Research work proposed for a PhD (China Scholarship Council)

Title : Distributed Artificial Intelligence for Smart Cities deployment

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Context and thesis topic :

One of the key challenges for contemporary research is to develop and maintain livable, sustainable and resilient cities. For the first time in history, the majority of the world's population live in urban spaces. The complexity of urban areas necessitates interdisciplinary approaches to be taken in research and development. Goods and services have to be available at short notice. Mobility must be affordable and reliable. Technical infrastructure needs to be easily accessible. Citizens require appealing living quarters embedded in open spaces with green and blue infrastructure. Often, these demands are contradictory, thus imposing considerable challenges. An example of application of these techniques can be found in [Zhu et al, 2019].

The goal of this PhD thesis is to contribute to the above-mentioned challenges by defining Distributed Artificial Intelligence tools and methods in order to ease the management of smart cities relying on technological devices, such as computer systems of course, but also, every connected thing that are distributed throughout our physical and information environments [Basso et al, 2016] . These objects are increasingly implicated in our everyday actions. For example: connected watches, tablets, phones and more generally Internet of Things. Data and information issued from all these devices are generated at unprecedented speeds and volumes from an increasingly diverse range of sources and via ever more sensor

types. It is then combined in unforeseen ways, limited only by human imagination. Such kind of systems necessitate Distributed Artificial Intelligence as they are composed of several interacting entities called agent acting autonomously and following specific goals. For these systems, there exist ongoing research works contributing to their engineering [Cossentino et al, 2014].

Among the challenges, the work of this PhD consists in defining an architecture for technological devices that allow both the interaction with humans [Esmaeili et al, 2020] and overall goal achievement such as the concepts described in [Evertsz et al, 2015]. In order to do so, these connected devices should be aware of global goals or there should be a coordination mechanism that issue commands to the connected devices. The continuous organization of the devices should support self-organization, openness and support a kind of goal planning technique. Machine learning techniques can ease the adaptation feature of such system [Hilaire et al, 2008 ; Pournaras et al, 2020].

Publications related to the subject :

[Basso et al, 2016] Gillian Basso, Massimo Cossentino, Vincent Hilaire, Fabrice Lauri, Sebastian Rodriguez, Valeria Seidita: Engineering multi-agent systems using feedback loops and holarchies. Eng. Appl. Artif. Intell. 55: 14-25 (2016)

[Cossentino et al, 2014] Massimo Cossentino, Vincent Hilaire, Nicolas Gaud, Stéphane Galland, Abderrafiaa Koukam: The ASPECS Process. Handbook on Agent-Oriented Design Processes 2014: 65-114

[Evertsz et al, 2015] Rick Evertsz, John Thangarajah, Nitin Yadav, Thanh Ly: A framework for modelling tactical decision-making in autonomous systems. J. Syst. Softw. 110: 222-238 (2015)

[Esmaeili et al, 2020] Esmaeili, Ahmad & Gallagher, John & Springer, John & Matson, Eric. (2020). HAMLET: A Hierarchical Agent-based Machine Learning Platform.

[Hilaire et al, 2008] Vincent Hilaire, Abderrafiaa Koukam and Sebastian Rodriguez. An Adaptative Agent Architecture for Holonic Multi-Agent Systems. In ACM Transactions on Autonomous and Adaptive Systems, vol. 3, pp. 1-24, 2008.

[Pournaras et al, 2020] Pournaras, E., Yadhunathan, S. & Diaconescu, A. Holarchic structures for decentralized deep learning: a performance analysis. *Cluster Comput* **23,** 219–240 (2020). https://doi-org.ezproxy.utbm.fr/10.1007/s10586-019-02906-4

[Zhu et al, 2019] Jiawei Zhu, Fabrice Lauri, Abderrafiaa Koukam, Vincent Hilaire, Yishuai Lin, Youquan Liu: A hybrid intelligent control based cyber-physical system for thermal comfort in smart homes. Int. J. Ad Hoc Ubiquitous Comput. 30(4): 199-214 (2019)