FUZZY INTERPRETATION OF SEQUENCES OF MULTI-SENSOR DATA FOR AN AUTONOMOUS MOBILE ROBOT

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EXTENDED ABSTRACT

Data interpretation is one of the most relevant issues to support autonomy in robotic, mobile agents. The integration of data from different sensors and the study of their temporal evolution may increase the reliability of the models used to control the agent.

In this paper, we present an approach to interpret in real time data sequences provided by different sensors. Our system interprets data clusters in terms of fuzzy sets and uses this interpretation as a basis to recognize more complex situations both from the co-occurrence of classification patterns provided by different sensors, and from sequences of classification patterns by the same sensor. Thus, we can build models of the environment based on *terms* similar to those adopted by the designer of the control system to reason about the task. This reduces the design cost and increases the quality of the control system.

We identify *classes of homogeneous sensors*, that is sensors that share some data characterisic, and we define for each of them: how to characterize the terms we are interested in, how to map sensor data to these terms, and how to operate with the identified terms. In the application we present in this paper, we have considered three sensor classes, concerning data from the *odometer* (the device measuring the agent's movement), from *sonar sensors*, and from an omnidirectional image sensor (*COPIS*[5]). In this paper we focus on sonar data.

We have implemented a system that can produce 8 sonar readings every 150 ms[3]. This data rate makes it possible to identify relevant aspects of the temporal evolution of the readings. We cluster short sequences of readings from each sensor and we interpret them in terms of fuzzy sets. We have two main reasons to adopt this approach: first, sonar data are affected by errors, and their fuzzy interpretation is more robust than a crisp one; second, the identification of more complex terms, based on the simpler ones, is more robust when these last rely on partially overlapping, coexistent interpretations.

Once identified the basic terms, we consider sequences of such interpretations to define higher level terms. Finally, we consider parallel sequences of terms, each provided by a different sensor, to define higher level terms.

We adopt an augmented (fuzzy) *Petri Net* to classify by higher-level terms temporal sequences of lower-level terms provided by a sensor. Thus, we can define admissible sequences of lower level terms that can be identified in parallel, in real time. The main motivations for Petri Nets are that partially identified term sequences could be part of different term sequences, and term sequences could also overlap: Petri Nets allow for a real-time, parallel interpretation, needed in this case. We take the Petri Net approach also at a higher abstraction level, to model term sequences coming from different sensors.

We associate to each identified term the corresponding membership value. These term-membership pairs can be used as input for fuzzy logic controllers, to control the agent at different abstraction levels, from sensor-actuator control, to behavior selection and planning[4,2].

We have implemented this techinque on two robotic agents we have built in our lab: *Fuzzy CAT*[1], and *RAA*. The complete term identification is performed in real time, on board, providing updated terms every 150 msec. We are applying this type of symbolic control to a navigation task concerning document distribution among the offices of our department. The integration among sonar, odometer and COPIS implements a reliable and robust basis for multi-level fuzzy control.

Finally, the input-output mapping expressed in symbolic, fuzzy terms can be effectively learnt [1,2] and, eventually, tuned on the specific, faced environment.

References

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