> The medial Reticular Formation (mRF): a neural substrate for action selection? An evaluation via evolutionary computation.

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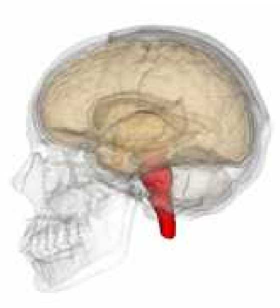
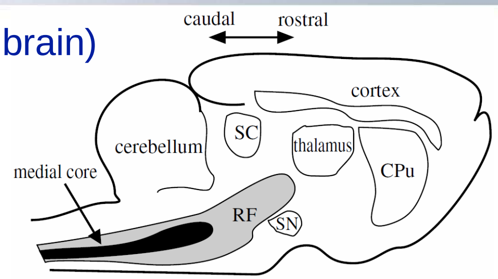
1. Introduction



(a cat's brain)



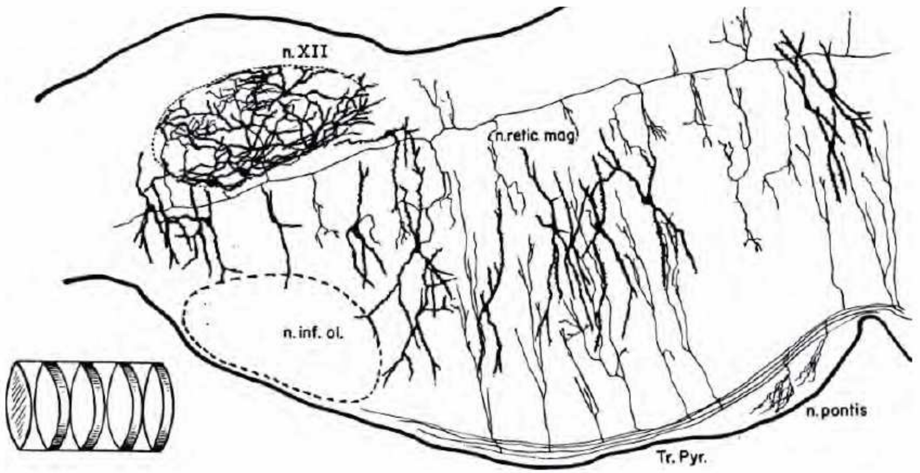
- **The mRF anatomy is similar among all animals.** [Nauta & Ramon-Moliner 1966] and the mRF is phylogenetically very old.

- **The mRF seems to be a low-level system for action selection.**
  - [Birkmayer and Pilleri, 1966]: rats with injuries to the RF demonstrate severe behavioral disorders.
  - [Woods, 1964] : rats who had undergone a complete cut in the posterior brainstem by removing the entire brain rostral to this cross-section, had a surprisingly coherent behavior.

Coherent with anatomical data:

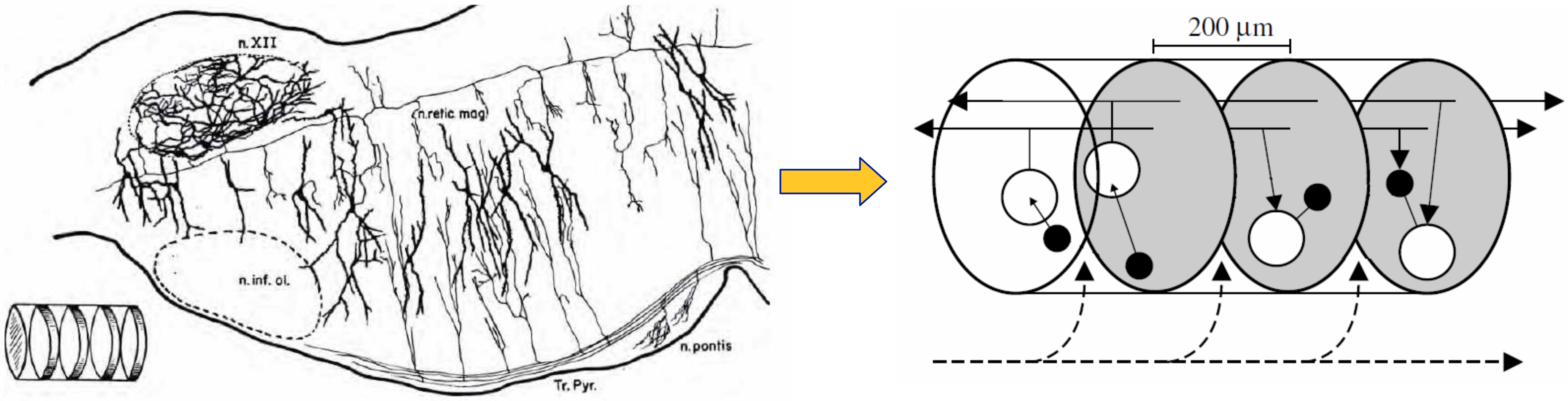
- Numerous sensory inputs,
- Many connections to the spinal cord (= potentially motor actions).

1. Introduction



Only 2 models:

- Model 1: Kilmer-McCulloch 1969



Only 2 models:

- Model 2: Humphries 2006.

✖ Does not take into account all anatomical data.

✖ Unfounded hypothesis: each cluster is associated to an action.

✖ Low survival time [Humphries2006].

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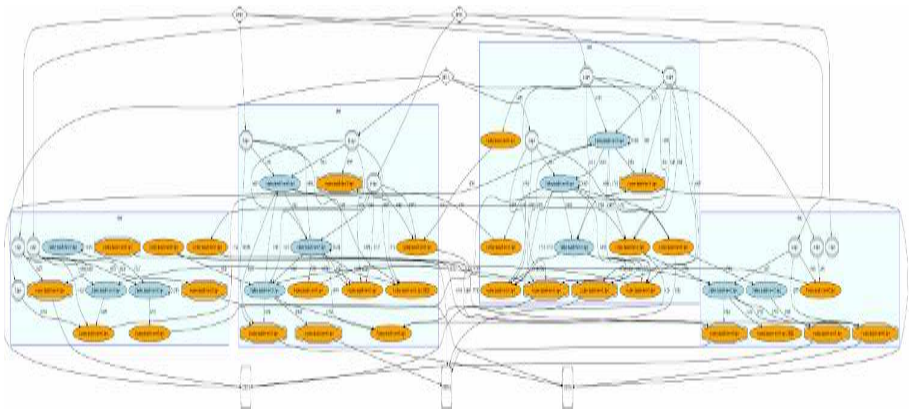
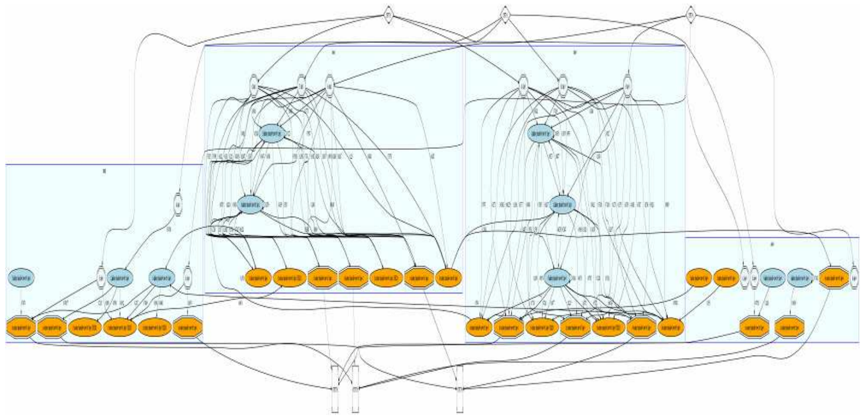
2. Method

Method's synopsis:

- Identify anatomical data of the mRF,
- Use selection tasks of the literature,
- Generate neural network of type mRF capable of achieving the tasks (use of a multi-objective evolutionary algorithm).

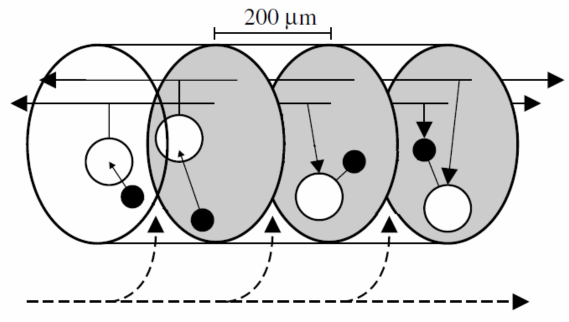


Example of a mRF model



Example of another mRF model

2. Method



List of parameters describing a network of type mRF:

1. **c** : the number of clusters (between 35 and 75) ;
   → **4**

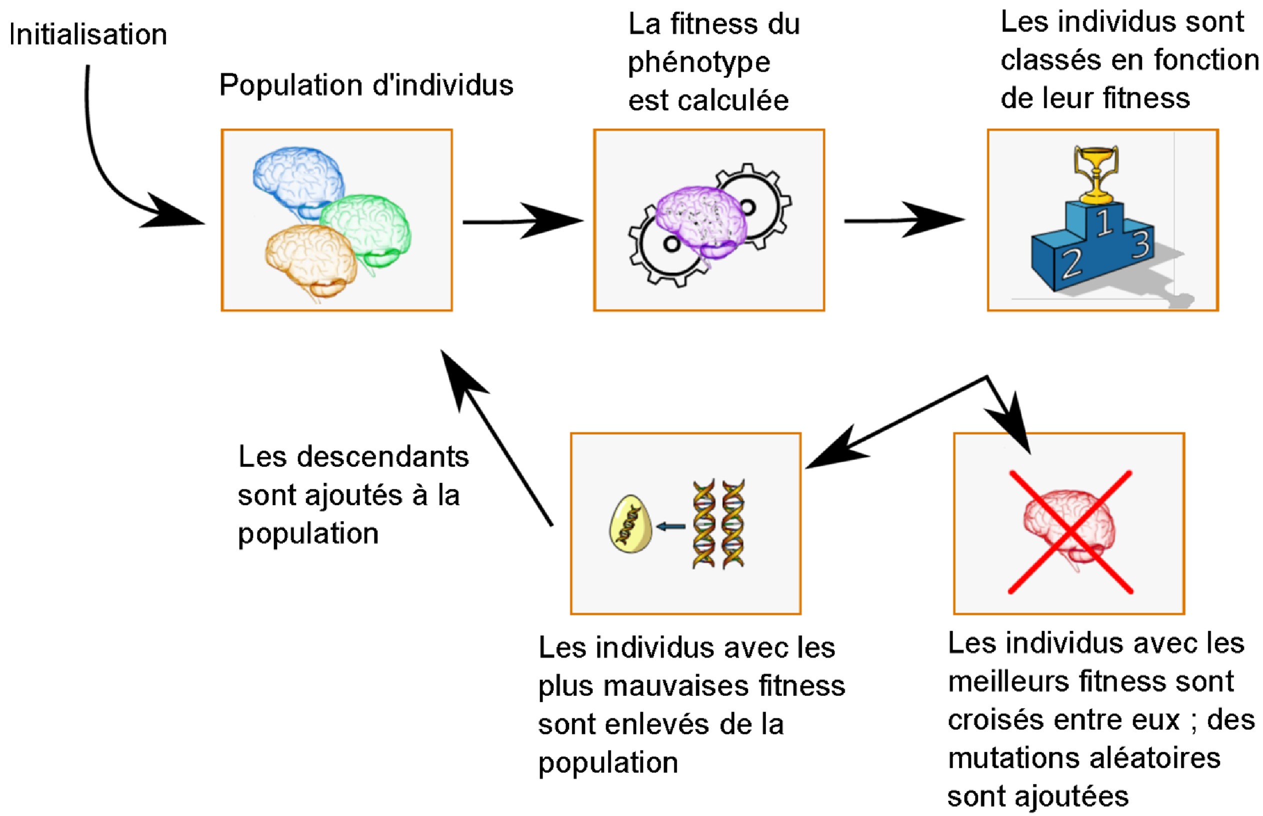
2. **n** : the number of neurons in one cluster (ca. 30 000) ;
   → **entre 10 et 30 IPDS**

3. **p** : the percentage of projection neurons (ca. 80%). The percentage of interneurons is therefore 1 - p ;

4. **P(c)** : the probability that one projection neuron project to a given cluster (P(c) = 0.25) ;

…

Multiobjective evolutionary algorithm:



Population size: 500 ; Number of Generations : 500 --> 500^2 evaluated models

Multiobjective evolutionary algorithm:

Objective 1: the mRF must take the expected decisions, depending on the selection task.

Objective 2: the mRF must make frankly these decisions (contrast objective) [Prescott1999, Girard2003]

$$contrast(X) = \sqrt{\frac{\left(\sum_{i=1}^{n}(x_i - x_k)^2\right)}{n-1}} \text{ où } k = \arg\max_i x_i$$

Objective 3: the mRF must respect the known anatomical constraints on the mRF (objective of anatomic plausibility).

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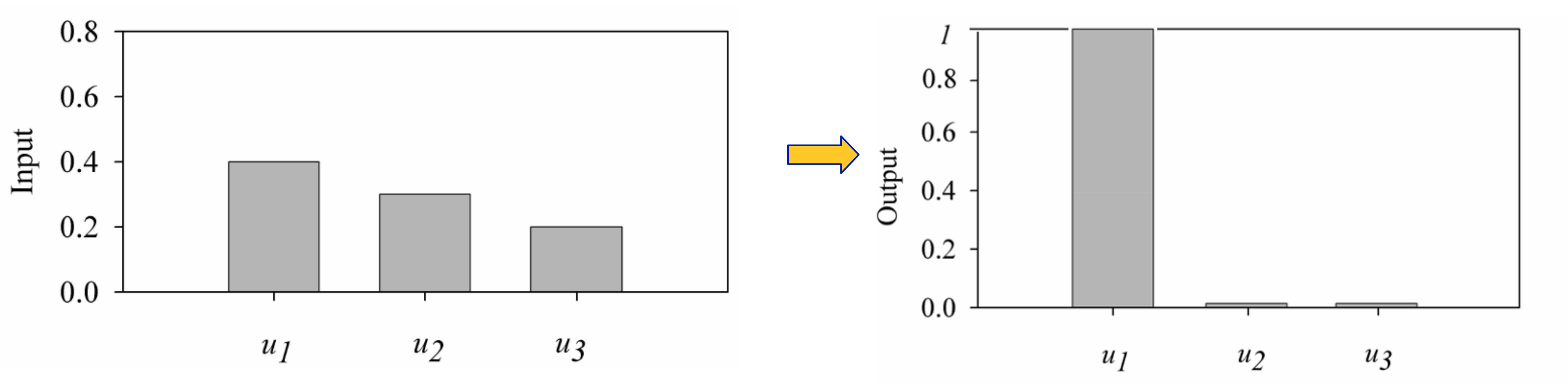
Expérience :

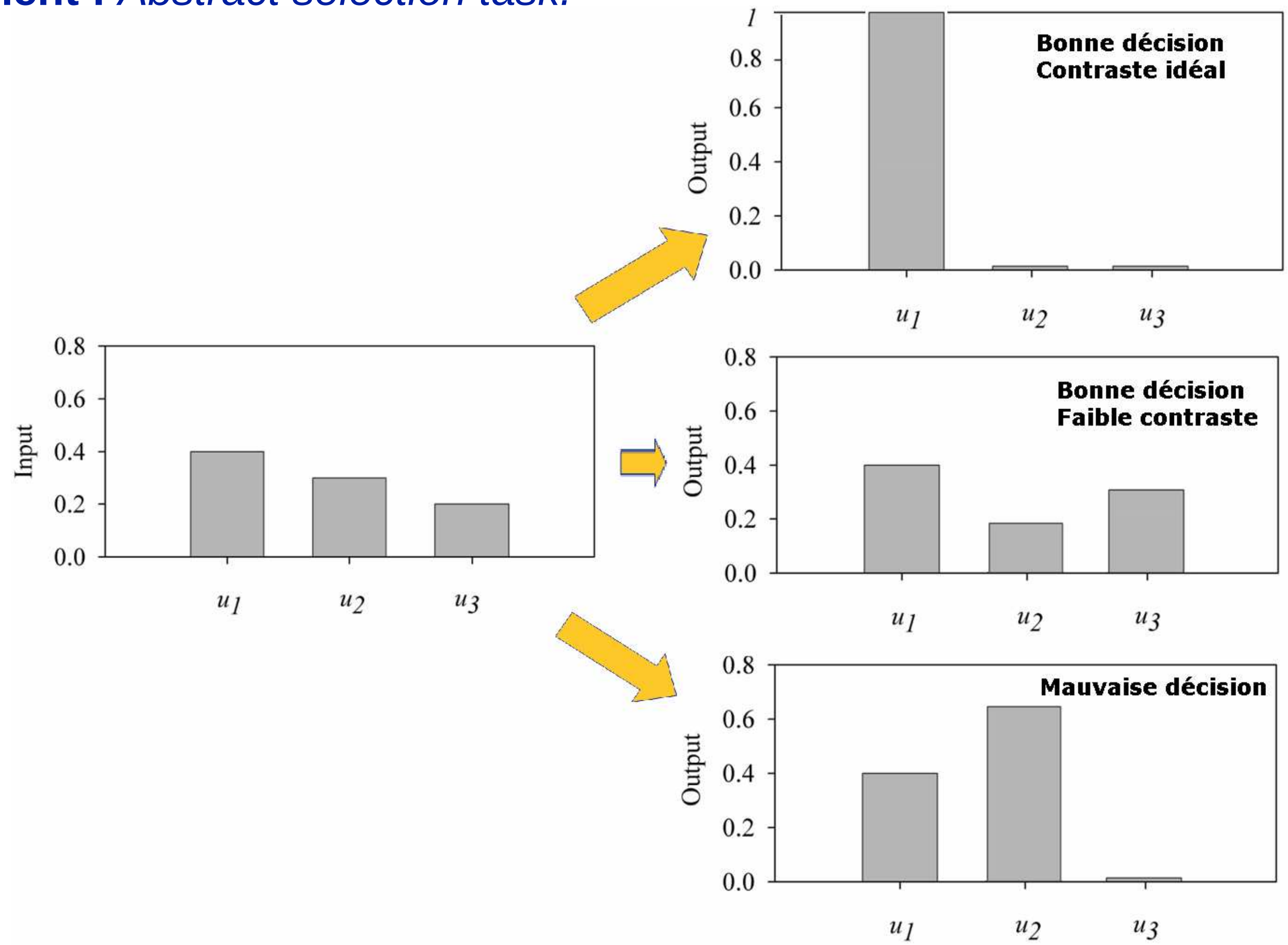
Abstract selection task.

We want the MRF to act as a WTA network (**Winner-Takes-All**) :



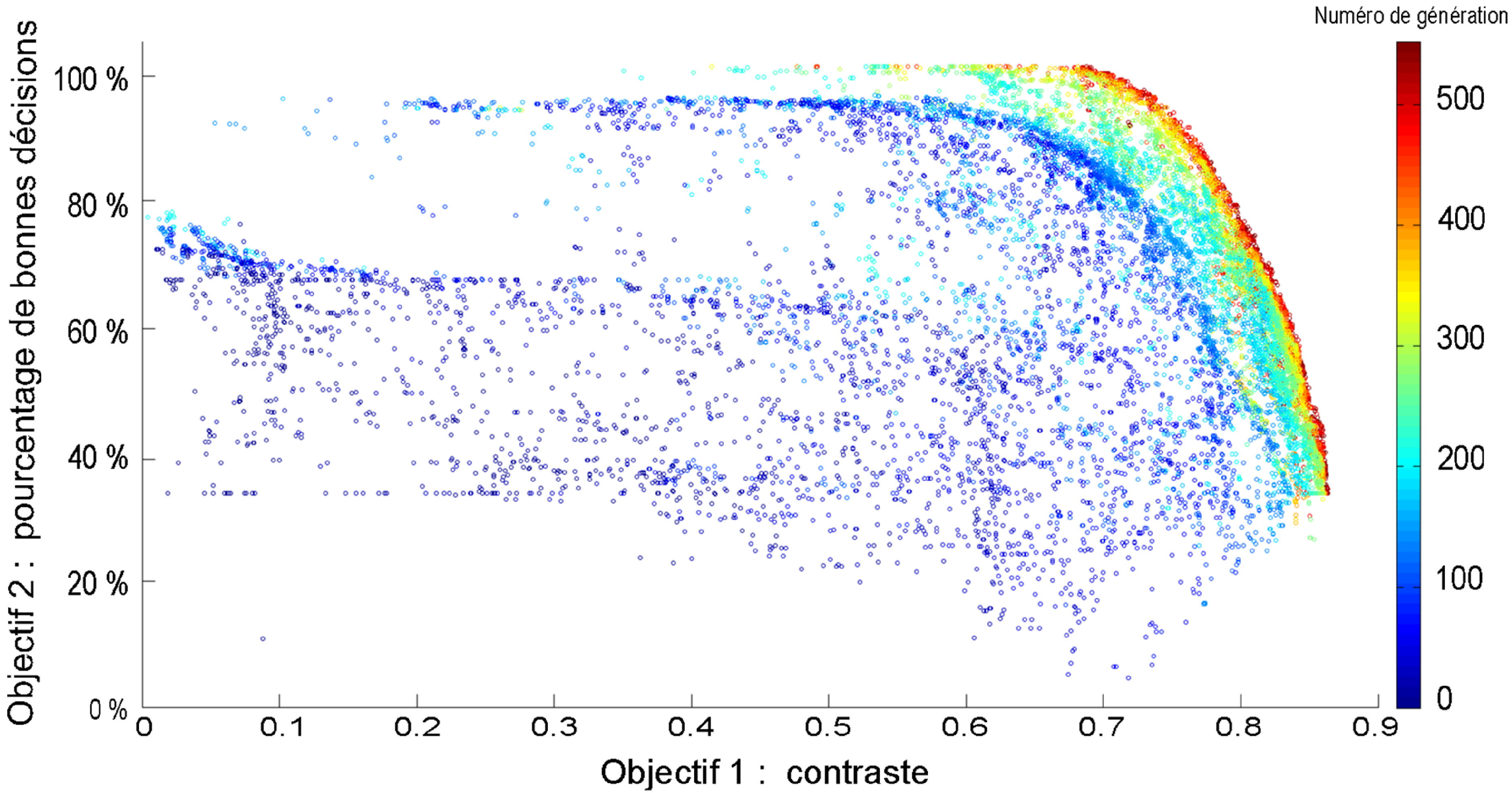
[Humphries2007]

Experiment : *Abstract selection task.*

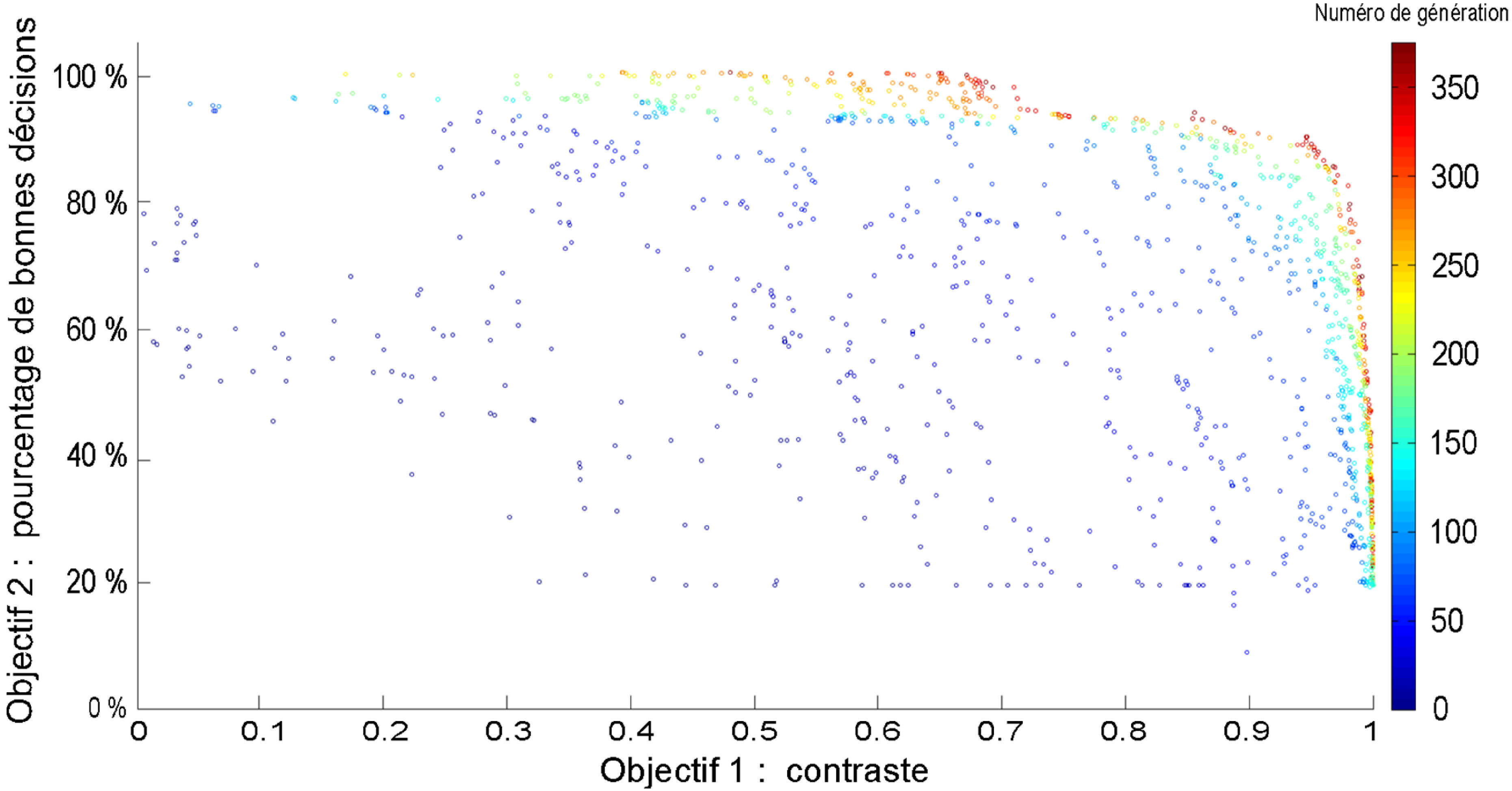


3. Disembodied task

Results obtained with mRF-type networks:



Results obtained with unconstrained networks:



3. Disembodied task

Conclusions:

1. A mRF-like network can perform a selection task.

2. The data on the known anatomical MRF represent neither an advantage (because there are other network structures equally successful) nor a disadvantage for selection.

3. Humphries obtained about 75% of good decisions with his model without considering the contrast. Our method to evolve models is thus more efficient, which tends to confirm the soundness of our approach:

    1. Add more neurons per cluster,
    2. Remove the hypothesis of a cluster-action mapping,
    3. Consider more anatomical data,
    4. Use evolutionary algorithms to evolve the network structure.

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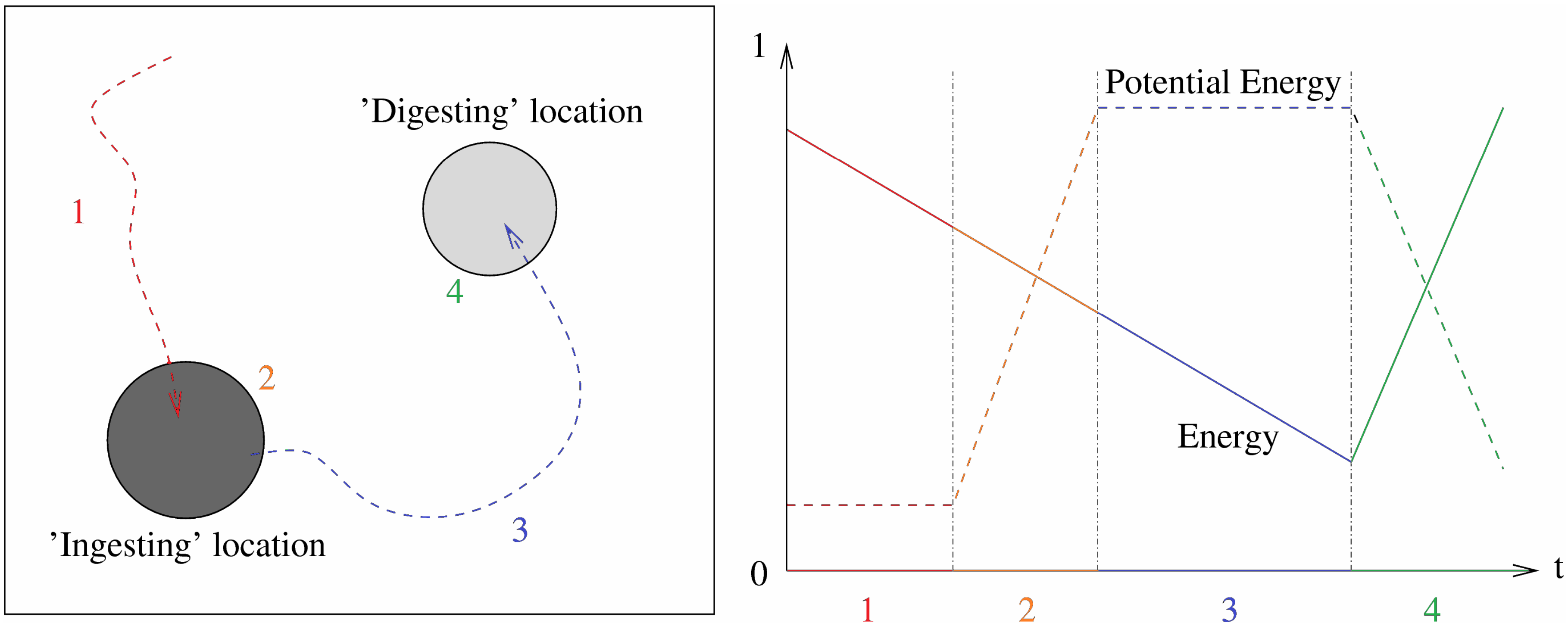
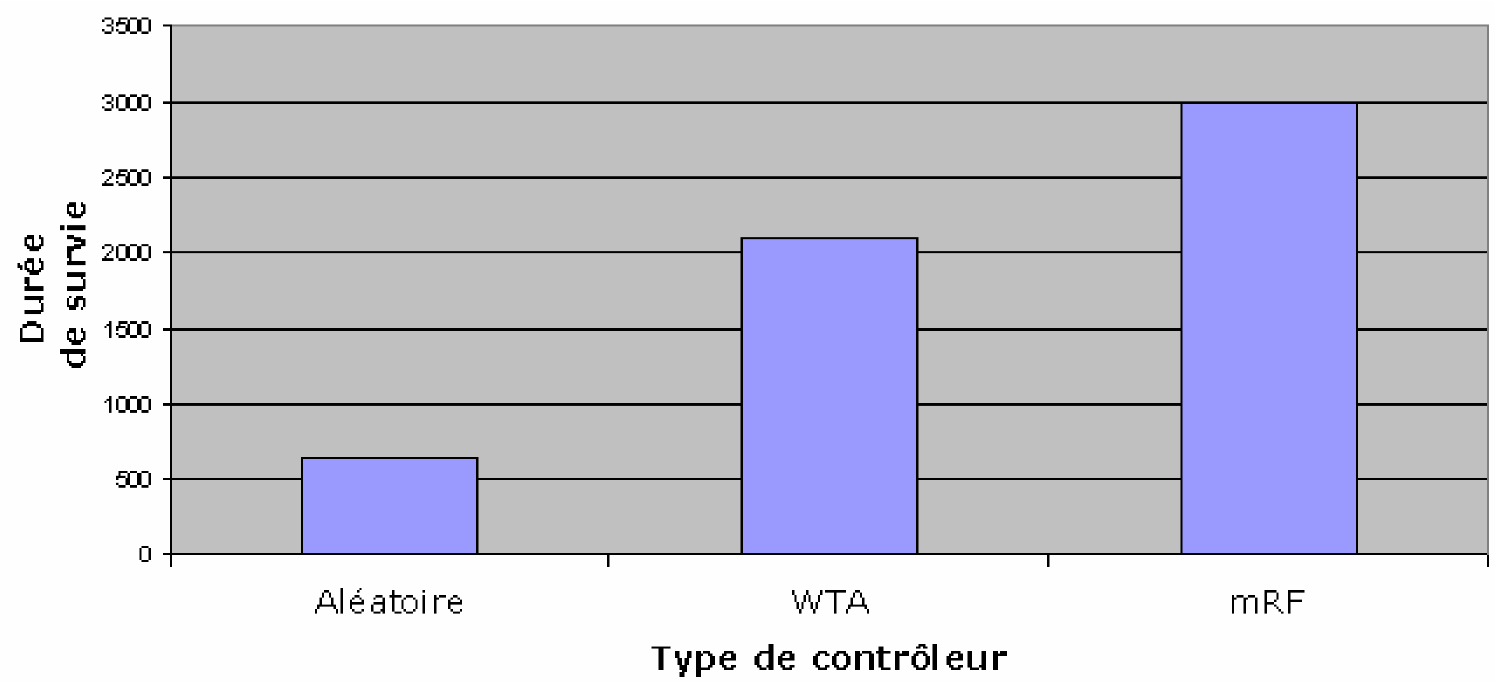
4. Embodied task

Experiment: Evaluation with the survival task [Girard2003, Humphries2006]



Results

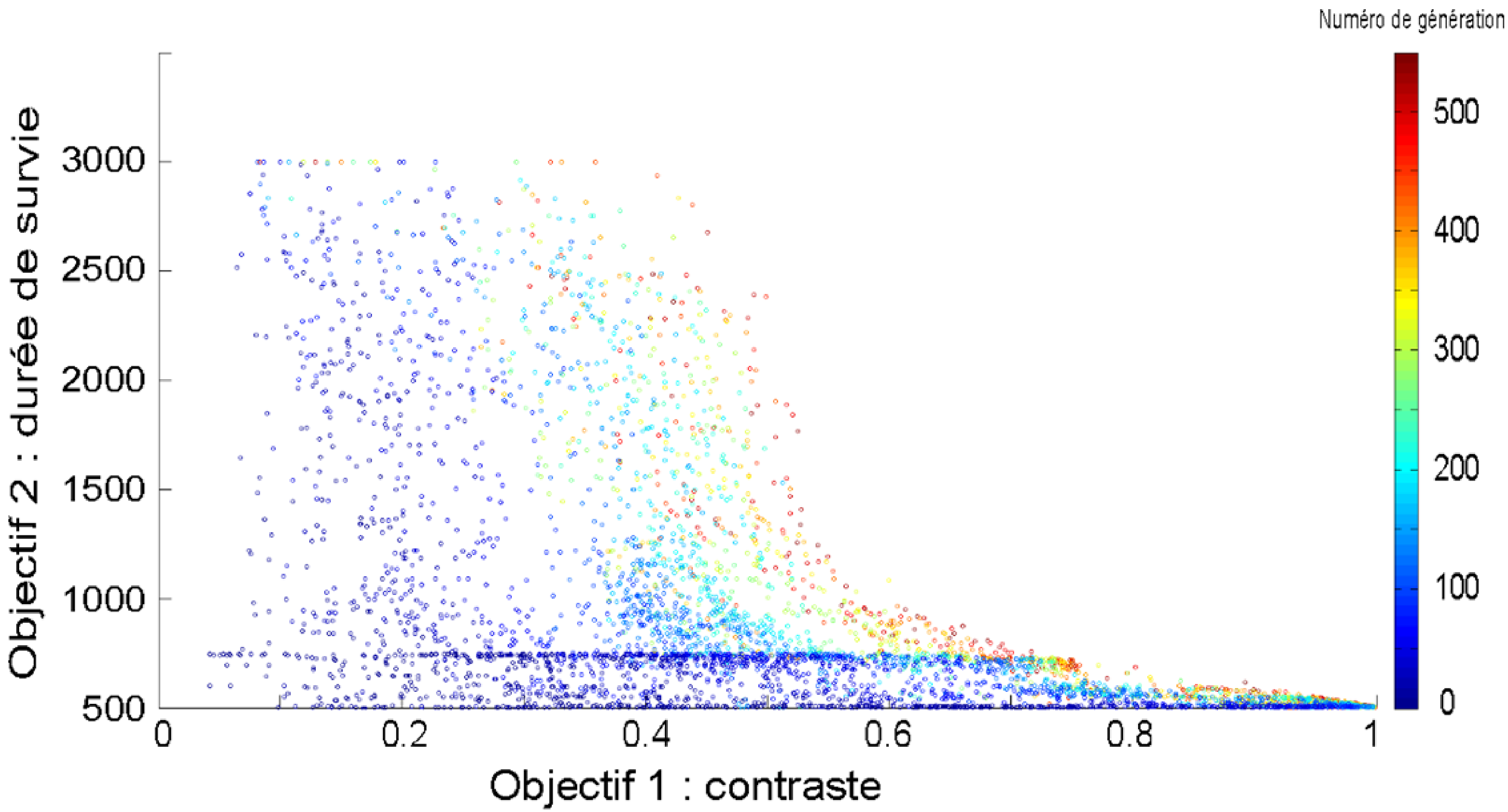
Best average on 5 tasks:



Humphries: performance between random and WTA controllers

4. Embodied task

Results:



4. Embodied task

Conclusions:

The mRF is generally more effective than a WTA and a controller even more effective than a random controller.

→ This means that the mRF is not only able to make action selections, but that it can deal with complex situations where a WTA would not.

→ In addition, according to our estimates, we achieved better results than those of Humphries' model.

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5. Conclusion

To conclude:

Disembodied task: computational capacity of the MRF to perform a task selection.

Embodied task : computational capacity of the MRF to perform action selection in simulated environment.

mRF-like structure : neither an advantage nor a disadvantage in these two tasks .

Predictions :

Compare free parameters of our models with real anatomical data (not known at this time). E.g.: p (l) = p (p) = 8%.

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