Selection of Spitzer YSO candidates using Deep Learning classifiers

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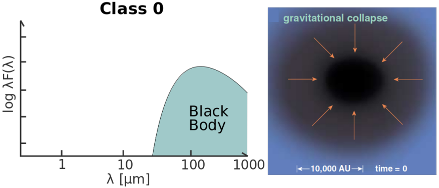
EWASS 2018, Software in Astronomy

Young Stellar Objects

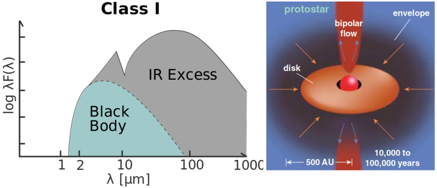
Young Stellar Objects YSOs → characterize star forming regions.

Class 0



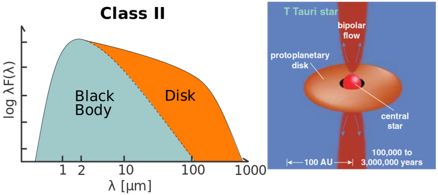
Faint protostar deeply embended

Class I



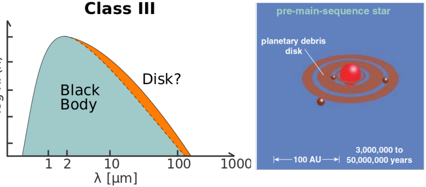
Protostar with infalling envelop

Class II



Pre main sequence with thick disk

Class III



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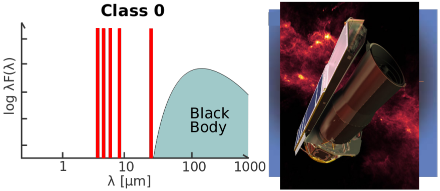

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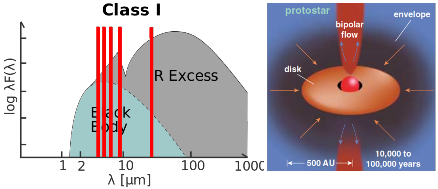

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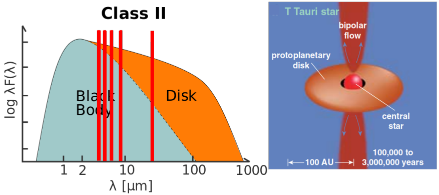

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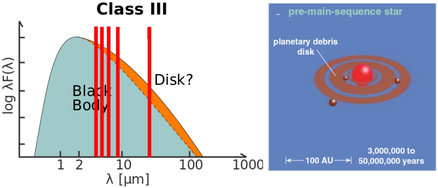

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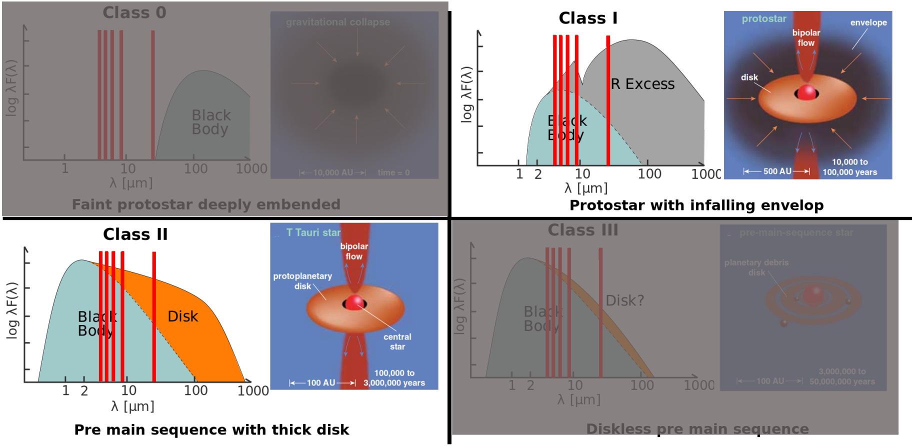

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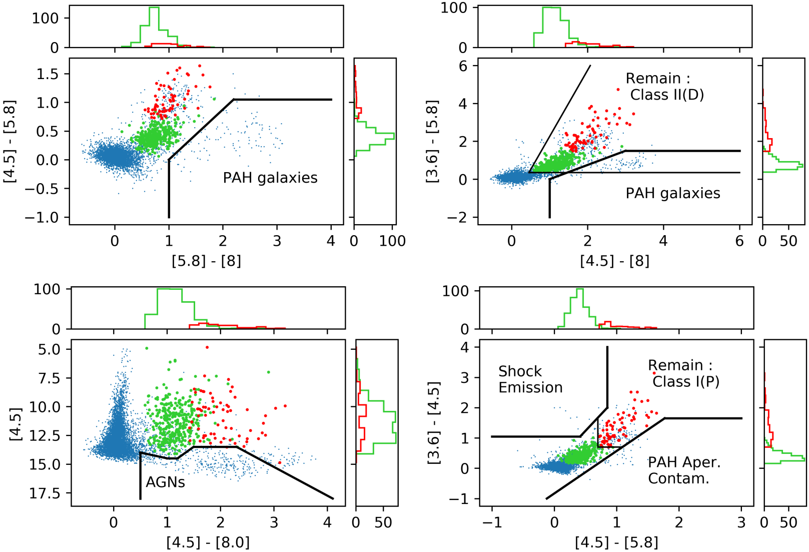
Commonly used classification scheme



Adapted from Guthermuth et al. 2009. Class I in red and Class II in green.

Machine Learning interest

Core concept : extract statistical information about a data set and adapt the response to it

Supervised

- A training set with the expected targets is provided
- Generalise to respond correctly to all possible inputs.

Unsupervised

- Data set with no target.
- Try to find similarities in the inputs and categorise them together.

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Main objective for YSOs : Replacing straight cuts with statistically learned splitting to perform a classification as impartial as possible.

Artificial Neural Network

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Showing you why you should give it a try. The basic element of such a network is the **neuron**.

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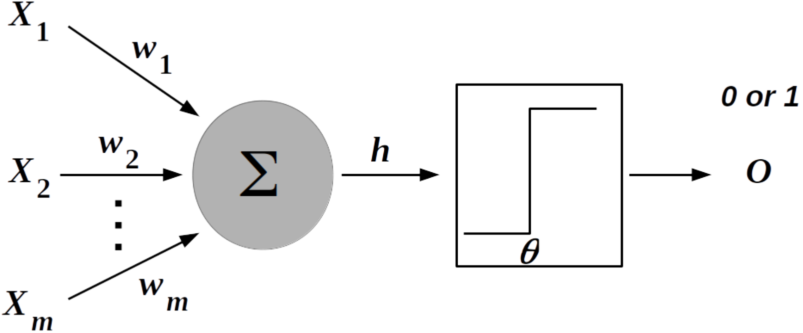


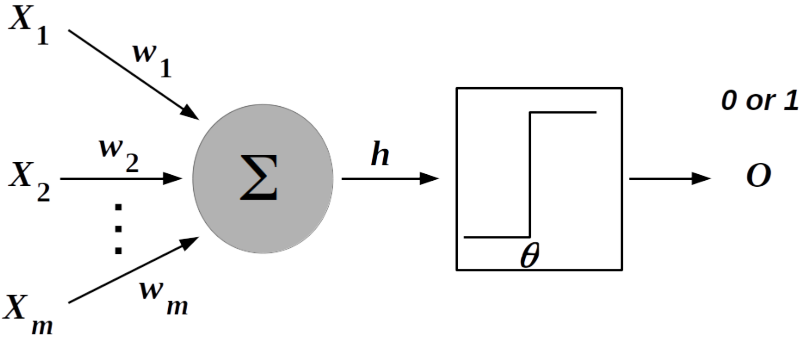
$$h = \sum_{i=1}^{m} X_i \omega_i \qquad O = g(h) = \begin{cases} 1 & \text{if} \quad h > \theta \\ 0 & \text{if} \quad h \leq \theta \end{cases}$$

McCulloch and Pitts' model of a neuron

Learning process

How does a neuron learn ?

A given input vector $(\boldsymbol{X_1, X_2, ..., X_m})$ in the training set is associate with a target $\boldsymbol{t}$



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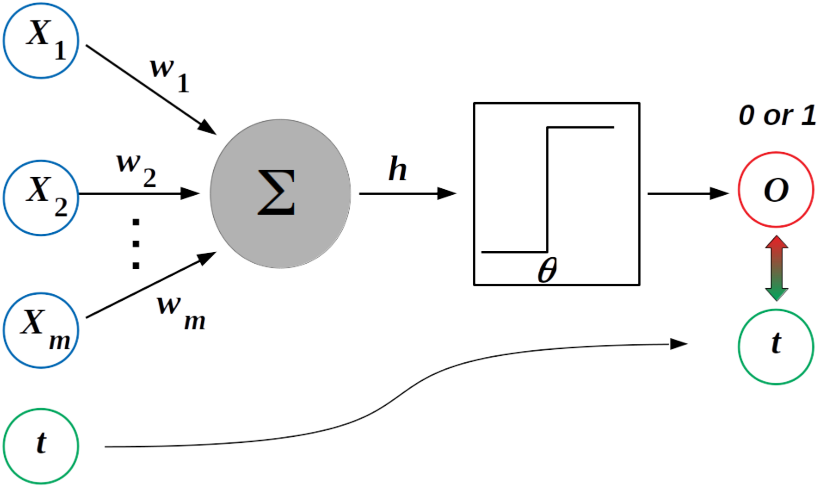

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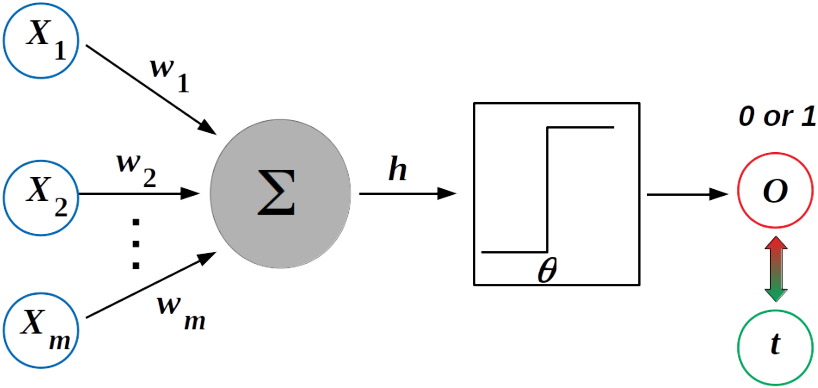

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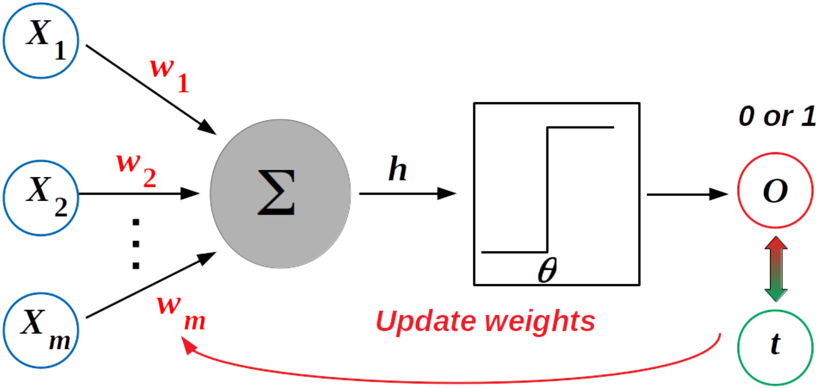

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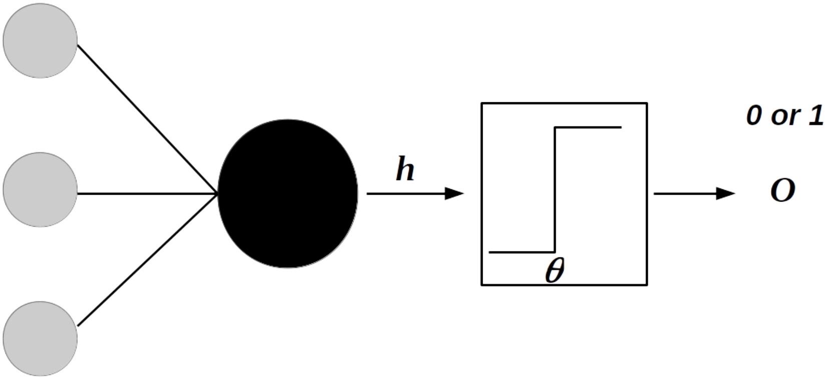

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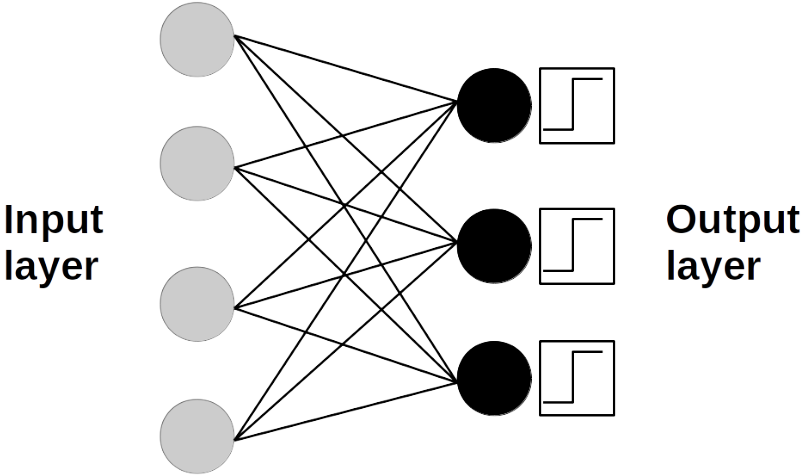
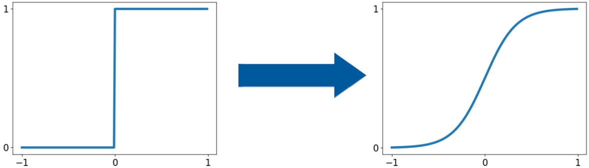
The Perceptron

more neurons → the perceptron algorithm



Improvement : beyond linear combination

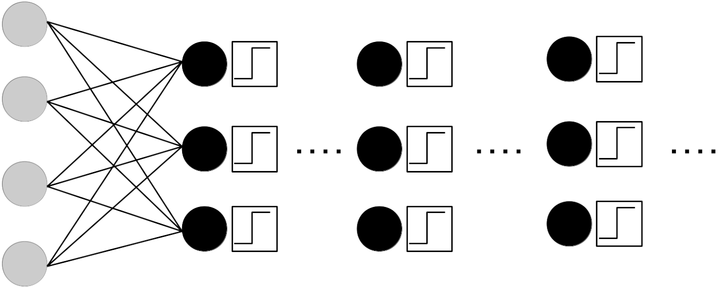
Change activation function



Threshold

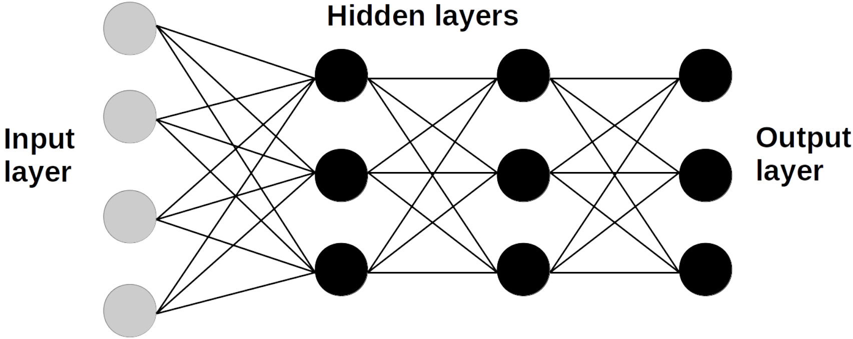
Sigmoid

Adding layers



Multi Layer Perceptron algorithm

Adding layer gives us the deep learning MLP algorithm, a Universal Function Approximator..



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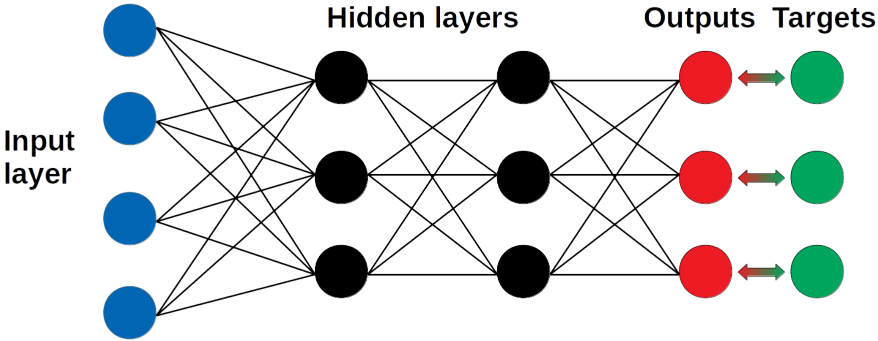
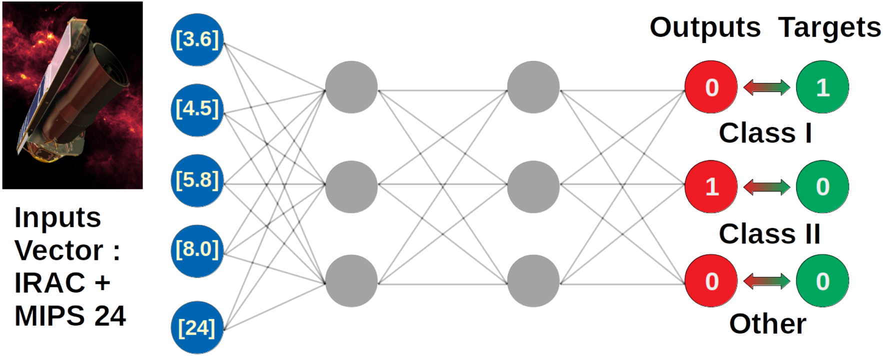


$$\frac{\delta E}{\omega_{\zeta\kappa}} = \frac{\delta E}{\delta h_\kappa}\frac{\delta h_\kappa}{\delta w_{\zeta\kappa}} \qquad \delta_\kappa \equiv \frac{\delta E}{\delta h_\kappa} = h'(o_\kappa)\sum_\zeta \omega_{\zeta\kappa}\delta_\zeta$$

YSO classification with MLP



Inputs Vector : IRAC + MIPS 24

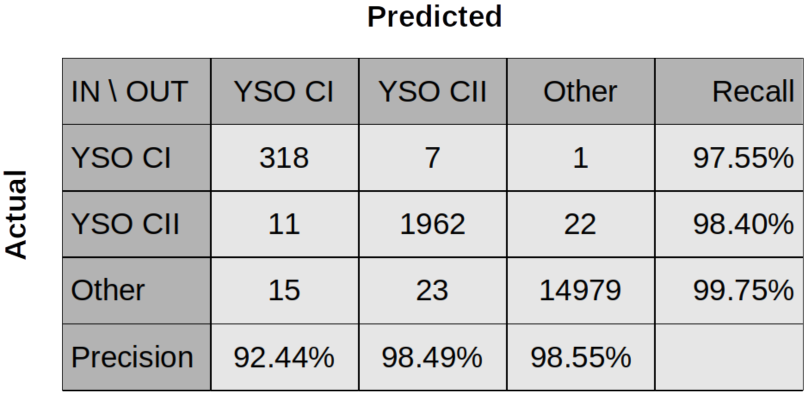
The number of hidden neurons is explored to maximise results

Training set :

- Objects from Megeath+ 2012 Orion catalogue ≈ 300 000 objects
- Detection in all 4 IRAC bands only ≈ 19 000 remaining objects
- Guthermuth+ 2009 classification → actual targets
- Keep a part of the data away, for testing after training

Orion MLP results

The Confusion Matrix



Predicted

Actual

IN \ OUT	YSO CI	YSO CII	Other	Recall
YSO CI	318	7	1	97.55%
YSO CII	11	1962	22	98.40%
Other	15	23	14979	99.75%
Precision	92.44%	98.49%	98.55%	

Results obtained from a mini-batch training on 3/4 of the data set with 30 neurons in one hidden layer only and forwarded on the full Orion catalogue.

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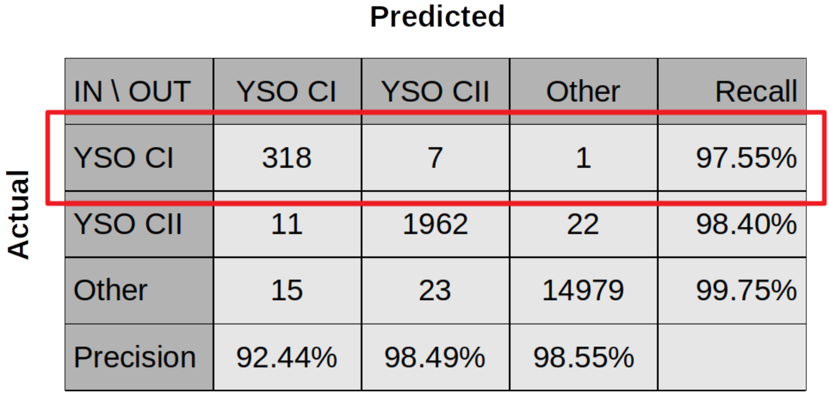

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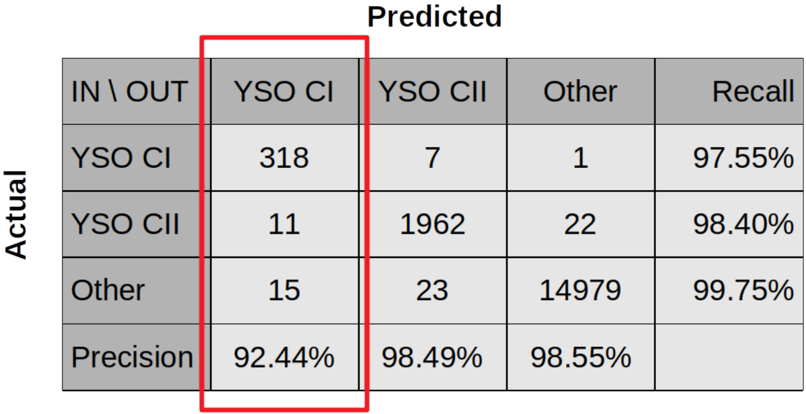

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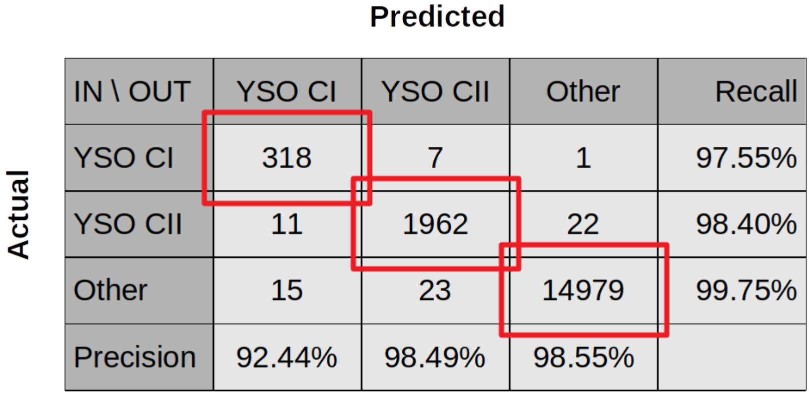

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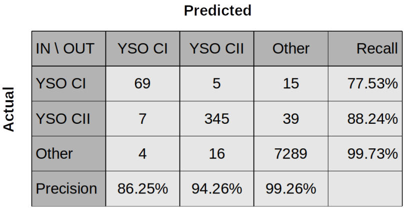
Other area and combined results



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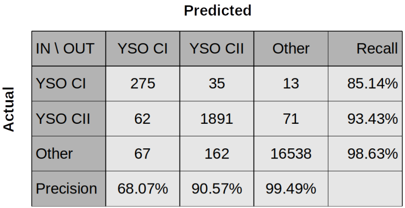
IN \ OUT	YSO CI	YSO CII	Other	Recall
YSO CI	69	5	15	77.53%
YSO CII	7	345	39	88.24%
Other	4	16	7289	99.73%
Precision	86.25%	94.26%	99.26%	

Trained on Orion, forwarded on NGC2264



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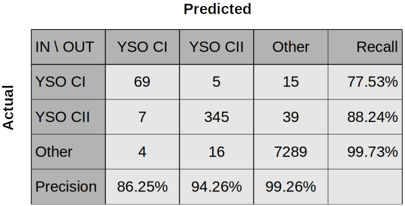

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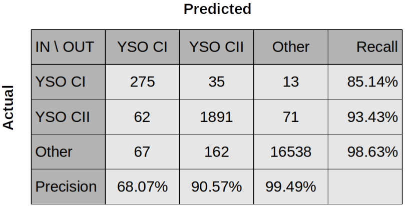

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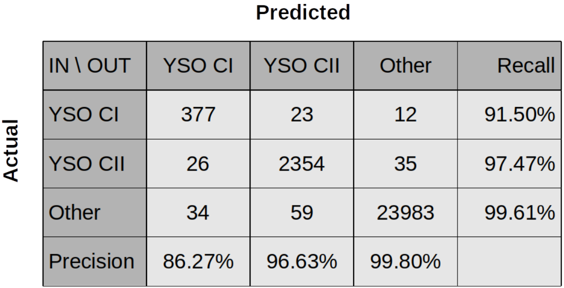

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IN \ OUT	YSO CI	YSO CII	Other	Recall
YSO CI	377	23	12	91.50%
YSO CII	26	2354	35	97.47%
Other	34	59	23983	99.61%
Precision	86.27%	96.63%	99.80%	

Cross trained and forwarded

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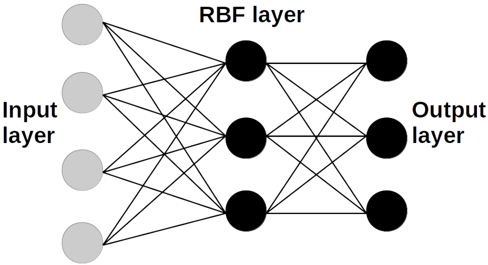
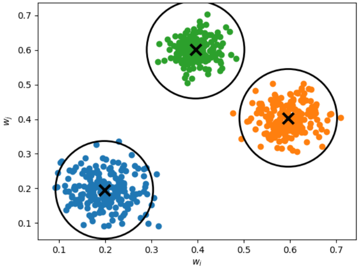
The Radial Basis Function Network





Predicted

Actual

IN \ OUT	YSO CI	YSO CII	Other	Recall
YSO CI	262	26	38	80.37%
YSO CII	21	1816	157	91.07%
Other	27	152	14838	98.81%
Precision	92.44%	98.49%	98.55%	

Ongoing work

Currently done :

- Develop and train an MLP network performing YSO classification
- Develop and train an RBF
- Compare different cloud training
- Perform cross training

Planned :

- Try out a more recent Deep Learner DBN → semi-supervised
- Train with an higher amount of different regions
- Use GAIA to perform distance estimation → extract structural information