The Critterbot: a Subjective Robotic Project

M. Bellemare, M. Bowling, T. Degris, A. Koop, C. Rayner,
M. Sokolsky, R. Sutton, A. White, E. Wiewiora

A traditional way of solving an AI problem is to represent the different objects or notions composing the problem with a formalism and then use algorithms in this formalism to learn, manipulate or exploit these notions. For instance, if one wanted a robot to do some navigation tasks, then a spatial map of the environment is defined and utilized for localisation and/or path finding. With x and y coordinates, it is easy for the designer to know where the robot thinks it is and to manipulate this information to do some processing such as computing a trajectory or planning for a path. We name such approach *objective robotics*.

However, the x and y representations, chosen by the designer, might not be the best to represent notions such as "a place where infrared sensors of the robot have low values" or "a place where high intensities on the motors are necessary for movement". Moreover, if the robot has to push a button to open a door to enter a room, then the x and y representations are not enough. So, the designer will probably add additional representations to x and y (the current status of the button, for instance) to take into account this new problem. This need to re-engineer representations to allow for new notions makes it difficult for AI to adapt to new problems.

As suggested by the previous example, another approach is to based the different representations only on the relationship between the sensors and the actuators of the robot, without necessarily mapping these representations into a human representation. Our goal is to experiment learning representations grounded in the robot experience with a bottom-up approach. We think that in doing so, it might be easier to learn that before entering a place with low values on the infrared sensors, it is necessary to have one bump sensor activated (to push the button). We name such approach *subjective robotics*.

The Critterbot[1] is a new research platform to evaluate the subjective robotics approach. The poster will first present the current status of the hardware and software of the Critterbot platform. Second, we will present some of the data we have collected from the robot and that are available for the RL community. Finally, we will present some of the research going on with the robot on learning representations. An overview of these topics is described respectively in the next three paragraphs of this abstract. Finally, we propose to bring the robot to the workshop and demonstrate it with by running learning algorithms or having people control it.

The Critterbot The first version of the Critterbot, Mach 1, is now operational[2]. It has been design for running on long periods of time. The robot is holonomic, so translation and rotation of the robot are independent of each other, thanks to 3 omniwheels designed for the Critterbot. These wheels are oriented with an offset

[1] `http://www.cs.ualberta.ca/~sokolsky/critterbot`

[2] A simulator of the Critterbot is also available: see on the website for more information.

of 120 degrees between each of them and driven by one motor each. The action space for the Critterbot is a low level control (voltage or velocity) on these 3 motors. Additionally, a ring of 16 polychromatic LEDs are on top of the robot and can be used to communicate either through agent control or automatic feedback of internal information (such as the value function or policy).

The robot contains the following sensors: 4 ambient light sensors, a 3-axis accelerometer, a single-axis gyroscope, 10 infrared sensors and the current and velocity for the 3 motors. More sensors will probably be available by the time of the workshop.

The robot will be presented during the workshop and people will be able to control its movements with a joystick pad or interact with it while doing a task (for example, pushing it or add obstacles in its way).

Data from the Critterbot `Disco`, the software layer implementing the communication between the agent and the robot, records the inputs and outputs of the robot when it is running. These data are grouped into log files which are available on the Critterbot web site. The poster will show some of these data. Depending on the sensors, the robot position or activities, and many other factors, inputs can be very noisy. Such noise is part of all real world problems. The poster will show some examples illustrating that, despite the noise, data are exploitable and interesting for AI research projects.

Learning representations A common property shared by all the problems the Critterbot might be able to solve is its embodiment. So, representations utilising relations between sensors and actuators for a given problem might be useful for another problem. For instance, knowing that setting the same high voltage on all the motors at the same time rapidly increase the rotational velocity can be useful for different situations: kicking a rattle, moving when stuck against a wall or pointing a sensor in some direction.

But knowing in advance what representations are useful to solve a problem is difficult and the representation the robot uses constrains the class of problem it can solve. Thus, one of our directions of research is to search through the space of features and predictive questions to discover useful representations to solve different problems the Critterbot might address.

Our current direction of research is: given a set of primary predictive questions, generates a set of predictive auxiliary questions and a set of features. Then, using temporal difference algorithms, learns the answers to the auxiliary questions as well as the primary questions. At the same time as learning, it is possible to use different heuristics to evaluate the utility of generated features and auxiliary questions. Some of these features and questions can be removed and new ones generated from the existing set of features and auxiliary questions.

The poster will report the current status of this research and touch on some other research area currently active in the Critterbot project, such as a light seeker agent. Successful research at the time of the workshop will be demonstrated on the robot.