Selecting Information based on Artificial Forms of Selective Attention

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Abstract.
We describe an approach based on artificial forms of selective attention for overcoming the problem of information and interruption overload of intelligent agents so that these can autonomously select relevant information of the environment while ignoring other less relevant information in order to allocate processing resources on it.

1 INTRODUCTION

Humans are dealing with an overabundance of information, forcing them into a state of continuous partial attention and causing interruption overload. As predicted by Alvin Toffler [11] this is a huge problem having many negative implications not only in personal life but also in organizations, business, and in general in world economy. Information technology may be a primary reason for information overload due to its ability to produce more information more quickly and to disseminate this information to a wider audience than ever before. Interruptions and distractions take many forms such as ringing phones, text messages, alerts to incoming e-mail, blogs, RSS feeds, web sites, not to mention "old media" sources as books and newspapers. The brain simply doesn't deal very well with this multitasking process: there is a waste of time as the brain switches from one task to another and back again [3]. This phenomena of "interruption overload" [7] is especially problematic (or dangerous) if the human agent is performing critical tasks like driving a car. Actually, there is evidence indicating that mobile devices are the cause of many vehicle accidents (e.g., [12]).

In this paper we describe an artificial selective attention mechanism that may be used by artificial agents so that only relevant information is selected and forward to processing units, including, if integrated into information/technological systems, communication to their human masters. Our approach relies on the psychological and neuroscience studies about selective attention which defend that variables such as unexpectedness, unpredictability, novelty, surprise and uncertainty demand attention.

2 A COGNITIVE COMPUTATIONAL MODEL FOR FORMS OF SELECTIVE ATTENTION

Selective attention may be defined as the cognitive process of selectively allocation of processing resources (focus of the senses, etc.) on relevant, important or interesting information of the (external or internal) environment while ignoring other less relevant information. But what makes something interesting? In cognitive science, attentional focus is linked with expectation generation and failure, i.e., with surprise [8]. Therefore, it is reasonable to consider that any model of selective attention should rely on a cognitive model of surprise. However, surprise is not enough. Happiness/pleasantness, which according to cognitive theories of emotion and specifically to belief-desire theories of emotion [9] is directly related to congruence between new information and the human's intentions/goals/motives/desires, may also play a fundamental role on attention [10]. For this reason, the system must also incorporate a measure of the expected satiation of the desires, i.e., expected reward or utility of the information for a specific human agent, based on her/his particular intentions and desires at hand. Other variables, such as novelty (different, unfamiliar), complexity (hard to process, challenging, mysterious), uncertainty, coping potential [1, 10] (according to previous studies, there is evidence indicating that these variables elicit curiosity/interest [1, 2, 10]) might also be taken into account.

In order to accomplish all those requirements, we developed an architecture for a personalized, artificial selective attention mechanism (see Figure 1). We assume this mechanism is incorporated in an agent which interacts with the external world receiving from it information through the senses and outputs actions through their effectors. We also assume the agent is a BDI agent, exhibiting a knowledge or belief container, a module of feelings, as well as intentions and desires. These intentions and desires define the profile of the agent. In addition, we also assume the agent contains other resources for the purpose of reasoning, decision-making ad communication. The first of the steps is concerned with getting percepts. The second is the computation of the current world state. This is performed by generating expectations or assumptions, based on the knowledge stored in memory, for the gaps of the environment information provided by the sensors (module 2 in Figure 1). We assume that each input information resulting from this process (module 1 in Figure 1), before it is processed by other cognitive skills, goes through several sub-selective attention devices, each one evaluating information according to a certain dimension such as surprise (module 4 in Figure 1), novelty (module 5 in Figure 1), uncertainty (module 6 in Figure 1), complexity (module 7 in Figure 1), coping potential (module 8 in Figure 1), and motive-congruence/incongruence (i.e., pleasentness/unpleseantness — happiness; congruence to agent's goals and desires) (module 9 in Figure 1) taking into account some knowledge container (memory — preexisting information, that should reflect the human information) (10), and the intentions and desires (motives (module 12 in Figure 1)). The values of surprise, novelty, uncertainty, happiness,

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etc., are computed by the feeling module (module 11 in Figure 1). There is a decision-making module (module 13 in Figure 1) that takes into account the values computed by those sub-selective attention modules and computes an overall relevance/interesting value for each input information (e.g., an average of the values provided by each sub-selective attention modules). Then, this module of decision-making selects the higher relevant information and appropriately allocates resources (reasoning, processing, displaying, communication resources, etc.) (module 14 in Figure 1) to deal with it. In this sense, the selective attention mechanism is on the basis of other cognitive abilities of the agent in that it decides in which information those other cognitive abilities should focus.

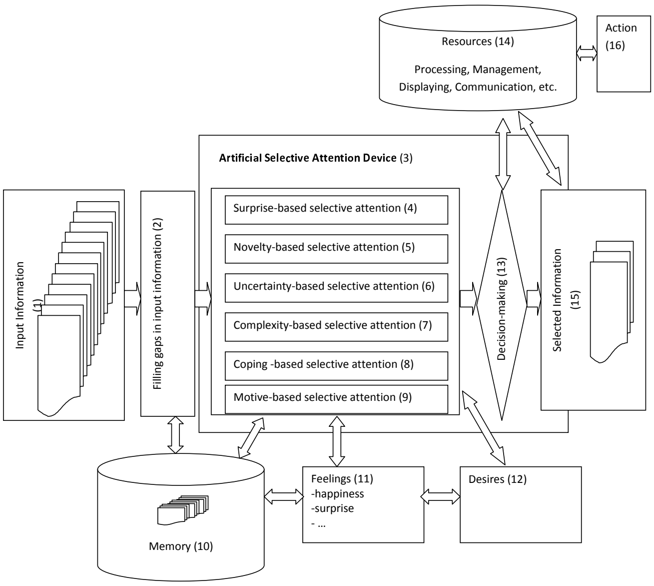

Figure 1. Architecture of an artificial selective attention agent.

In this paper we focus on the surprise-novelty-uncertainty-based selective attention mechanism. More details about the computational models of surprise, novelty and uncertainty may be found in [4].

We conducted an experiment with an agent whose task is to explore the environment populated with objects in order to build a map [4, 6]. The goal of the experiment was to assess the influence of its selective attention mechanism in preventing the agent from visiting regions of the environment that elicit novelty, surprise and uncertainty below a certain threshold, i.e., to prevent the agent from making effort for looking at information that seem to be less relevant. The comparison of the performance of the agent in map building by exploitation taking and not taking into account that apparently less relevant information is a good indicator of the significance of the selective attention mechanism. In this sense this effort is considered an unnecessary interruption or distraction to the exploratory behaviour of the agent. With this end, we let the agent explore various environments with different degrees of complexity and with different attention-triggering thresholds. The size of the memory of the agent at the end of those runs differs since using different attention-triggering thresholds, the agent don't visit always the same regions and entities of the environment. On average the lower the attention-triggering threshold the larger the memory size. At the end of each run we let the agent build a map for a new environment by exploiting the knowledge acquired in previous exploration. The performance of the agent was measured by the degree of inconsistency between the map built and the real map.

The results show that on average, the lower the attention-triggering threshold, the higher the number of interruptions that don't contribute significatively to improve performance, the higher the memory size, the lower the map inconsistency. Considering these results we may present the advantages and disadvantages of interrupting the agent attention to visit regions and entities. The main advantage of using a selective attention mechanism is that it requires less time and less energy than that of involving a complete exploration of the environment. In fact, the agent is prevented from exploring all the regions of the environment. The disadvantage of this exploration approach based on a selective attention filter is that the amount of knowledge learned may lead to more inconsistent maps when the agent exploits that knowledge to build the map in a different environment. However, this inconsistency is not very significant which justifies the use of the selective attention mechanism.

Agents equipped with a selective attention filter may be used as personal assistants of humans, integrated for instance in mobile devices, so that their human masters are prevented from unnecessary interruptions which may be critical in situations such as driving a car (see [5]). While in the exploration domain described in this article, the advantage is less time and energy to explore an environment, in intelligent transport systems the advantage is less vehicle accidents and less deaths, and in organizations the advantage may be an improvement in their workers productivity and therefore less costs. This lead us to conclude that the selective attention mechanism may be a functional necessity for agents as it plays an important role in their vital mechanisms.

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