Modeling and Simulation for Supporting Investigative Inquiries in the JP And PS Sector

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Abstract: The paper proposes the application of Virtual Reality and Simulation to support reconstruction of a crime scene in order to support Police investigations and judiciary analysis. The possibility of use M&S and VR Techniques for anti-terrorism investigations and repression are presented and discussed in the paper as well as the potentials offered by Data Mining Techniques in monitoring contents of intercepted conversations and messages.

Key-words: Virtual Reality, Crime Scene, Investigations, Simulation, Aniterrorism

1. Introduction

The current international scenario has radically transformed the roles and functions that police must carry out to assure the State and citizen safety. Particularly a wider role is played by the inquiry techniques becoming the core of a problem approach based on the collection of information, the knowledge structuring and the decisional process.

Even if in the past the phase of data collection has been considered as critical for the chronic lack of the information, today the situation seems completely upset. The information systems, which we meet every day, can produce an impressive amount of data that is necessary to put in order and structure. The information, indeed, displays an extremely poor content of knowledge if it is not put in relation with other data and brought back to its natural contest. This phenomenon is more clear when the inquiry subject is represented by a group of individual scarcely related each other. Therefore there are both technological impediments, essentially due to a lack of information standardization making the integration among the database extremely difficult, and methodological barriers slowing down the process of knowledge creation and organization. The following step of data analysis and decision would therefore require a contribution able to separate the lower level decisional processes from those displaying a higher added value by allowing the second ones to keep a higher advantage from the automation of the first ones.

From the point of view of the methodological and technological progress, which took place during the last years, without any doubt we can make reference to the works of the Newcombe [1] who as first towards the end of the '50s put down the inquiry technical bases inside the data assemblies. These studies put into evidence as a mathematical approach to the problem of the correspondence and relation detection among different database can be used to check fraudulent identities or reconstruct criminal facts.

This process, which had a rigorous mathematical formulation by the merit of Fellegi and Sunter [2], has then evolved in the most recent techniques of Data Mining, which have had a remarkable application also in the industrial sector. These studies had pointed out as the collected information quality is determinant for its effective use and that a great part of the efforts must be carried out to assure in reasonably short times the greatest evidence possible of the collected data. Therefore, it should not neglected the trend to import from abroad already developed models and methodologies, which in the past produced evident technique adaptation and cultural mediation problems.

2. Development in the Information Technology sector

In the Information Technology (IT) sector, recent developments permitted to achieve important

progresses making possible the sharing of the greatest amount possible of information with relatively low costs and complexity. With the coming of the World Wide Web (WWW) it as been finally possible to create complex network of data exchange able to support the main decisional processes independently form the physical localization of the decision maker and by sharing the effort among different subject in real time (Grid Computing).

Many of these technologies are today commercially available and they can be applied with success to the different scenario of the Judicial Police and Public Safety intervention.

To be simpler, we will group the technologies and the approaches according to their sphere of influence and the positioning in the logic-operative flux.

- Support tools to the data collection: they are mainly represented by the relational database (RDBMS) and multidimensional database (MDBMS), some software structure able to preserve the information by making it available to the user in the wanted manner. To support the remote access to these databases in the course of the years, we adopted different telecommunication technologies both proprietary (legacy) and based on international standards (ex. TCP/IP). Particularly the standardization effort in this sector allows today being able to operate on structured database and available through a standard query language called SQL. In the information distribution sector we can remember the recent development of the Web Services (UDDI, WSDL, SOAP) making possible, along with the older architectures (CORBA), the achievement of a really wide and capillary decision support system.
- Support tools to the known data structuring: even if they are not developed as the database technologies, in the course of the years the research made available a series of enquiry techniques to determinate relationships and correspondences starting from fragmentary data and affected by errors and incongruence. Among the different techniques we can remember the Microdata Confidentiality and Associated Re-Identification Methods or the Analytic Linking of Scheuren and Winkler. These tools have been in more recent time put aside to other artificial intelligence techniques as the Genetic Algorithms and the Artificial Neural Networks (cfr. Revetria et. Al. MIC2002, Innsbruck A). It should made particular mention to the

Autonome Agents, independent software structure equipped of a decisional ability to make possible a coordination among them and carry out some specific tasks inside particularly complex informative architecture. An application of this methodology is in progress between the Lockeed Martin and the Pennsylvania State University School of Information Science and Technology.

- Data presentation and analysis tools: in the last years they met the public favor through the evolution of the database concept into the data warehousing one, in which different operating fact sources (data marts) cooperate so as to achieve a multidimensional structured view of the phenomena through on-line data analysis tools (OLAP). Besides to these technological supports it should be remembered the contribution given by the study of the Attribute Relational Graphs (ARGs) for the achievement of the Social Networks Analysis (SNA) to identify potential menaces to the security or suspect behaviors in groups of individuals. These methodologies are essentially based on the graph theory and make possible in a rigorous way to extract abnormal elements inside a great amount of heterogeneous data and show them in a correct manner to the decision maker.
- Decision support tools: they have been developed starting from the '50s and affirmed themselves as standard firstly in the military sector and then in the industrial one, among the different techniques and methods we can remember the simulation (M&S), the Bayesian techniques and the Multi Criteria Decision Making (MCD) through which we can evaluate different scenario and brought back to a set of reduced decisional parameters.

3. Proposal of an integrated architecture

The proposed architecture provides for a beginning phase of the currently database related available information sharing through the development of suitable interface able to feed the database of the single interconnected seats. Instead of achieving a single monolithic database which is impossible to consult, they will carry out suitable local database kept updated with the information kept from the considered source. Then a database will have such dimension to reduce the cost deriving from the complexity of a single centralized data source. The function of the information research and the

following phase of analysis aiming to identify possible correlations shall be carried out by suitable Software Agents able to physically displace along the network to search the required information. According to the inner behavior rules defined a priori, these agents will be able to autonomously decide the following database to contact and eventually physically displace towards this target. Some trials of this kind has been already carried out by the authors on December 2002 in cooperation with the Boston College using a proprietary architecture developed by exploiting the Jini® framework of SUN Microsystem. During this trial it has been verified the ability of the autonomous agents to displace through the normal internet network to look for the necessary information. Again, trials of this kind have been carried out during 2000-2001 at the USN Navy Warfare Development Command showing surprising results. So as to make operative from the practical point of view this architecture it is necessary to predispose the suitable masks to access the system able to lead the user towards the definition of the targets, these masks will be accessible only by user able to correctly authenticate with the system.[3]

In the research of the evident links among different facts inside the databases the architecture will provide to integrate a suitable mathematic model and support this function also through an artificial Neural network. Examples of these applications has been carried out by the authors and applied to an industrial case already during 2001. Finally the amount of the collected data and analyzed by the agent architecture will feed suitable analysis tools which we will expect to carry out with the OLAP technology with the help of the already achieved experiences and consolidated in the warehousing sector.

In order to offer a suitable system access point in any circumstance it will be possible to carry out modules of interface to the existing information system (ex. Vehicular terminals, command and control posts). Moreover it will be possible to access in an integrated and distributed way to the system so as to ease the Shared Mental Model formation and the team work.

At the IT current state, this project seems compliant with the more recent developments and it can benefit of consolidated operating standards as business technological tools of proved reliability.

4. Virtual Reality, Increased Reality and Crime Scene Representation techniques

The main goal of the JP and PS forces is to reconstruct with high fidelity the crime scenario in order to identify easily the responsibilities and the culprits; anyway these activities need a strict cooperation among different professional figures which are skilled in the different identification sectors. By the isolation of the activity of the crime scene "reconstruction" it has been possible to identify a series of critical processes that need a huge support in terms of technology.

The phases of evidence study and analysis are subjected to a regenerative phenomenon, so an evidence discovery could have a positive or a negative regeneration that strengthen or weaken the starting evidence phenomenon providing a process which is continuous and non linear.

By using a simulated reconstruction in a real environment it is possible to define a correct space-time relationship among the evidences and the different possible scenarios, but in this case it is required the simultaneous presence of different expert on the crime scene and to recreate with fidelity the environmental conditions of the crime time.

Often this operation is not allowed because it is impossible to recreate a credible crime scene and so it is sufficient to think to a crime reconstruction where a fire or an explosion has occurred.

Nowadays the new modeling techniques and 3D reality representations allows reconstructing the virtual crime scene thanks to computer graphics and, with an Internet access, to share it with different individuals spread over the world canceling geographical constraints.

In literature there are many examples of virtual scenarios reconstruction spacing in different fields of application: from the architecture to the aerospace industry passing by the medical and military applications.

An interesting example of Virtual Reality (VR) application is provided by Mindrevolver.com S.A.S. reproducing Savona Campus of the University of Genoa, which could be explored by different users with a simple Internet connection (for further informations: http://www.mindrevolver.com/world/test/start.html) downloading a plug-in in order to start exploring this virtual world. This model provides to set up the physical features of every user into the scenario (Avatar) but also to define different light and weather condition (fog, rain, night, etc…) and the physical limits of the objects (color, hardness, transparency). This method provides an impressive potentiality in order to represent a scene by integrating the formalization of knowledge with the VR and having reasonable results in a very short time.[4]

Further developments of these models could be provided using interfaces that allow the user manipulating the virtual object guaranteeing a multisensorial representation of reality. Towards this direction are focused projects like GHOST (General Haptics Open Software Toolkit) of the American SensAble Technologies and the project

NASA Payload Design Evaluation of the NASA Langley Research Centre in Norfolk
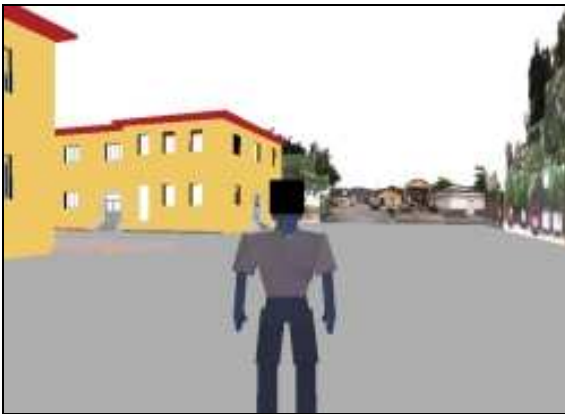
M&S (Modeling and Simulation) is a powerful tool not only for reconstructing a crime scene, but also to study and prevent phenomena of terrorist attacks; in fact after September 11, 2001 and the following anthrax menaces, the struggle against terrorism requires more sophisticated techniques in terms of information technologies such as data mining and data automated analysis techniques.[5]

Anyway these tools could generate controversies because they require analyzing also private data and guidelines to be followed in order to reach the goal correctly, so policymakers need to acquire knowledge in data mining and automated data analysis in order to set the correct parameters and to encourage a responsible use of these techniques.

It is so preferred to use model-based techniques because present more advantages than the traditional methodologies, in fact each analyst has his experience in order to evaluate and filter data putting emphasis on the most significant parameters and minimizing the less significant ones.

Simulation model operate automatically starting from the collected data and analyzing them: the outputs provided by the model are useful to generate reports of possible warnings, threats and methods that the terrorists could use for their attacks.

The model operates using input data (usually text data) searching for key words like names, places, dates and events; and relationships between words. The detected information are translated into mathematical variables that are combined into metrics and provided output values that are interpreted by the experts in useful information.

There are two different kinds of models that could be used in order to prevent terrorist attacks:

World Terrorism Metric (WTM) that measures the current terrorism activity

Target Threat Assessment Model, which estimates possible threats generated by potential terrorist attacks.

The WTM is an automated model which collects filters and evaluates direct and indirect measures of the current terrorist activities while the Target Threat Assessment Model combines inputs provided by the matter experts with news in order to estimate the potential terrorist menaces against places and populations.

5. Conclusions

What is expressed above, describes a scenario where the answer time to the terrorist menaces tends to dramatically reduce by making necessary to support the human decisional process through suitable technological tools. After an analysis of the more recent developments in this sector it seems clear as the solution can be found through the joined application of many techniques and the use of the more advanced IT tools. The experience of authors who are directly engaged in project of research strictly correlated to that delineated above, believes therefore that is not always possible to import technologies from the more advanced countries but that it is necessary to develop, according to its own environment and cultural realities, some solution ad hoc able to solve the problem in an effective manner.

It has been proposed a directly operative architecture able to support the process of founding, analysis and presentation of the decisional data applied to the JP and PS sector which can constitute the starting point of a more complex and effective IT reorganization of the sector.

References

[1]. H. Newcombe et. Al. Automatic Linkage of Vital Records *Science* 130 pp. 954-959 (1959)

[2]. Fellegi & A. Sunter A Theory for Record Linkage *Journal of American Statistical Association* 64 pp. 1183-1210 (1969)

[3]. Revetria R., Bruzzone A. G. (2003) VV&A for Innovative Concept Design in New Vessels Simulation and Virtual Prototypes *International Journal of Simulation* series ISSN 0735-9276, Volume 35 Part 3 pp. 748-754;

[4]. Revetria R. Mosca R. (2007) Distributed Simulation in Industry chapter 2 from Dr. Evon M. Abu-Taieh, *Simulation and Modeling: Current Technologies and Application* Idea Group, Inc., Hershey, PA 17033, USA

[5]. Polymenopoulos *Information System & Modeling for Counterterrorism* Plenary Lecture of 8th WSEAS CSCC (2004) Vouliagmeni, Greece.