Rat meets iRat

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***Abstract*—Biorobotics has the potential to provide an integrated understanding from neural systems to behavior that is neither ethical nor technically feasible with living systems. Robots that can interact with animals in their natural environment open new possibilities for empirical studies in neuroscience. However, designing a robot that can interact with a rodent requires considerations that span a range of disciplines. For the rat's safety, the body form and movements of the robot need to take into consideration the safety of the animal, an appropriate size for the rodent arenas, and behaviors for interaction. For the robot's safety, its form must be robust in the face of typically inquisitive and potentially aggressive behaviors by the rodent, which can include chewing on exposed parts, including electronics, and deliberate or accidental fouling. We designed a rat-sized robot, the iRat (*intelligent rat animat technology*) for studies in neuroscience. The iRat is about the same size as a rat and has the ability to navigate autonomously around small environments. In this study we report the first interactions between the iRat and real rodents in a free exploration task. Studies with five rats show that the rats and iRat interact safely for both parties.**

***Index Terms*— bio-robotics, rodent-robot interactions**

I. Introduction

This project involves developing a rat-sized robot called the iRat (*intelligent rat animat technology*) as a modeling platform for neuroscience studies, useful for testing neural models of bio-inspired navigation algorithms and for behavioral studies showing rat-robot interactions. The robot was designed, built and programmed by the first three authors at the University of Queensland [1].

Rats are used in a wide range of behavioral studies and are beginning to be used in robot interaction studies [2, 3]. This project involves using the iRat in laboratory settings in which real rodent behaviors are tested. The autonomous navigation abilities and physical size of the robot are critical to the project's goals of comparing iRat and real rat behaviors.

There are many advantages for developing a rat-sized robot. On the ethical side, biorobotics complements experimental approaches to provide a more ethical approach towards an integrated understanding from neural systems to behaviour, and one that is not feasible with living systems. On the educational side, the iRat has already begun to receive media coverage for its role linking neuroscience and robotics.

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II. iRat Design

The challenge for developing a robot rat for neuroscience lies in designing a robot that is both small enough and has sufficient computational power to function autonomously on typical navigation tasks in a real rodent lab. The iRat has autonomous behaviours which enable it to explore its environment [1], and also to monitor its battery level, returning to a charging station when required (see Fig 1). It has a fully functional navigation system, based on the rodent-inspired RatSLAM system [4] (see Figs 2 and 3), which provides it with the ability to explore an unknown environment, creating a map that enables the extraction of place cells and conjunctive grid cells.

The iRat code base has been developed based on widely used frameworks, Player-Stage and Robot Operating System (ROS). These frameworks facilitate rapid development cycles by interfacing to code that can be run on or off the robot over a wireless network. Models can be developed in simulation with support provided for Python, MATLAB and C, and then translated directly to the robot for real-world studies. The use of the system has been demonstrated through the development of a spiking neural controller enabling the iRat to seek specific temporal stimuli [5].

III. Rat-iRat Interaction Studies

The initial studies were purely observation, as a pilot of rat-robot interaction studies. The two open issues were (1) whether the rat would be scared of the robot or (2) a danger to it. The behaviours were recorded on video and frames from one such trial are shown in Fig 4 which demonstrates that the rat is cautious but interested and did not show any fear-related behaviors such as freezing. It also shows that the rat was no danger to the robot (or vice versa). Over a period of four days, five rats were tested, and all had similar behaviors, some a little more timid, one that seemed to like riding on the iRat (but only in a dark arena and not when a camera was pointing at it).

Several interesting observations resulted from this pilot study: the rats need very little time to familiarise themselves with the iRat. They did not treat it as a con-specific, but nor did they treat it as a simple object. Many of the rats observed the iRat from the running track, peeping over the wall to check where it was, and often tracking around behind it. In virtually every approach from the running track, the rat would position itself to approach the iRat from behind as shown in Fig 4.

IV. Conclusions and Further Work

In conclusion, the rats are cautious, but actively approach the iRat. In future we aim to study iRat behaviors that elicit competition and cooperation with the real rats. For these studies the iRat will need new abilities to initiate interactions and respond in behaviorally meaningful ways to the natural behaviors of the real rats.

Fig. 1. iRat with its docking station. The iRat monitors its battery levels and returns to its docking station for recharging when necessary.

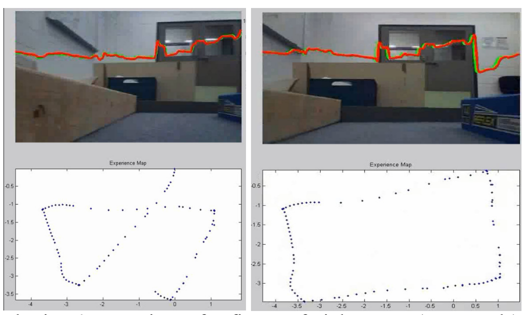

Fig. 2. The iRat's eye view of a figure of eight maze (top panels) and the experience map just before (left) and after (right) recognising a familiar location (closing the loop).

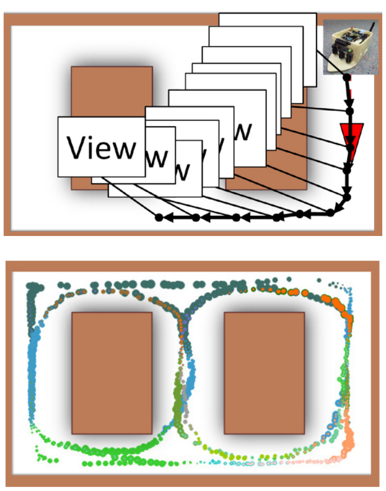

Fig. 3. Forming an experience map (top) and resulting place cells (bottom).

References

[1] Ball, D., et al., A Navigating Rat Animat, in *Artificial Life*. 2010.

[2] Laschi, C. et al, Design and Development of a Legged Rat Robot for Studying Animal-Robot Interaction, *BioRob 2006.* pp. 631-636.

[3] Ishii, H., et al., Experimental Study on Task Teaching to Real Rats Through Interaction with a Robotic Rat, *From Animals to Animats* 9, S. Nolfi, et al., (Eds). 2006, Springer Berlin. pp. 643-654.

[4] Milford, M. and G. Wyeth, Persistent Navigation and Mapping using a Biologically Inspired SLAM System. *The International Journal of Robotics Research,* 2010. **29**(9): 1131-1153.

[5] Wiles, J., et al., Spike-time robotics: a rapid response circuit for a robot that seeks temporally varying stimuli, in *17th International Conference on Neural Information Processing (ICONIP)*. 2010: Sydney, Australia

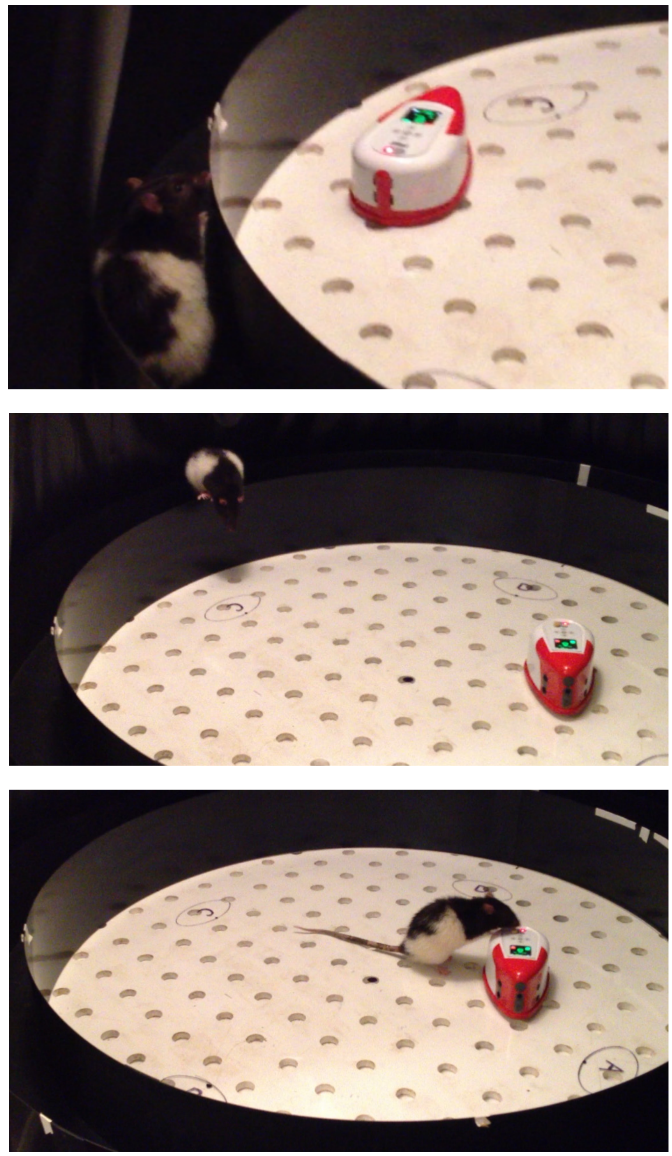

Fig. 4. A rat interacting with the iRat. These are frames from a movie showing the whole interaction. The iRat moves around the cheeseboard inside the circular track. The real rat is free to roam around the cheeseboard or jump into the circular track which forms its outer boundary. Initially the rat runs around the track, and periodically checks on the iRat by peeing over the track wall (top frame). After five or more of such checks at different points around the perimeter, the rat jumps over the wall (middle frame), and then approaches the iRat to retrieve a food reward (bottom frame).