Intelligent Agents – Autonomy Issues

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ABSTRACT
Autonomy of agents is a critical issue in the field of intelligent agents. It is indeed becoming central and relevant in the design and development of agents and multi-agents systems. In this paper we intend to articulate some fundamental concepts and concerns of the autonomy of agents. Some critical attributes in autonomy are reviewed from the perspective of a number of researches projecting current realities on the issue. The dimensions of autonomy on such issues as situational and regulated or adjustable autonomy were examined. It is observed that autonomy of agents is necessary but needs regulation.

Keywords: Intelligent agents, autonomy, adjustable autonomy and situated autonomy

1. DISTINGUISHING INTELLIGENT AGENTS

The term “Intelligent agent” is derived from the concept of agency in human business practice. When an individual, called an agent, is employed to act on another’s behalf in a given business transaction, that person represents the employer and interacts with other players in the performance of a specific task. In like manner intelligent agents operate in intelligent systems, mainly computers, to help the user perform specific task while interacting with other system users and/or programs. Intelligent agents are computer programs [1]. Several other names have already been given to these programs. A number of these names portray the type of agents or level of agency. Such names include software agents, wizards, software daemons, and softbots [2].

This interesting concept in application software and system resource utilization has been given different definitions by different researchers over the years of its development. Each of these definitions tends to capture the vital characteristics of these agents especially the autonomy of agents. Some of them have been highlighted with the goal of projecting the place of autonomy in the functionality of intelligent agents.

i. According to Maes, [3] autonomous agents are computational systems that inhabit some complex dynamic environment, sense and act autonomously in that environment, and by doing so realize a set of goals or tasks for which they are designed.

ii. Franklin and Graesser [4] defined autonomous agents as a system situated within and part of an environment that senses the environment and acts on it, overtime, in pursuit of its own agenda, so as to effect what it senses in the future.

iii. Knapik and Johnson [5] opined that intelligent agents are software entities that carry out some set of operations on behalf of a user or another program, with some degree of independence or autonomy, and in so doing, employ some knowledge or representation of the user’s goals or desires.

iv. Wooldridge [6] says that intelligent agents continuously perform three functions: perception of dynamic conditions in the environment, action to affect conditions in the environment, and reasoning to interpret perceptions, solve problems, draw inferences, and determine actions.

v. Hess et al [7] describes an intelligent agent as a software implementation of a task in a specified domain, on behalf or in lieu of an individual or another agent. The implementation contains homeostatic goal(s), persistence, and reactivity to the degree that the implementation (1) will persist long enough to carry out the goal(s), and (2) will reach sufficiently within its domain to allow the goal(s) to be met and to know that fact.
vi. Russell and Norvig [8] defines intelligent agent as an autonomous entity which observes and acts upon an environment (i.e. it is an agent) and directs its activity towards achieving goals (i.e. it is rational).

The character of autonomy is evidently either directly or indirectly conveyed in these definitions from the researchers referenced in the foregoing. In fact, some researchers refer to intelligent agents as autonomous agents. This underscores the importance they attach to the character of autonomy in the operation of agents in intelligent systems. This then informs our motivation to review vital issues on autonomy of intelligent agents.

2. DEFINING AUTONOMY OF INTELLIGENT AGENTS.

An intelligent system is one consisting of intelligent agents and possibly, humans and/or other conventional software. Generally, in an intelligent system the assignment of responsibilities and authority, i.e. autonomy, is either fixed or switches between a small number of fixed configurations. Autonomy implies that the agent has the ability to act on its own. It portrays or connotes empowerment or authority. The agent is capable of taking decisions on its own in the pursuit of set goals while acting on behalf of a user or agent software as it interacts with its environment. It must be able to modify its course of operation as it encounters obstacles so as to find a way towards its desired goal [1], [3].

The general concept of agent’s autonomy is often interpreted as freedom from human intervention, oversight, or control [9], [10]. However this definition is suitable for domains involving single-agent-to-human-user interaction. But in multi-agent environments, a human user is often far removed from the operations of any particular agent, some researchers define autonomy in a more broad sense as a property of self-motivation and self-control for the agent [11], [12], [13]. This sense of the word autonomy captures the concept of freedom from intervention, oversight, or control by any other agent, but including but not limited to, a human.

Consequently, Barber and Martin [14] argue that agent’s autonomy becomes its active use of its capabilities to pursue its goals without intervention, oversight or control by any other agent. From a purely conceptual or theoretical perspective, devoid of any practical considerations, autonomy can naturally be regarded as absolute without dimension or degree of measure. It has been observed [15] that this strong view of autonomy contrasts with much of the practical work with agents in which autonomy is taken to be the same as independence, a very distinctly relative notion. In what might be called this weak view, a non-autonomous agent either depends on others or is fixed, while an autonomous agent can either be independent or depending on others. It is this last point that seems to suggest that autonomy is not the same as independence – an agent does not simply lose its autonomy by virtue of depending on another for a particular goal; situation of dependence occur also for autonomous agents [15].

It could be argued that the notion of independence can be used as an approximation for autonomy with the added benefit that it admits the dimensions and measures of degrees that are missing from the strong views [15], [1]. In this sense it might be considered as a valuable practical realization of autonomy, and provides a way to characterize different dependence situations. Efraim Turban et al [1] imply that agent’s autonomy is derived and is dependent upon other characteristics of agents as interactivity, reactivity, pro-activity, intelligence, collaboration, and mobility.

3. DIMENSIONS AND DEGREES OF AUTONOMY OF INTELLIGENT AGENTS.

The interplay of the various attributes and characteristics of intelligent agents with its autonomy results in some dimensions as well as degrees of autonomy of these agents. In multi-agent domains, agents can never be completely autonomous from one another. There is need for necessary sacrifices in autonomy to facilitate the required interaction. Barker et al [16] specify these sacrifices to fall along three dimensions; in the amount and type of information that agents exchange with one another; in the physical modification that must be made to allow an agent to interact with others; and in the amount of control an agent has over its own actions and tasks during problem solving. While completely autonomous artificial intelligent systems are clearly desirable in many situations, a great many domains require agents which make some sacrifices of autonomy for the purpose of cooperative behaviour [17]. These dimensions of sacrifice of autonomy give rise to some dimensions, degrees of autonomy which we here review.

3.1 Situated Autonomy

The consideration that agents refer to a situation and a goal in the course of its activity influences its level or degree of autonomy. Autonomy of an agent maps an agent, a situation, and a goal to a stance towards the goal such that the stance will be used to generate the most appropriate or the most relevant action for the agent [18]. Situated autonomy view considers agent’s moment-to-moment action selection instead of a long-lived agent characteristic. For every given situation the agent’s position towards the goal will be whether to abandon it or to decide its overall stand. This definitely amounts to deciding on a degree of autonomy which is related to the responsibility for a goal in the given situation.

Hexmoor [18] argues that time and teammates both provide contexts or situations for an agent’s autonomy to be regulated or modified. An agent that must have fast action selection decisions does not have time for deliberation and will use instinctual means to produce its stance, whereas one with more leisurely action selection requirements can use reasoning and perhaps its Beliefs, Desires, and Intentions before producing a stance. With respect to teammate context, once an agent is motivated to form or to participate in a team toward a common goal, its stance will require the agent to dynamically monitor and adjust its stance relative to teammates.
Situation in autonomy consideration should not only involve the state of the world as it pertains to the agent’s goal, but also the agent’s model of teammate situations and autonomies. Unlike the view that autonomy is lowered with cooperation with teammates [11], it is strongly believed that an agent’s cooperative attitude is not opposed to its autonomy.

3.2. Adjustable Autonomy
Adjustable autonomy is a recent idea that means that the autonomy of agents and humans/other agents in a system vary dynamically. In an intelligent system with adjustable autonomy, the system can flexibly configure the assignment of autonomy between the people and agents to best fit the situation. The goal is to optimize overall system performance. Flexible assignment of autonomy means a system can deal with a wider range of situations more effectively. Thus, adjustable autonomy allows the intelligence and autonomy of agents to be fully exploited without being stuck with their inadequate decision making when situations which the agent cannot handle (or which humans could handle better) occur [19]. A key problem to be addressed when building adjustable autonomy is to determine an appropriate distribution of autonomy and provide mechanisms to realize the autonomy changes. The distribution of autonomy should change according to the current situation and sub-goals, reconfiguring so as to best organize the system resources to achieve the system’s goals.

Adjustable autonomy becomes necessary and desirable because of a number of benefits. First, it allows the client to gradually increase a contractor’s autonomy as client becomes more confident in the contractor’s competence and performance. From the client’s view, to adjust the autonomy means to modify the level of delegation of responsibility to the agent. Second, it allows the contractor to dynamically change its own autonomy on the basis of its needs, external constraints, etc [20]. Falcone [21] argues that in adjustable autonomy control cannot be completely lost and delegation cannot be complete, not only because of lack of confidence and trust, but also for reasons of distribution of goals, knowledge, and competence, and for an effective collaboration. In such situations, it is very important that the level of an agent’s autonomy could be changed (adjusted) during interaction in its environment. Adjustable autonomy can be viewed as bilateral (the client and the contractor) or bidirectional (by either increasing or decreasing the amount of autonomy itself) [22]. To adjust the level of autonomy and to arrive at a dynamic level of control in multi-agent systems it is fundamental to specify the different dimensions and levels of delegation where the issues of trust and control are defined.

3.3 Autonomy Through Motivation
The behaviour of the agent is what determines its autonomy. Behaviour of individuals to a large extent is a function of their motivation. The interaction of agents influences their separate autonomy based on goals and motivations [23]. Autonomous agents possess goals that are generated within rather than adopted from other agents. These are goals generated by internal motivation. They are non-derivative components characterizing the nature of the agents that can be regarded as any desires or preferences affecting the outcome of a given reasoning or behavioural task. For example, greed is not a goal in the classical artificial intelligence sense since it does not specify a state of affairs to be achieved, nor is it describable in terms of the environment. However, it may give rise to the generation of a goal to rob a bank. The distinction between the motivation of greed and the goal of robbing a bank is clear, with the former providing a reason to do the latter, and the latter specifying what must be done.

This dimension of autonomous agent is based on the generation and transfer of goals between agents. That implies that for an entity to be an agent, it should be seen as satisfying a goal that is first created and then, if necessary and appropriate, transferred to another. It is the adoption of goals that gives rise to agenthood, and it is the self-generation of goals that is responsible for autonomy. Thus, an agent is just something either that is useful to another agent in terms of satisfying that agent’s goals, or that exhibits independent purposeful behaviour [15]. Importantly, agents rely on the existence of others to provide the goals that they adopt for instantiation as agents. In order to escape an infinite regrets of goal adoption, however, autonomous agents can be defined as agents that generate their own goals from motivation [21], [15].

4. CONCLUSION

Autonomy of agents is obviously delicate. This arises because it exposes systems to some risks, such as lack of control, unpredictable outcomes, and intrusiveness. However, this survey exposed its usefulness and near indispensability in intelligent systems. Its necessity has the following arguments in its favour;

- Limited knowledge, competence, time and capacity of the user/client agent, that make “delegation” (reliance) necessary and in particular open delegation i.e., the delegation to “bring it about that …” without specifying the necessary actions or plans.
- Local and updated information to be taken into account in reasoning and problem solving (open and uncertain world; moving around).
- Required local and timely reaction and learning.

While some theoretical issues of autonomy have been surveyed, it is important to note the difference in purpose and context of the dimensions of autonomy of agents. This will ensure one is not dogmatic in practical situations. Clearly, there is value in studying the general concepts of autonomy regardless of practical concerns, but we must also address the practical implications. Issues of levels or degrees of autonomy still need to be given further consideration by researchers.

REFERENCES


Author’s Brief

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