

The Artificial Physicist

or

fully automatic modeling with statistical learning

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Statistical Learning

- ▶ Learning *what* ? *What for* ? In which *scope* ?
- ▶ Most often : **predefined models**, estimation of **parameters**
- ▶ Range of models thus **learnable** ?
 - ↳ Model selection : within a family (idem : meta-parameters)
- ▶ How to learn the model itself ? the algorithms ? **Creativity** ?
- ▶ Flexibility, expressivity, evolvability ?
 - ↳ **Expressivity** : of classifiers [Vapnik], of languages...
 - ↳ **Evolvability** [Valiant] : what is learnable ? evolutionary (genetic) algo.
- ▶ **Genuine AI** : **No absolute prior model** (everything questionable)
 - ↳ **No restriction** (could discover any kind of new model)
 - ↳ **Be creative** : expressivity = useless if no way to propose new models
 - ↳ **Strategies for exploration** (to find new models)

The Artificial Physicist

- ▶ **Aim** : to model the world
 - ↳ fully unsupervisedly (surprise us !)
- ▶ **Which world ? Which scale ?**
 - ↳ Physics : quantum mech. / Newtonian mech. / relativity
 - ↳ Chemistry : molecular / material science
 - ↳ Daily life : constant gravity / solid mech. / heuristics...
- ▶ **Which criterion ?** to assert whether a model is good
 - ↳ **Compactness** : Kolmogorov complexity, min. descr. length
 - ↳ **Time complexity** : crucial and better-posed (computable) :
time needed to detect / recognize / use / apply
 - ↳ All parts in a model should be **justified**/optimized :
a concept makes sense only with fast recognition/appl. methods
 - ↳ Hierarchical models : intuitive... but justification ?

The Artificial Physicist (... bis...)

► What ? (data observed)

- ↳ Emergence of patterns at a given scale ?
- ↳ Recurrent patterns :
 - self-organization
 - self-replication (life, etc.)
- ↳ Statistical relevance : frequency, correlations...

► How ?

- ↳ No restriction to predefined (meta-)models
- ↳ Be sure the span of algorithms (models) reachable is not limited
 - requires a new way of programming
- ↳ Stochastic search ?
 - not necessarily : e.g. exhaustive deterministic search
 - not just stochastics : need good laws (**strategies**)
 - algorithms/models preferred to be reachable first ?
 - Levin's measure : $2^{-Kolmog(algo)}$
 - time expectancy before finding suitable model ?
 - no free lunch ?
- ↳ Related to : Efficient ways to explore... mathematics ? to prove theorems ? to do research as a community ? (or no free lunch !?)

The Artificial Physicist (... ter)

- ▶ How many suitable models ?

- ↳ Structure from chaos :

- in a randomly-chosen world, given a scale where processes *seem* to be chaotic, what is the probability to find another scale and an **arbitrarily-simple model that fits approximately arbitrarily-well the phenomena ?**

- ↳ i.e. probability of **emergence of approximate structure**
or, equivalently, of existence of **suitable approximate models**

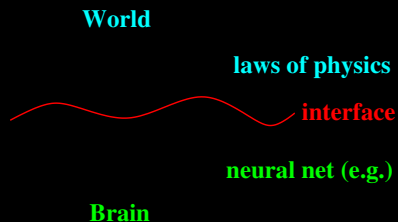
Modeling the problem of modeling

World

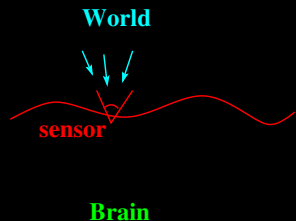


Brain

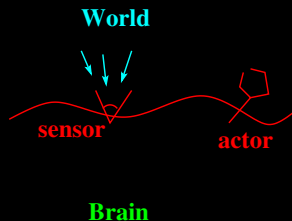
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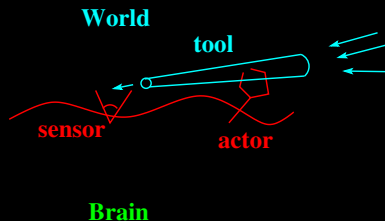
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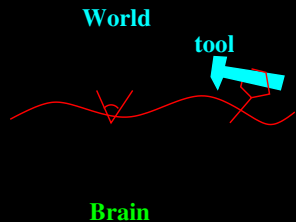
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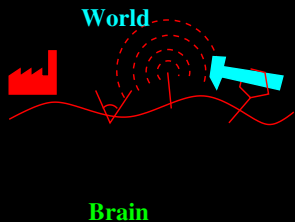
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Modeling the problem of modeling



Modeling the problem of modeling



Brain

▶ **Ergo-systems [Gromov] :**

structure of the brain \leftrightarrow **structures in the world understandable by the brain**

↪ hence list all mathematical structures, to get clues on a mathematician's brain

↪ cf. also M. Galtier's PhD (NeuroMathComp)

▶ **Expressive power** of the brain should be sufficient

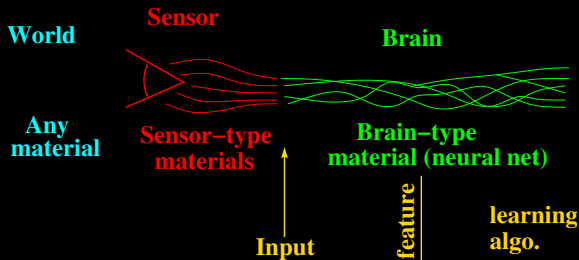
↪ **approximate Turing machine**, provided stability and basic computations possible

→ independent of the materials ? of the universe structure/laws ?

↪ cf. game theory : ant colonies, Conway's game of life : expressivity = Turing but low efficiency/representation

Sensors

- ▶ In classical machine learning : kernels methods :
equivalence **choice of the features** \leftrightarrow **choice of the kernel**
- ▶ But here : sensors and brain are **of different nature !** (materials, physics...) :
no equivalence choice of sensors \leftrightarrow choice of information retrieval algorithm
- ▶ New sensors ? Need actors.



Tools

- ▶ to operate better or to make new sensors, i.e. for **new scales/modalities** in action/sensing. Think of Human Kind without technology.
- ▶ by **exploiting physical properties** of the (external) world
- ▶ require **experiments** (to discover these properties)
- ▶ require analysis & modeling by the brain
- ▶ Note : tool can be an **external brain** (with different materials & properties)

Discussion

▶ follows.