Intelligence in one-page

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200,000 years ago homo sapiens was born. What makes it different from other species? Neocortex and language. Thus, we must conclude that these two elements convey crucial aspects of our intelligence.

The three levels of intelligence by Marr are encoded in our DNA (algorithms + hardware), all the rest is learned during our life. Therefore, we should distinguish between some aspects that are hard-wired and some other that are soft-wired (brain plasticity).

Each task that defines our intelligence can be formulated as a "predict next word" problem in some language, that maps a prompt $x \in X$ into an answer $y \in Y$. Let Ω be a set of problems. The computational objective of intelligence is

$$\min_{f} \; \mathbb{E}_{(x,y) \sim \Omega} \left[d_x\big(f(x), y\big) \right]$$

where d_x measures an error incurred in approximating y with $f(x)$.

How our brain build f? Through the Concept Management System (CMS) which takes as input preprocessed sensorial input from the old brain and outputs an answer.
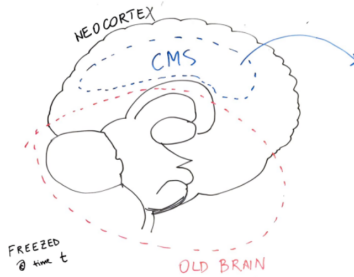

Figure 1

The CMS organizes information using graphs. A model of the world is built as a (knowledge) graph. Units of information (primitive nodes) are called "concepts" and represent irreducible sensorial experience associated to a sound and to a written word (learning language is intertwined with developing intelligence). Abstract (more complex) concepts are represented as combination of primitive nodes (like words in a dictionary).

The principle of decision making is to maximize some utility function that can be represented as combination of concepts in CMS.

We continually build models and hypotheses of how the world works, which we then gradually update and on the basis of which we make decisions (Bayesian inference). This stems from the fact that we are always projected to predict the future (derived as efficient behavior for survival).

Online brain functioning is a real-time input-output system based on triggers (external sensory signals). Each sensory signal generates the modification of brain activation, which reflects in the activation of patterns in the CMS.