Using Explanations of Agents to Increase Understanding of Simulations for Tutoring Police Allocation

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Abstract

This article describes the ExpertCop tutorial system, a simulator of crime in an urban region. In ExpertCop, the students (police officers) configure and allocate an available police force according to a selected geographic region and then interact with the simulation. The student interprets the simulation results with the help of an intelligent tutor, the Pedagogical Agent, observing how crime behaves in the presence of the allocated preventive policing. The pedagogical agent implements a strategy of explanation of the agent's individual behavior to make simulated phenomena better understood.

1. Introduction

Simulation aims to represent a phenomenon via another one and it is useful to measure, demonstrate, test, evaluate, foresee, and decrease risks and costs. In educational terms, simulation is important because it allows learning through the possibility of doing. Simulation has been shown to be a good teaching tool, especially for complex situations, with high cost and risk.

Social or urban environments are dynamic, non linear, and made of a great number of variables, characterizing a complex system. The use of Multi-agent Systems (MAS) with geographical information systems (GIS) in the simulation of social or urban environments characterize the geosimulation [1]. The simulation *per se* isn't a sufficient tool for education. It lacks a conceptual form (both graphic and interactive) for the student to understand the simulation model. Therefore, some works have tried to integrate the notions of Intelligent Tutoring System (ITS) and simulation in order to better guide learning and to improve understanding of the simulation process.

Despite recent proposals on new models and implementation of instructional layers in simulators [2], few tools have been created specifically for geosimulation. These applications involve particular features as the geographic ones that generate a great amount of data deriving from the occurred interactions in the simulation process. It becomes necessary to make chronological, geographical and statistical associations among these data to understand the cause and effect of the simulated events. Thus, we propose the use of an intelligent tutor agent as data analysis supporting tool, the Pedagogical Agent. This agent implements interaction strategies between the student and the geosimulator, designed to make simulated phenomena better understood.

This article describes the educational tutorial system ExpertCop. It aims to teach police officers to better allocate their ostensive police force in an urban area. This software produces, based on a police resource allocation plan, simulations of how the crime behaves in a certain period of time based on the defined allocation. The goal is to allow a critical analysis by police officers that use the system, making them to understand the cause-and-effect relation of their decisions.

2. ExpertCop architecture

ExpertCop Architecture is composed of a MAS system, a GIS, a database and an interface. The interface in ExpertCop allows the student to move among the functionalities and processes of the system in a logical, ergonomic and organized way. The GIS is responsible for generate, manipulate and update a map of the city to be studied in a small scale. The system database contains i) the information about each student and about his/her simulations, ii) the configuration data, iii) the real data on crime and statistics on crime yielded for the department of state police and iv) the

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domain ontology. The most important component is the MAS platform which is made up of three groups of agents and implemented in JADE [3]: domain agents, control agents, and the pedagogic agent. The *domain agents* are the actors of the domain. They are notable points which represent buildings relevant to the objective of the simulation, such as shopping, banks, parks and drugstores; Police teams which have the mission of patrolling the areas selected by the student; and criminals which have the mission of committing a specific crime. The criminal's task is to evaluate the viability of committing the crime. The evaluation is based on risk, benefit, geographical features as public illumination, proximity of escape routes and personality factors. A description of these agents is beyond the scope of this work, see [5] for further details. The control agents are responsible for the control, communication and flow in the system. The most important control agents are the *GIS agent* that is responsible for answering requests from the graphical interface, domains and control agents; the *manager agents* which are responsible for the coordination and interaction with domain agents and control pre-programmed activities as activation and deactivation and the *Log agent* that is responsible for recording all interactions among system agents. Other important control agent is the Pedagogical Agent (PA). It is endowed with pedagogical strategies, and aims to help the user in the understanding of the simulation process and results. PA will be discussed in details in the next session.

3. ExpertCop pedagogical proposal

The pedagogic agent uses two distinct forms to explain the events of the system. a micro level, and a macro level explanation.

In the micro level explanation, the Pedagogical agent, explain the simulation events (crimes), using a tree of proofs describing the steps of reasoning of the criminal agent responsible for the event. This tree is generated from the process of the agent's decision making. The agent's evaluation of a crime is represented by a set of production rules explored by an inference engine. The student can obtain the information on the crime and the process that led the agent to commit it or not, by just clicking with the mouse on the point that represents the crime on the map. Each crime, represented by a point on the screen, is associated with a proof tree.

Explanations expose the reasoning process used by the criminal when deciding whether to commit the crime. ExpertCop uses this input to induce a critical analysis and provides recommendations for increasing or decreasing the levels of police surveillance and placement aimed at improving police effectiveness.

ExpertCop can explain why crimes did or did not happen. It can also answer follow-up questions such as "how was the Risk evaluated?" or "what is Risk?" Figure 1 shows the ExpertCop system interface composed by a map where crimes are plotted. The figure also shows an example of an explanation level after a user selection on the map. For each selected place, ExpertCop identifies whether crimes occurred and allows users to request explanations.

The first explanation in Figure 1 shows the criminal agent decision "to commit the crime" because it knows that crimes are committed if the risk level is "medium", opportunity level is "medium", the danger level is "medium" and financial compensation is "medium". The user requests a follow-up explanation about why the risk level was evaluated to be "medium". The system responds that the risk level is medium because the police officer proximity is "far", the place population density is "low", and the public illumination is "good". The user requests a second follow-up explanation about why the police officer proximity is "far". The answer was that the criminal knows that if the police distance is greater than 500 meters then the police proximity is classified as "far" and in the current situation, the police officer distance is 808 meters.

The explanations were derived from the tree of proofs and rendered as a hypertext.

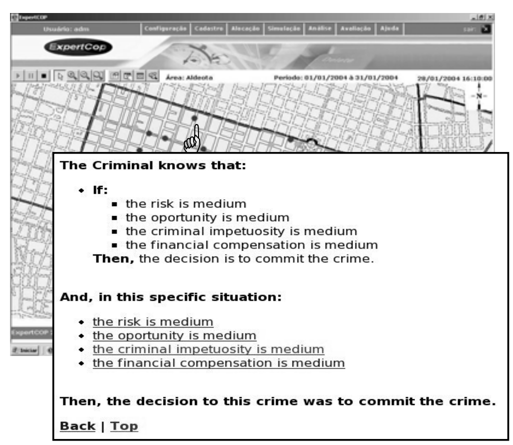

Figure 1. The ExpertCop interface and an example of an explanation to the user

The explanation at a macro level aims at showing the effects of individual events in crime, its increase or reduction, criminal tendencies and seasonableness. For this, PA tries to identify patterns of behavior from the database generated in the simulation. The simulation data are events generated for the interaction of the agents as crimes (date, hour, motive, type), patrols (start time, final time, stretch), and geographic information as escape routes, notable place coordinates, distance between events, agents and notable places. PA identifies patterns by means of the probabilistic concept formation algorithm COBWEB [4]. The generated concepts are characterized according to their attribute/value conditional probabilities. That is to say, a conceptual description is made of attribute/values with high probability. Having the probabilistic concept formation hierarchy constructed, the agent identifies and filters the adequate concepts for being transformed in questions to the student. The heuristic procedure used to filter which concepts will generate questions to the student can be seen in [5]. It suffices here to describe that a probabilistic concept generated by COBWEB is displayed to the student as the following question: **"**Did you realize that *crime*: theft, *victim*: vehicle, *week day*: Saturday, *period*: night, *neighborhood*: Aldeota frequently occur together?". Having this kind of information, the student can reflect on changes in the allocation, aiming to avoid this situation.

4. Evaluation of ExpertCop system

ExpertCop was used to support a course at the Ministry of the Justice and the National Secretariat of Public Safety - SENASP. The audience was made up of three groups of thirty professionals in the area of public safety: civil police officers, chiefs of police, and military police officers (which are the majority).

In the course, the use of ExpertCop occurred in two distinct stages. One explanatory, where the participants were instructed on the process of allocation of police resources, what it is all about and how it occurs in practice. The other is an evaluative one where training was carried out by simulations in city areas with different characteristics.

From the use of ExpertCop in the course we hypothesized that the use of the pedagogical support of the system would help the students in the understanding and identification of new beliefs regarding crime and the allocation process. The identification of new beliefs would be reflected in the data collection after the simulation. The acquisition of new concepts and beliefs would make the student improve his allocation and consequently obtain better results in the simulations.

Before the simulation training, we observed that the definition of patrol working hours or a more careful analysis of the patrol areas was ignored. In the subsequent simulations the patrol areas were defined more carefully, being created with more appropriate covering area. We could observe that the students tried to identify the critical points and the periods of crime risk.

Evaluating the beliefs collected in the two phases, we observed that most of the participants altered their initial beliefs on the reasons that favored crimes. More specific and practical beliefs replaced those initially observed, which were more generic. Time factors, such as the relationship between the periods of the day, the week and the month and the number of crimes occurred, began to be taken into consideration..

Moreover, analyzing the quantitative results of the simulations (how many crimes were avoided), we observed that the participants obtained new concepts and beliefs and so they improved their allocation and consequently obtain better results in the simulations. The improvements were dependent on their experience level and their activity. In general we conclude that the learning level is higher in participants with little or no experience in the domain or in the treatment of information. A detailed report about these results can be seen in [5].

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