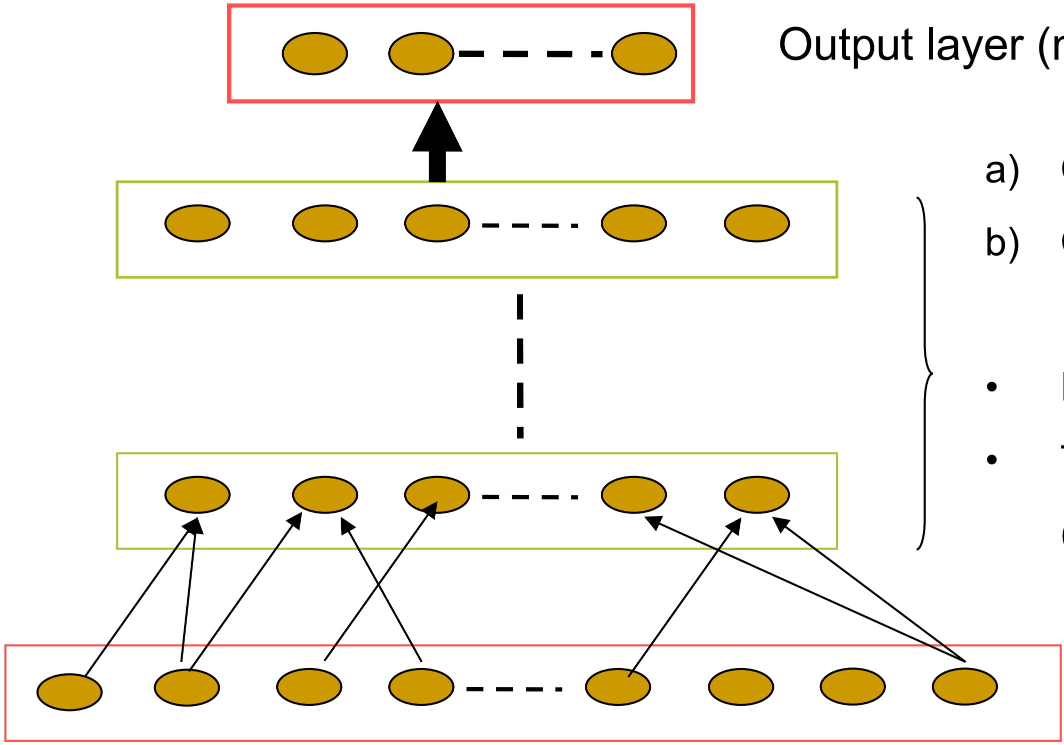
This story might be apocryphal, but it doesn't really matter. It is a perfect illustration of the biggest problem behind neural networks. **Any automatically trained net with more than a few dozen neurons is virtually impossible to analyze and understand**. One can't tell if a net has memorized inputs, or is 'cheating' in some other way. A promising use for neural nets these days is to predict the stock market. *Even though initial results are extremely good, investors are leery of trusting their money to a system that* ***nobody*** *understands*

Neil Fraser [2003]

Problem : Settings

Multilayer perceptron

process



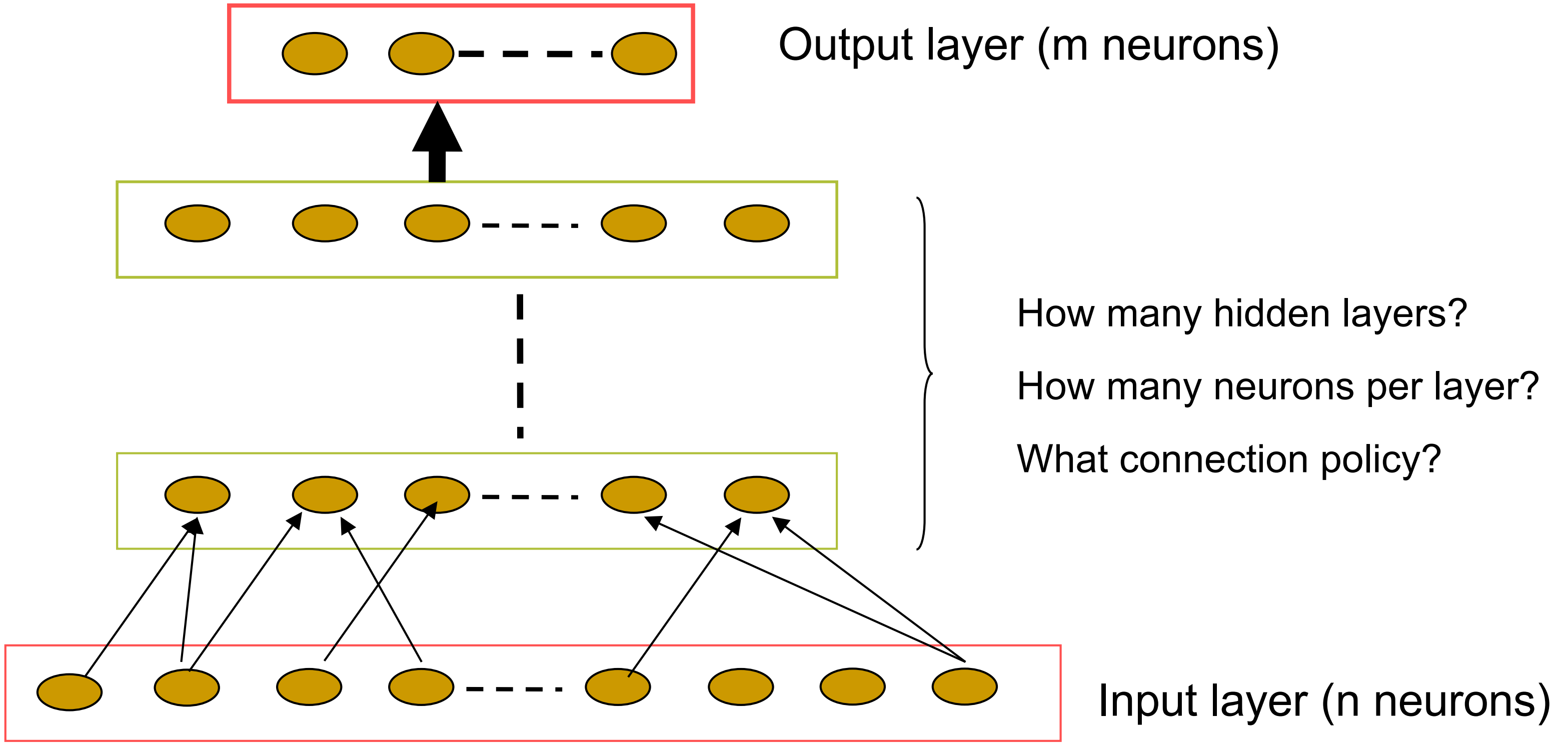
Output layer (m neurons)

a) Choose a topology
b) Choose an activation function
   (sigmoïd, …)
- Initialize the connection weights
- Train the neural network
  (BackPropagation, …)

Input layer (n neurons)

Problem : Settings

Multilayer perceptron *topology*



Problem : Background

- Assumptions :
  - MLP Feedforward networks are universal approximators
    - K. Hornik, M. Stinchcombe, and H. White, Neural Networks, vol. 2, pp 359-366, 1989
  -

Problem : Background

- Existing approaches
  - Adhoc approach
    - One hidden layer: number of units equal to the average between the number of output units and the number of input units
    - ….
  - Automatic approaches
    - Dynamic construction of ANN from the training set
    - Use of an apriori domain knowledge (set of rules)
    - Concept-lattice based ANN

Problem : our contribution

Propose an automatic approach of defining interpretable ANN architecture when the domain knowledge is not available

- E. Mephu Nguifo et al., M-CLANN: Multiclass Concept Lattice-Based Artificial Neural Network. **Constructive Neural Networks** 2009: 103-121.
- Lauraine Tiogning Kueti et al., Boolean factors based Artificial Neural Network. **IJCNN 2016**: 819-825
- Norbert Tsopzé et al., Towards a generalization of decompositional approach of rule extraction from multilayer artificial neural network. **IJCNN 2011**: 1562-1569

Our proposal

Architecture of ANN :

- Input layer = input data
  - One (neuron) unit for each attribute [+ bias]

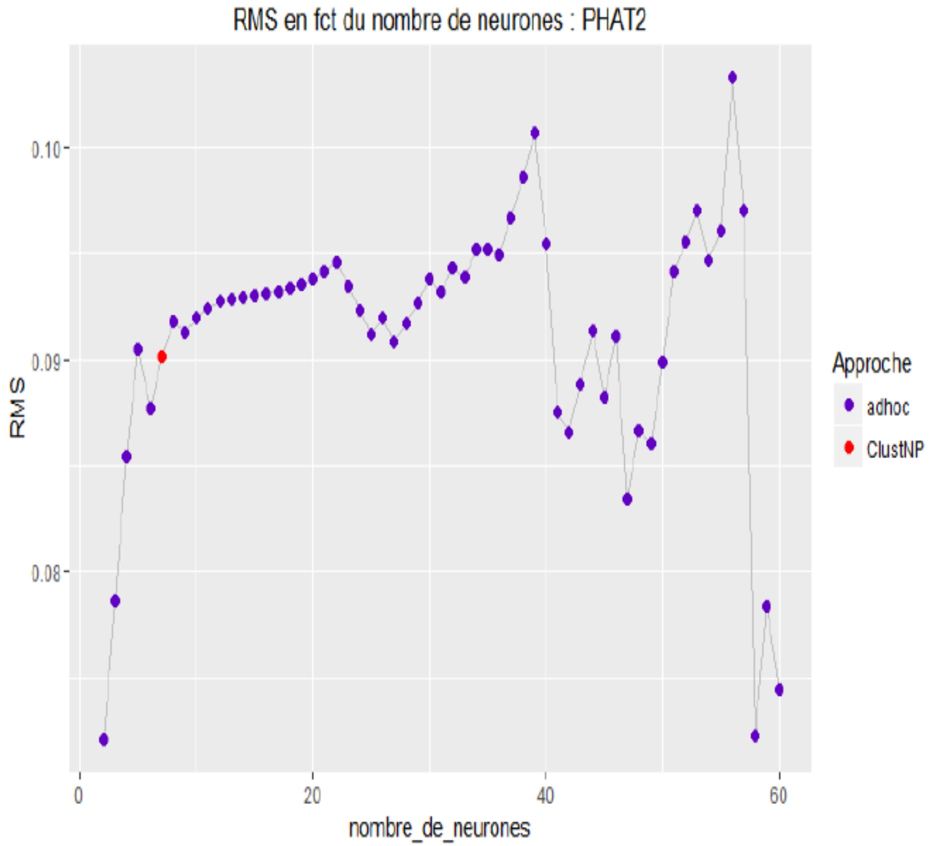
- Hidden layer : one
  - One neuron = one Boolean factor
  - Input layer are fully connected to hidden layer

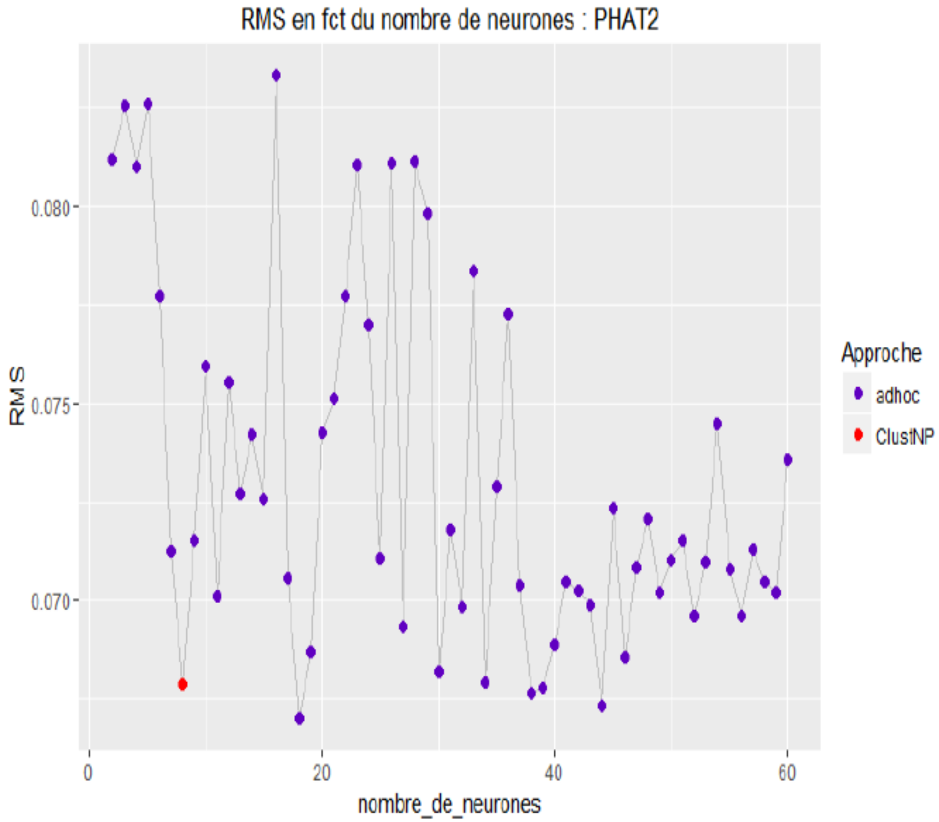
- Output = one neuron (Regression)

Experimentations

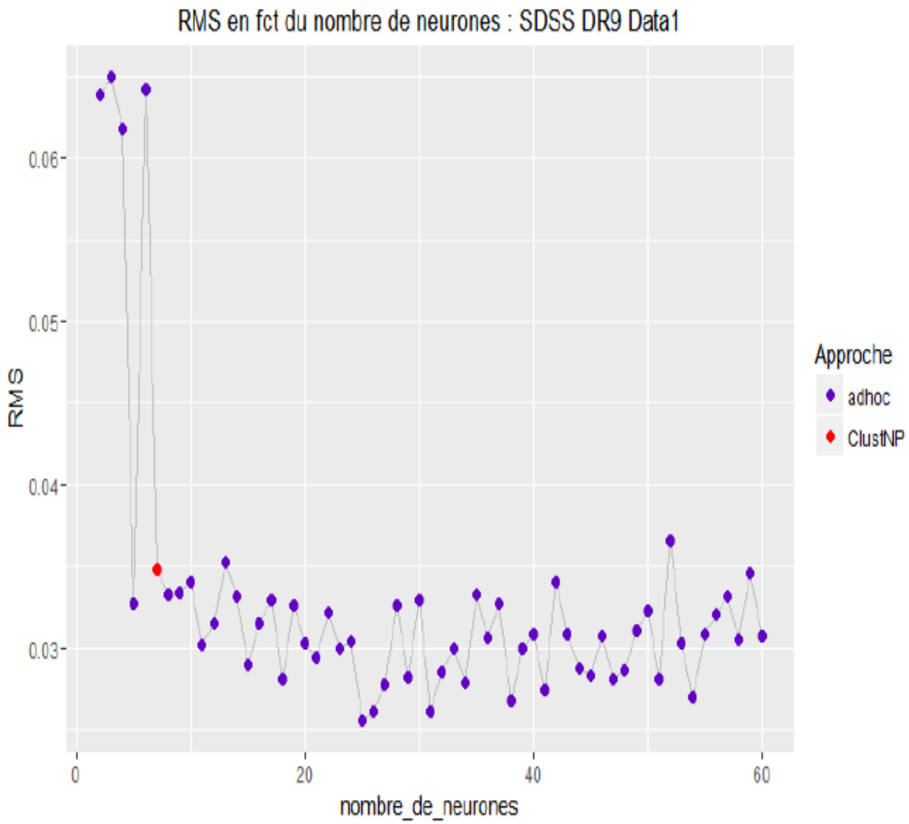
Jeu de données	Nombre d'objets	Taille (après prétraitement)	Nombre de bandes
PHAT2	316	52 Ko	18
PHAT1	515	84 Ko	18
PHAT0	1984	328 Ko	18
SDSS DR9 Data 1	5000	621 Ko	10
SDSS DR9 Data 2	12000	1477 Ko	10
Deep2 DR4 _sans_1	10838	735 Ko	6
Deep2 DR4 _sans_0_1	11784	677 Ko	6
SDSS DR10 Data 1	300 000	32 119 Ko	10
SDSS DR10 Data 2	500 000	53 536 Ko	10

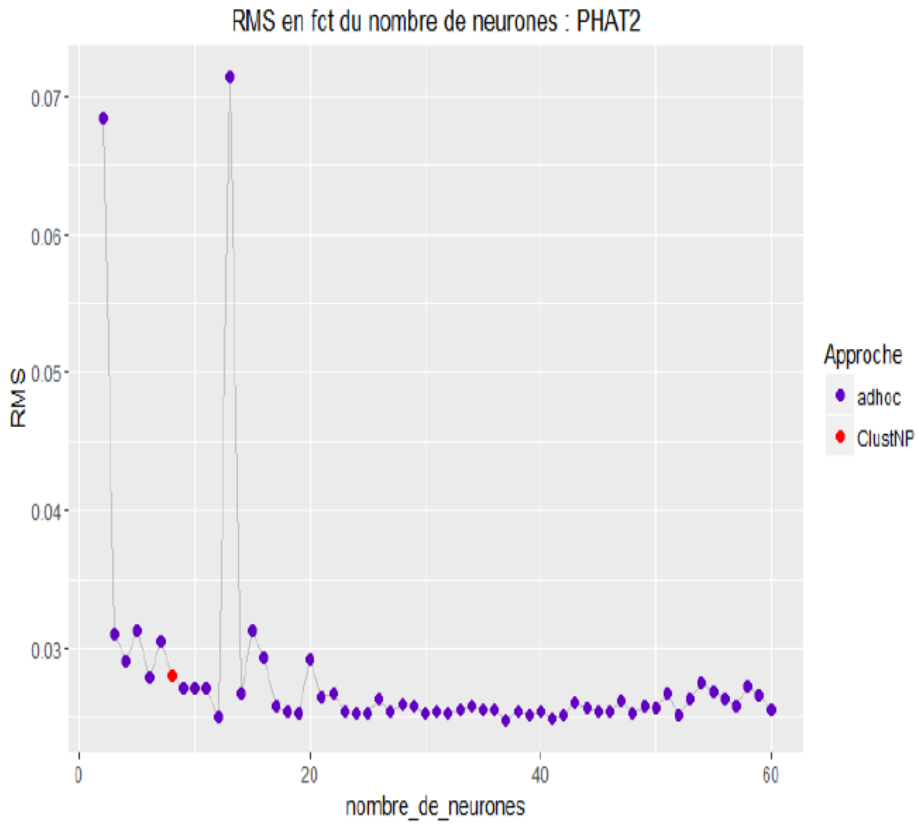
Experimentations



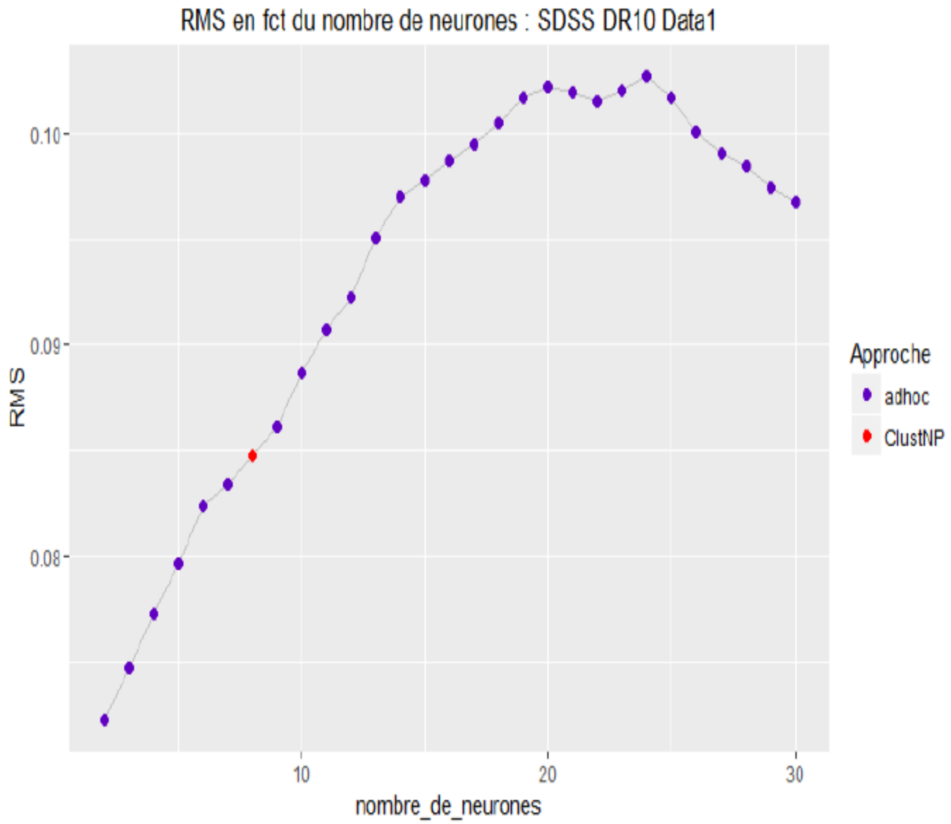


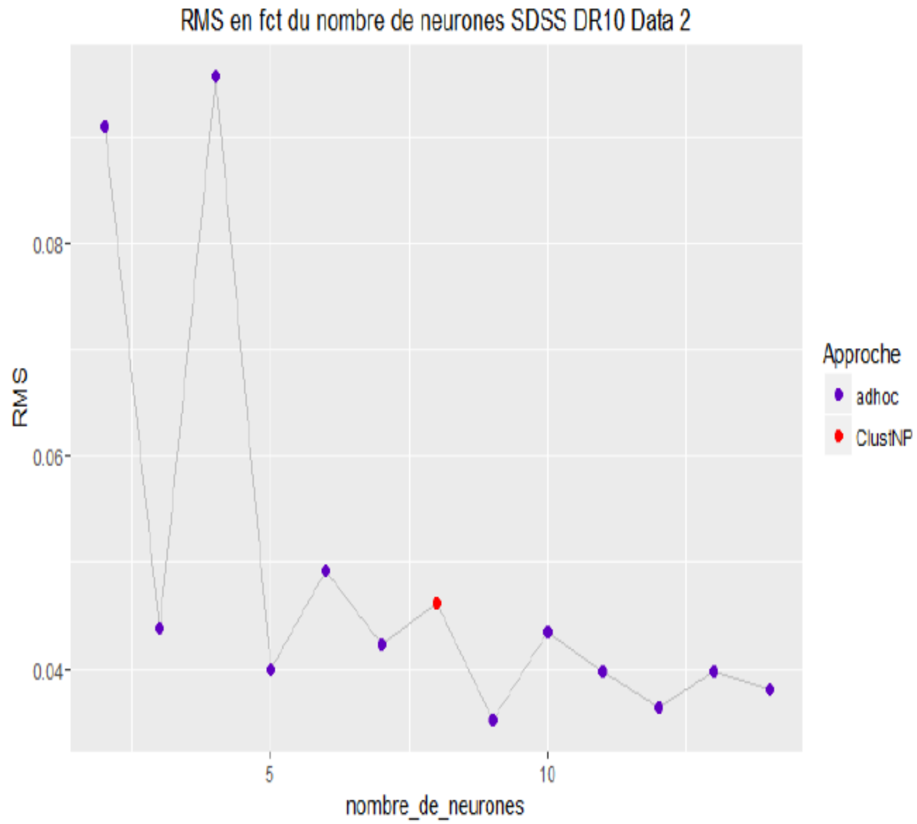
Experimentations





Experimentations (Results)





Experimentations (Results in the Literature)

	class	std(Δz_{norm})	bias(Δz_{norm})	$\mid \Delta z_{norm} \mid > 0.15$
[2]	galaxies	0.041	-0.003	0.99%
[3]	galaxies	$\sigma_{68} = 0.03$	-0.001	1.56%
[9]	galaxies	$\sigma_{68} = 0.0248$	0.0008	0.73%
[13]	quasars	0.15	0.032	$> 0.3 : 6.53\%$
[7]	galaxies	0.0490	-0.0081	7.6%
[10]	galaxies	0.024	0.0	1.51%
[6]	galaxies	0.0205	0.00005	4.11%

Conclusion

- BF-ANN, new approach to find **interpretable ANN** architecture when domain knowledge is not available
  - Semantic of neuron
  - Two variants
  - Preliminary validation seems promising

- Next :
  - Rules extraction (Tsopze et al. IJCNN 2011)

Thanks !