A Step Towards Autonomy in Robotics via Reservoir Computing

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Autonomous mobile robots form an important research area due to their applicability in the real world as domestic service robots. The autonomy of a robot strongly relies on its ability to extract information from the environment. A robot must also be aware of the current situation for an improved interaction with humans or other robots. However, it is very difficult to achieve robotic autonomy in a simple way. Robot tasks such as event detection, robot localization, plan execution, intent recognition are examples of complex tasks that can not be easily solved by standard robotic approaches. These tasks have to be performed using a limited number of sensors with low accuracy, as well as with a restricted amount of computational power.

This work uses the recently emerged paradigm of Reservoir Computing (RC) [1] for grasping information in several contexts of autonomous robotic tasks. RC is a new concept for efficient handling of recurrent networks. With RC, the states of a random and high-dimensional dynamical system made of a reservoir of recurrent nodes are mapped onto the desired output via a simple linear readout. Only the readout output layer is trained using standard linear regression techniques which are simple and fast to implement (the recurrent part or reservoir is left fixed).

This work presents recent and ongoing research carried jointly by two research groups on several robotic tasks. By using RC, we can solve the tasks without any model of the environment neither of the task itself. We consider distinct levels of complexity for the robotic tasks: event detection, localization, plan recognition and intent detection [2]. Event detection consists of detecting simple occurrences local in time and space. It is not a trivial task: for instance, the events of 'passing through door 1' and 'passing through door 2' can seem identical for a robot. It is very important that we are able to distinguish between very similar events. The next step is towards robot localization, in which we rather want to predict the current location of the robot based on the same kind of sensory information. We consider three different granularities for the problem of robot localization: coordinate detection in the cartesian map; location detection in a grid of small discrete areas; location detection in a more realistic environment composed of rooms of distinct sizes. The following robotic task corresponds to plan recognition. Particularly, we are interested in recognizing robot actions during a navigation task such as: the robot is navigating to goal number 1 (which means a possible robot action in a number of distinct goals). Finally, with intent detection we aim at predicting the current intent of a human. It is different from action in that we consider here the case of disabled user who can not always act according to his/her intents. For all four complexity levels, we use RC as a black-box model for learning the task, where the inputs are only distance sensors. In addition, in the context of robot localization, we further extend the experiments to map and path generation. This is achieved by using the RC network in a generative setting, which makes possible to easily extract the maps and the trajectories stored internally by the reservoir.

This work aims at achieving increasing degrees of robotic autonomy by using a simple and efficient technique, namely, RC. We show that we can efficiently solve all aforementioned robotic tasks with RC. Finally, we believe that RC can be applied to a wide range of robotic tasks, enhancing the robot's autonomy, its interaction with (disabled) humans or other cooperating robots.

References

[1] Verstraeten, D., Schrauwen, B., D'Haene, M., Stroobandt, D.: A unifying comparison of reservoir computing methods. Neural Networks **20** (2007) 391–403

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