Bio-inspired Sensory Data Aggregation

A. De Paola, M. Morana

In Advances in Intelligent Systems and Computing, vol. 196, 2013, pp. 367-368.

Bio-Inspired Sensory Data Aggregation

Alessandra De Paola and Marco Morana

The Ambient Intelligence (AmI) research field focuses on the design of systems capable of adapting the surrounding environmental conditions so that they can match the users needs, whether those are consciously expressed or not [4, 1].

In order to achieve this goal, an AmI system has to be endowed with sensory capabilities in order to monitor environment conditions and users' behavior and with cognitive capabilities in order to obtain a full context awareness. Amy systems have to distinguish between ambiguous situations, to learn from the past experience by exploiting feedback from the users and from the environment, and to react to external stimuli by modifying both its internal state and the external state.

This work describes a modular multi-tier cognitive architecture which relies on a set of pervasive sensory and actuator devices, that are low intrusive and almost invisible for the users [3]; these features are achieved by adopting the ubiquitous computing paradigm, stating that the sensory and actuator functionalities have to be distributed over many devices pervasively deployed in the environment [5].

The pervasive sensory subsystem is controlled by a centralized AmI engine that allows to guarantee a unitary and coherent reasoning, and that is responsible for further stimuli processing. A parallel can be drawn with the nervous system of complex biological beings, composed by a peripheral nervous system, responsible of collecting and transmitting external stimuli, and a central system, responsible of performing cognitive activities. Whenever the sensory subsystem performs a partial stimuli aggregation, it basically mirrors some components of the human peripheral nervous system which are responsible for filtering perceptual information by means of distributed processing among several neurons [9]. In most cases, the peripheral nervous system does not perform this aggregation; indeed this may not be appropriate when the observed phenomena are not characterized by any apparent regularity.

The main contribution of this work is the transposition of this way of aggregating and processing sensory data, typical of biological entities, in an artificial Ambient

Alessandra De Paola and Marco Morana
University of Palermo, viale delle Scienze ed.6, 90128 Palermo (Italy),
e-mail: {alessandra.depaola, marco.morana}@unipa.it

Intelligence system. This approach is strengthened by several works in literature, belonging to diverse research fields [6, 2], showing the usefulness of aggregating and processing data at different levels of abstraction.

A large set of sensory devices deployed in the same environment, allows to observe the manifold facets of an irregular phenomenon [7, 8]. The rough aggregation of gathered sensory data implies the loss of pieces of information; nevertheless, in order to efficiently deal with a large flow of distinct sensory measurements, it is necessary to choose a suitable architectural paradigm.

We propose to adopt a multi-tier cognitive architecture able to transfer sensory data through increasingly higher abstraction levels. Our modular architecture mimics the behavior of the human brain where the emerging complex behavior is the result of the interaction among smaller subsystems; in this model, the outcome of lower level reasoning is fed into the upper levels, dealing with the integration of information originated by multiple lower-level modules.

Just as a child brain performs self-organization in order to develop areas that will be activate when meaningful concepts are formulated, the proposed system is able, by means of adaptive learning, to enable a natural rise of meaningful concepts. These concepts might not correspond to those used by human beings, but instead they will be meaningful within the system itself; namely, emerged concepts will be those most useful for driving the system in choosing the most appropriate actions to achieve its goals.

References

1. Aarts, E., Encarnação, J.L.: True Visions: The Emergence of Ambient Intelligence. Springer (2006)
2. Agostaro, F., Augello, A., Pilato, G., Vassallo, G., Gaglio, S.: A conversational agent based on a conceptual interpretation of a data driven semantic space. In: Proceedings of the 9th conference on Advances in Artificial Intelligence, AI*IA'05, pp. 381–392. Springer-Verlag (2005)
3. De Paola, A., Gaglio, S., Lo Re, G., Ortolani, M.: Sensor9k: A testbed for designing and experimenting with WSN-based ambient intelligence applications. Pervasive and Mobile Computing. Elsevier **8**(3), 448–466 (2012)
4. Ducatel, K., Bogdanowicz, M., Scapolo, F., Burgelman, J.C.: Scenarios for Ambient Intelligence in 2010, Tech. Rep. Information Soc. Technol., Advisory Group (ISTAG), Inst. Prospective Technol. Studies (IPTS), Seville (2001)
5. Estrin, D., Girod, L., Pottie, G., Srivastava, M.: Instrumenting the world with wireless sensor networks. In: Proc. of Int. Conference on Acoustics, Speech, and Signal Processing (ICASSP 2001). Salt Lake City, Utah (2001)
6. Gaglio, S., Gatani, L., Lo Re, G., Urso, A.: A logical architecture for active network management. Journal of Network and Systems Management **14**(1), 127–146 (2006)
7. Gatani, L., Lo Re, G., Ortolani, M.: Robust and efficient data gathering for wireless sensor networks. In: Proceedings of the 39th Annual Hawaii International Conference on System Sciences (HICSS'06), vol. 9, pp. 235a–235a. IEEE (2006)
8. Goel, S., Imielinski, T., Passarella, A.: Using buddies to live longer in a boring world. In: Proc. IEEE PerCom Workshop, vol. 422, pp. 342–346. Pisa, Italy (2006)
9. Kandel, E., Schwartz, J., Jessell, T.: Essential of Neural Science and Behavior. Appleton & Lange, New York (1995)