From Ability to Capability

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Abstract

Abilities and Capabilities are different concepts. Classical challenges in robotic arise between theoretical computations and realistic efficient feedbacks. We propose a software platform, trying to split the necessary level of (1) actions (abilities), (2) perceptions of sequences of actions, (3) diagnosis and (4) supervision in order to introduce more reactivity and bring together Artificial Intelligence and Autonomous Robotics. Our first experiments will cope with cognitive mapping representations and necessary adaptations needed when inconsistent landmarks are introduced.

Keywords : Robotic, Cognition, Software platform, realistic experimentations.

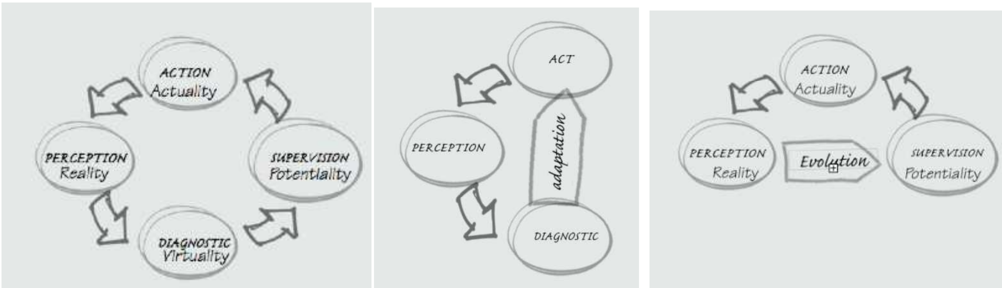
Capabilities and abilities are different concepts. All robots have functional and mechanical abilities but most of the time, the necessary algorithms to exploit them have to be specifically built. If you want to achieve a full use of the possible capabilities of a robot, you need to deeply link this algorithm at the physical level. Robotic area is still pushing these limits with humanoid robots for example. If you want to achieve deep cognitions (emotions, expertise, discovery), to perform clever actions (and inter-actions) in a robotic field, you need a high level representation of your capabilities but unfortunately also some well connected feedback from the realistic part of your computation to make them efficient (embodiment).

What we propose is a software platform, trying to split the necessary level of (1) actions (abilities), (2) perceptions of sequences of actions, (3) diagnosis and (4) supervision in order to introduce more reactivity and bring together Artificial Intelligence and Autonomous Robotics.

The proof of the generic use of this platform will be illustrated on four different “devices”: Minstorm robot (from Lego) (Bourreau et al, 2009); four wheels autonomous robot, Peekee; four legged autonomous dog Aibo (from Sony) (Garrido, 2010) and two legged humanoid robot HOAP (from Fujitsu). We perform the same experiments and try to compare and analyze the resulted memories build by the robots.

Working on autonomous robot is a useful strategy to understand the base of human intelligence. (Oudeyer et al., 2007) works on an architecture for a baby robot which is guided in the way it creates its world representation. In Munich, (Bauer et al., 2009) test the ability of the robot to find its way in a town, asking the pedestrians that it meets in the street. (Coeeckelgergh, 2009) suppose that robots are quasi human. The good practice of capabilities can be used as an efficient test for the degree of autonomy that can be offered to a robot.

By interpretation, we denote a sequence of actions produced by a specific causal cycle. During this cycle, the system performs actions, perceives previous actions, describes reality, analyses its perception in order to suggest possible actions, and finally decides of potential actions to be executed. Adaptation and Evolution transform the interpretation. Adaptation process translates the diagnostic into constraints on the “Action” subsystem. Evolution process translates the perception into contextual modifications of the “Supervision” subsystem. A representation of the interpretation is a contextual ontology in adequacy with the interpretation. This model captures the core of the Brooks architecture (Brooks, 1985) and of the behavioral architecture.



Figures 1,2,3: the Robot behaviour (fig1) is based on a causal temporal cycle producing an interpretation given by a sequence of actions. Brook Architecture (fig2) and the behavioral architecture (fig3) are based on more simple causal temporal cycle.

Technically, the diagnostic subsystem, done by (Paulin 2008), is using constraint programming (Mackworth, 1977). The suggested action scheduling is an extension of the STRIPS (STanford Research Institute Problem Solver) (Fikes et al.,1971) in constraint programming (Lopez, Bacchus, 2003).

To evaluate the actions of the robot, the supervisor uses four modalities (fig 4). These modalities express the supervisor judgments and are used to tell the robot of the nature of the supervisor’s judgment. The series of events are saved in the episodic memory of the robot. It is able to learn and adapt its behavior accordingly.

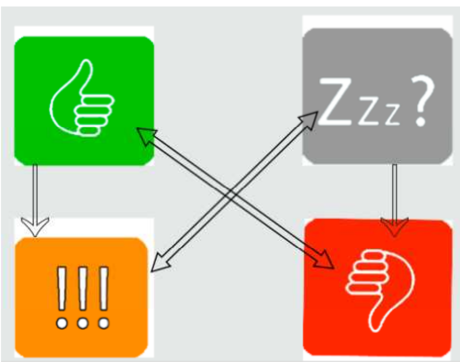


Figure 4: four modalities which are a) green thumb up indicating agreement b) red thumb down indicating disagreement c) grey Zzzz? indicating misunderstanding d) Orange !!! indicating “interest in the matter”. Meaning of the arrows: for logical reasons a =>d and c=> b and it is impossible to simultaneously have “a and b” or “c and d”.

Our platform gives us the experimental environment to test the efficiency and the limit of our architecture. As first experiment, we will deal with Cognitive Mapping and adaptation to Inconsistent

Landmarks. The concept of Cognitive Mapping refers to a process that is essential to the survival of all intelligent species and involves cognitive strategies which lead to mental representations of routes, itineraries, and critical landmarks. Such representations are necessary for successful navigation in a physical environment. We suggest that cognitive mapping can be exploited to investigate the adaptive behaviour of "intelligent robots".

Psychological theory (Tolman, 1948; Denis, 1997) claims that skeletal representations of routes are constructed through the iterative learning of physical and/or symbolic landmarks along routes on the basis of intrinsic or relative or intrinsic spatial reference frames (Levinson, 1996). A relative reference frame gives the robots' position in space (left, right, back, or front) with regard to a reference object or symbol, a so-called landmark, and a target object or symbol. An intrinsic reference frame gives the position of a landmark with regard to the target.

Spatial reference frames and iterative route learning based on landmarks is exploited here to investigate the adaptive ("intelligent") behavior from the episodic memory of the robot trained with teacher-robot interactions. This supervised learning is used to make the robot learn to choose an "ideal route" through a maze towards a hidden target object by responding to specific physical or symbolic landmarks along that route. Learning is accomplished once the robot is capable of responding successfully to the landmarks given and finds the ideal route with a satisfactory success rate (>90%). A learning curve is computed as a reference measure.

After learning, the robot's capacity of adaptive behaviour is tested by introducing either physical or symbolic inconsistencies in the learnt landmarks. Psychological experiments with human observers in virtual maze environments, for example, have shown that removing learnt landmarks from a learnt itinerary does not noticeably affect navigation performances. Changes in the topographical organization of landmarks, however, may considerably affect navigation from destination to target and individuals then have to use other strategies to cope with the problem. Also, as can be predicted on the basis of clinical observations with patients presenting psychological disorders, the repeated perturbation of a learnt landmark code could be experienced as extremely stressful and therefore produce unsuccessful (non-adapted) coping behaviours, as in post-traumatic stress disorders or schizoid, obsessive-compulsory, hysterical and paranoid behaviour disorders, for example (Ishii, 2009).

Will we observe non-adapted stereotypic coping behaviours in the robot that match the stereotypic behaviours of clinical patients when the landmark code, which has previously allowed the robot to produce a highly successful behaviour, is repeatedly perturbed after learning?

How and how long it takes the robot to "unlearn" the learnt itinerary, can be assessed by comparing "post-traumatic" performances with the >90% successful trials at the end of learning.

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