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Adaptive Goal Selection for improving Situation Awareness: the Fleet Management case study

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Abstract

Lack of Situation Awareness (SA) when dealing with complex dynamic environments is recognized as one of the main causes of human errors, leading to serious and critical incidents. One of the main issues is the attentional tunneling manifested, for instance, by human operators (in Decision Support Systems) focusing their attention on a single goal and loosing the awareness of the global picture of the monitored environments. A further issue is represented by stimuli, coming from such environments, which may divert the attention of the operators from the most important aspects and cause erroneous decisions. Thus, the need to define systems helping human operators to improve SA with respect to the two aforementioned drawbacks emerges. These systems should help operators in focusing their attention on active goals and, when really needed, switching it on new goals, in a sort of continuous adaptation. In this work an adaptive goal selection approach exploiting both goal-driven and data-driven information processing is proposed. The approach has been defined and injected in an existing multi-agent framework for Situation Awareness and applied in a Fleet Management System. The approach has been evaluated by means of the SAGAT methodology.

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Keywords: Situation Awareness, Intelligent Transportation System, Reinforcement Learning

1. Introduction

Most of the critical incidents happened in the last twenty years in large-scale technological systems and control rooms (e.g., chemical process facilities, energy production and transmission systems, logistic operations control, etc.) which had serious consequences, have been considered just as the result of human errors. Actually, subsequent investigations showed that the human errors are just a contributing cause of such events [1]. What clearly emerges is that the ability of the operator to understand what is happening in the environment represents the most critical element for the prevention and the management of complex situations. Such cognitive capability is defined as Situation Awareness (SA) [2,3]. SA can be considered as the level of awareness that a person has with respect to the task he/she is performing and with respect to the surrounding environmental conditions, as well as the ability of making informed decisions and predicting the plausible changes of the situations in the near future [1]. Lack of SA often appears as the root of

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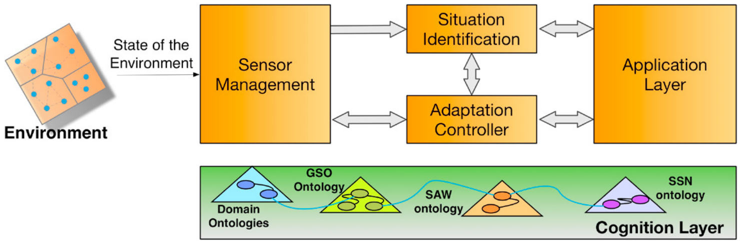

Fig. 1. Framework for Situation Awareness: architectural sketch

many incidents and errors, especially when operators have to consider multiple goals and multiple tasks require their attention. In such circumstances, users usually process data following two opposite approaches. The first one, namely the goal-driven information processing, is a very effective way to process information where data is elaborated with respect to a specific goal. In the second approach, i.e. the data-driven information processing, data is processed as soon as it is perceived by the users, without considering a specific goal. Both these two approaches suffer of some drawbacks with respect to the users' Situation Awareness. Indeed, although the goal-driven information processing is very effective as the users focus their attention on a specific goal without considering useless details, it may cause the so-called *attentional tunneling* problem[2,4]: the users remain overly fixed on certain data sources to the exclusion of others that do not relate with the current goal but may be just as relevant. On the other hand, the prevalent adoption of data-driven approaches could evoke another enemy of situation awareness: *data overload*. In this case, the rapid rate at which data changes quickly outpaces the ability of a person's sensory and cognitive system to supply that need[2]. The alternation among these two ways of processing information is critical for maintaining high level of situation awareness.

In order to face the aforementioned problems, this work proposes a computational approach for *adaptive goal selection* that is able to sustain human operators in switching coherently between different goals. The approach adopts *desirability* measures for goals in order to evaluate their relevance without the users' intervention and it is able to balance goal-driven and data-driven information processing in order to maintain high level of SA. Furthermore, the approach is adaptive, as it adapts the process for evaluating the desirability according to the users' feedback and, thus, it is able to learn from its positive or negative results. This is realized by means of a reinforcement learning technique.

2. Overall Picture

In this Section the proposed approach to *adaptive goal selection* (AGS) is described and integrated into an existing multi-agent framework for Situation Awareness, inspired by the well-known Endsley Model[5]. Such framework has been presented, in the various development phases, in previous works[6,7,8,9,10]. In this paper, the framework has been empowered by the proposed approach and subsequently instantiated for implementing a Fleet Management System (described in the case study provided in Section 5). Specifically, the framework provides methods, techniques and data models aimed at supporting the three levels of Situation Awareness described by the Endsley Model (perception, comprehension and projection) in order to implement Decision Support Systems in complex environments.

2.1. Framework for Situation Awareness

Figure 1 depicts the main modules of the existing framework. The framework consists of a set of agents asynchronously communicating by exchanging events via an event bus. The framework gathers data from the monitored environment via *Sensor Management*, whose aim is to handle lifecycle of the sensor devices, acquisition of raw data and representation/organization of such data. *Cognition Layer* handles a set of integrated ontologies for semantically representing sensor data (by means of the W3C Semantic Sensor Network Ontology SSNO[1]) as well as the goals (represented by means of the Goal-Service Ontology GSO[11]) and all the information the agents need in order

[1] https://www.w3.org/2005/Incubator/ssn/ssnx/ssn