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DEVS modelling and simulation of human social interaction and influence

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ABSTRACT

The social influence is at the centre of consideration in social science. In industrial engineering, although the enterprise has reached the age of the electronic communication, the human direct communication is not sufficiently considered even if it remains critical communication vector to transmit information. The idea is to predict some human attributes behaviour that will help enterprise to make efficient decision. The research in the domain gives significant results but the impact of information on individuals within a social network is, mostly, statically modelled where the dynamic aspect is not frequently tackled. The individual's reaction to a change within an organisation or ecosystem (implementation of a new system, new security instructions…etc.) is not always rationale. The opinion of individuals is influenced by information gathered about the attributes of the technology from other members of their social network. In addition, the works about modelling and simulation of the population's reactions to an event do not use explicit specification languages to support their models. A behavioural specification model is one critical missing link. Adding a clear behavioural model can help for specification verification and reuse. From literature, the DEVS formalism (Discrete EVent system Specifications) appears to be general enough to represent such dynamical systems (Zeigler et al., 2000). It provides operational semantics applicable to this domain. The contributions of this work are dynamic models of individuals using low-level language to simulate the propagation of information among a group of individuals and its influence on their behaviour. In more detail, we define a set of models of individuals characterized by a set of state variables and the mesh between the individuals within a social network. Then, we introduce the information diffusion based on epidemic spreading algorithms and we transpose them into the case of the message propagation in a social network. Finally, a basic scenario is used to give a beginning of validation to our models using a platform based on DEVS formalism.

1. Introduction and motivation

In the field of social influence, a fundamental problem is to develop a model for finding an efficient way to spread information within an informal network. It seems natural that many people are often influenced by their friends' opinions and recommendations. In industrial engineering, even if the enterprise has reached the age of the electronic communication, we assume here that the human direct communication is not sufficiently considered although it remains one critical communication vector to transmit information. This study is focussing on informal social networks that remain a critical communication vector such as coffee break or others informal meetings. The idea is to evaluate the informal communication existing in the enterprise or other organisations that takes other ways than hierarchical or process orders. These commutations can influence and change the members' opinion in the field of organisational management (for instance the implementation of a new information system). Therefore, the behaviours of individuals and user groups have to be modelled and integrated into simulators to get more realistic results. The research in social science domain gives significant results but the impact of information on individuals within a social network is, mostly, statically modelled where the dynamic and sequential aspects are not frequently tackled.

Social interaction plays an important role in studying the propagation of information, innovation, ideas, and influence among its members. When an event appears-for example, the use of cell phones among students, the adoption of a new information system within the enterprise, or the rise of a political movement in an unstable society-it can either die out quickly or make significant inroads into a population. Network diffusion process allows us to

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understand the dynamics and the propagation of information in social network. These networks can consist of individuals, group of person or organisations. The interactions could be done by physical contact, remote collaboration, any types of social meetings or some forms of verbal or written communication depending on the situations. The diffusion studies are numerous because diffusion phenomena are discussed in several disciplines: computer science (computer virus, information diffusion in a social network) (Girvan et al., 2002), biology (epidemics) (Cauchemez et al., 2011), physics, etc. In our case we diffuse a message enclosed in a data packet. This packet contains several pieces of information which influence the reaction of the individual and time life of the packet. The intention is to go further than most of the current models which generally reduce the individuals as simple obstacles or information transmitters without enough nuances in their behaviour and the influence they can have on a message.

The choice of an appropriate modelling technique to study the behaviour of complex systems is very important (Robinson, 2004). To inform the choice of modelling technique, the relevant literature spanning the fields of Economics, Social Science, Psychology, Retail, Marketing, Operational Research, Artificial Intelligence, and Computer Science have been reviewed. Agent-based Modelling and Simulation (ABMS) play an important role in the field of computational social science. It is a method of computational representation of individual interactions from which social patterns emerge; the latter is a method that affords (dynamic) structural analysis of (socio) structural patterns. Agent-Based Modelling (ABM) shows micro-level processes that affect macro level outcomes. The macro level behaviour is not explicitly modelled; it emerges from the micro-decisions made by the individual entities (Pourdehnad et al., 2002). Today, Agent-Based Models (ABMs) are mostly implemented as object-oriented computer programs. They consist of autonomous agents that can be perceived as computer programs themselves. Agents have in principal three features: they behave and interact according to a given set of rules, possess cognitive capabilities to process information, and constitute their own environment (Ferber, 1999). In this study we use the Discrete Event Systems specifications (DEVS) formalism to represent agents. DEVS has the interest to be timed, highly modular and hierarchical for the description of reactive systems. This low-level language permits a full control of the agents' models and it promotes modularity and reusability.

A cellular automaton is a very simple abstraction invented in the 1940s by John von Neumann to study self-reproducing systems (Von Neumann and Burks, 1966). Since then, Cellular Automata (CA) have been widely used to reproduce and better understand the dynamics of complex phenomena found in the real world, especially when these phenomena only require very simple programming to be reproduced digitally. Despite their high ability to describe complex phenomena, however, CA still suffer from a low ability in supporting structural rules at various levels. In this article, we recall an extension of the CA that compensates this missing structure by means of another simple but equally powerful mathematical abstraction called DEVS. First, we give a comprehensive description of the resulting Cell-DEVS formalism. Then, we demonstrate the ability of this formalism to express the phenomena of social influence. In more detail, this paper will participate in the definition of a set of models that address the entities, the structure of a population and the social interaction. We begin by recalling the DEVS formalism and the CD++ toolkit. In addition, we provide a model of individual characterized by a set of attributes using DEVS. Finally, we present a basic scenario of message diffusion over a population to validate our models using a platform based on DEVS formalism.

2. Background and related work

In this section we introduce the concepts used along the article and we analyse some related works from the literature. We first introduce the DEVS formalism and its extension (focusing on Cell–DEVS). Then we describe some DEVS simulation tools and we focus on CD++, the DEVS simulation environment in which the actual implementation of our work is based on. Finally, we analyse some related work on the diffusion model.

2.1. DEVS formalism

The DEVS formalism for modelling and simulation (Zeigler et al., 2000) is based on discrete events modelling. It provides a framework with mathematical concepts based on the sets theory and systems theory to describe the structure and the behaviour of a system. With DEVS, there is an explicit separation between a model and its simulator. Once a model is defined, it is used to build a simulator (i.e. a device able to execute the model's instructions). DEVS proposes two kinds of models: the atomic models, which describe behaviour, and the coupled models which describe a structure and hierarchy. DEVS has been used as a simulation paradigm for various systems (Sarjoughian et al., 2001). In our work, we use it to model human behaviour.

The DEVS formalism has numerous advantages. We can classify them into two aspects: theoretical and applicable perspectives (Fig. 1). In the theoretical perspective, the DEVS formalism allows the building of a very complex model by connecting different DEVS models, either atomic or coupled models, in a hierarchical manner (Fig. 1 Left Circle). Besides, the formalism provides simple but clear semantics for the basic model behaviour (Fig. 1 Top Circle). It can specify a specific state at any point of time as well as connect with other models with I/O events which are caused by state transitions. In addition it permits structural coupling to assembly DEVS and DEVS extension so it encourages interoperability (Fig. 1 Right Circle). It is well known and several implementations exist (Fig. 1 Down Circle).

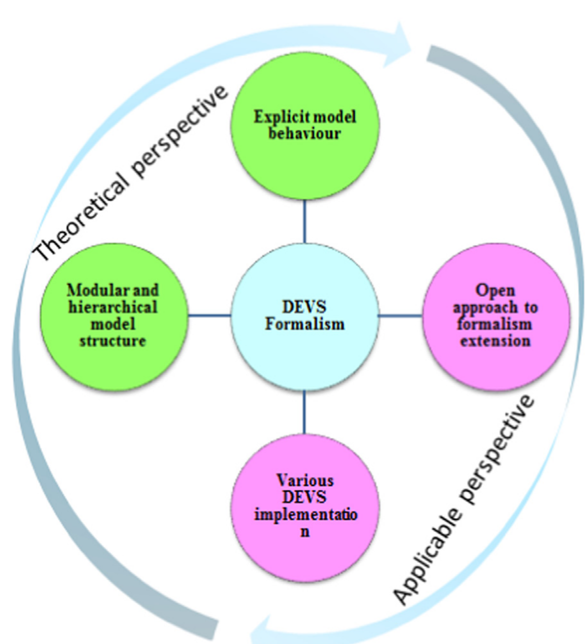

Fig. 1. Advantages of DEVS formalism from two perspectives.