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Philippe Tarroux

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# Frustration: a generic mechanism to improve autonomy in robotics.

Adrien Jauffret, Marwen Belkaid, Nicolas Cuperlier, Philippe Gaussier and Philippe Tarroux  
 ETIS laboratory - UMR 8051, F-95000 - Cergy Cedex, France.

LIMSI laboratory - CNRS(UPR3251) - 91403 Orsay Cedex, France.

email: {adrien.jauffret, marwen.belkaid, cuperlier, gaussier}@ensea.fr; philippe.tarroux@limsi.fr

## I. INTRODUCTION

In this work, we focus on how an emotional controller can be used to modulate robot's behaviors. We present a generic neural architecture, based on an online novelty detection algorithm, that may be able to self-evaluate any sensori-motor strategies. We show how a simple mechanism based on the prediction progress allows the system to monitor its strategies and communicate its disability in deadlock situations. We made several experiments that can account for such properties for two different behaviors (road following and place cells based navigation) in a simulated environment.

## II. A GENERIC MODEL FOR SELF-ASSESSMENT

In previous works, we showed how a robot could perform simple sensorimotor tasks by the learning of place/action associations [Gaussier&al 2002]. We also showed how to perform road fol-

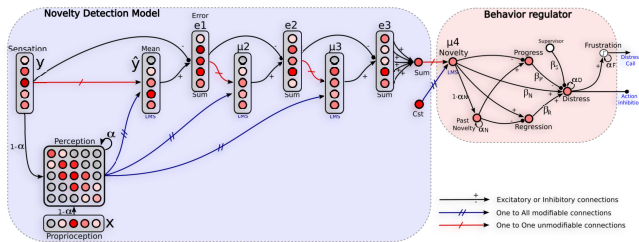


Figure 1. Neural architecture relying on self-monitoring. **Left** : network detecting unexpected events based on novelty. It learns the sensorimotor contingency involved and it is then able to detect novel event (prediction error). Such novelty level gives to the system a feedback on the quality of its behavior. **Right** : Emotional controller monitoring prediction progress and regress to regulate behaviors.

lowing by perceiving vanishing points in the scene [Jauffret&al 2013]. Independently, both strategies gave us satisfying results in most cases. However, the system was not able to select or inhibit strategies depending on the context, nor was it able to detect deadlocks while navigating unknown environments. To overcome these limitations, we propose to add a metacontroller able to detect sensorimotor novelty and thus regulate behaviors according to that novelty. This architecture learns contingencies between sensations and actions, giving the expected sensation from the previous perception. Prediction error, coming from surprising events, provides a direct measure of the quality of the underlying sensorimotor contingencies involved. An emotional controller monitors that prediction error by integrating prediction progress and regress. Such integration represent a distress potential that proportionally modulate the strength of the corresponding behavior. Frustration only appears when the distress level reaches a specific threshold, then the robot stops and call for human help.

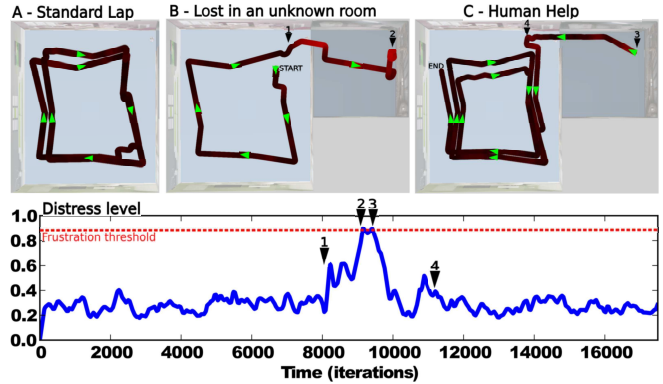


Figure 2. Results highlighting the need for a frustration mechanism to overcome deadlocks. The robot performs its task (a squared loop) **A** when it suddenly become lost in an unknown room **B**. Because of its inability to perform its task, the robot get frustrated so that it stops and call for help. Then, the human teacher assist the robot by showing it the right direction to escape this room **C**. The robot learns this advice so that it will be able to escape autonomously next time.

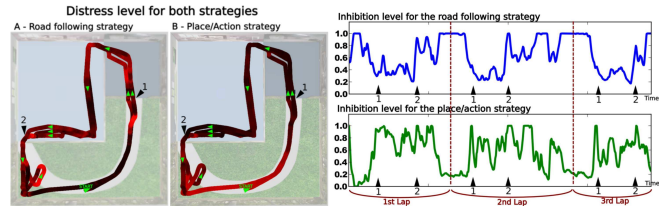


Figure 3. Results highlighting the synergy of cooperating strategies in a complex environment. The robot has learned to perform loops, passing through both rooms and outside part of the environment. A road links the two rooms from outside. The behavior is mostly driven by the place/action strategy in both rooms (rich of landmarks) but driven by the road following strategy while navigating outdoors (poor of landmarks).

## III. CONCLUSION

In this work, we highlighted the need for a metacontroller to take the decision to switch from one strategy to an other. We showed how a simple frustration mechanism can be used as an active judge to monitor and regulate strategies. Such mechanism highlight useful strategies, while discarding others, based on their confidency level. Moreover, the robot is able to stop and call for help if no relevant strategies are found (if switching strategy does not increase any progress at all). It is a useful skill for a robot to learn, from a human expert, only when needed (in un-mastered situations). Current work focuses on testing this model on real robot to perform autonomous navigation in complex environments. We will also evaluate the model performance on long range outside experiments (navigating several kilometers) on a real outdoor robot.