



FUNDAÇÃO EDSON QUEIROZ
UNIVERSIDADE DE FORTALEZA
ENSINANDO E APRENDENDO



Intelligent Tutoring and Decision Support Systems for Law Enforcement: A Multiagent Simulation Approach

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Introduction



☐ Vasco Furtado

- ☐ Professor at the University of Fortaleza since 1990
 - ☐ PhD in France - Artificial Intelligence
 - ☐ Visiting scholar in the Knowledge System Laboratory at Stanford University, Palo Alto, CA.
- ☐ About twenty years of experience in software development and IT management (in government institutions)

☐ Eight years of coordination of IT projects in the law enforcement domain

- ☐ Coordination of the CIOPS Project (911) in Fortaleza
- ☐ Coordination of the SIP (Police Information System) for crime registering in district precincts. In house Analysis, Design and implementation.
- ☐ A book written on IT for Law Enforcement, 2004 (Portuguese)

Context of the Work



- **City of Fortaleza: a metropolis with almost 2.5 M inhabitants**
- **A seven-year research project investigating new technologies for assisting police decision-making and training:**
 - **Agent-based Simulation**
 - **Intelligent Tutoring Systems**
 - **Decision Support Systems**

Motivation



- **Resource allocation is a complex activity that involves high risks and costs. It is the link that glues together preventive policing and crime analysis.**
 - **Fact:** It is not viable to make experimentations with novel resource allocation strategies in real life.
- **Questions not yet answered in terms of preventive police:**
 - **Where to allocate the police? Hot spots have limitations (difficult to identify crime evolution, migration)**
 - **Where do criminals come from?**
 - **What if I allocate the police in this area?**

Threefold Project



- **To develop an Educational System to assist the police experts in:**
 - ☑ Understanding the allocation process and eliciting the underlying relationships between crime factors → **ExpertCOP**
- **To develop a decision support tool that, from a reliable simulation model, assists the police experts in:**
 - ✓ Identifying hot spots and gateways that are related to these hot spots → **SIMPOL**
 - ✓ Automatically uncovering good patrol routes → **GAPatrol**



ExpertCop Project

Goals

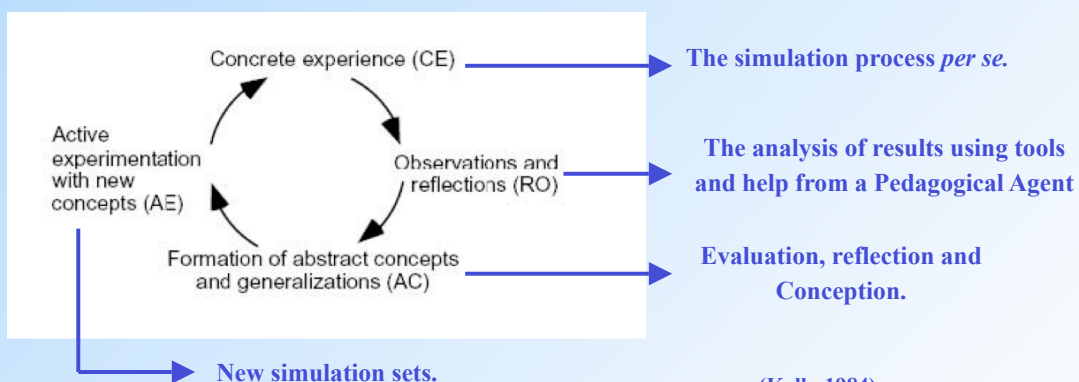


- To develop an educational tool to assist the police officers in:
 - ✓ Understanding the allocation process;
 - ✓ Training problem solving
 - ✓ Identification of the variables involved in the process;
 - ✓ Understanding the relation between resource allocation and crime;
 - ✓ Interpretation of criminal data.
- Requirements of the tool
 - ✓ Learning by doing
 - ✓ Pedagogical foundation
 - ✓ Playful and friendly

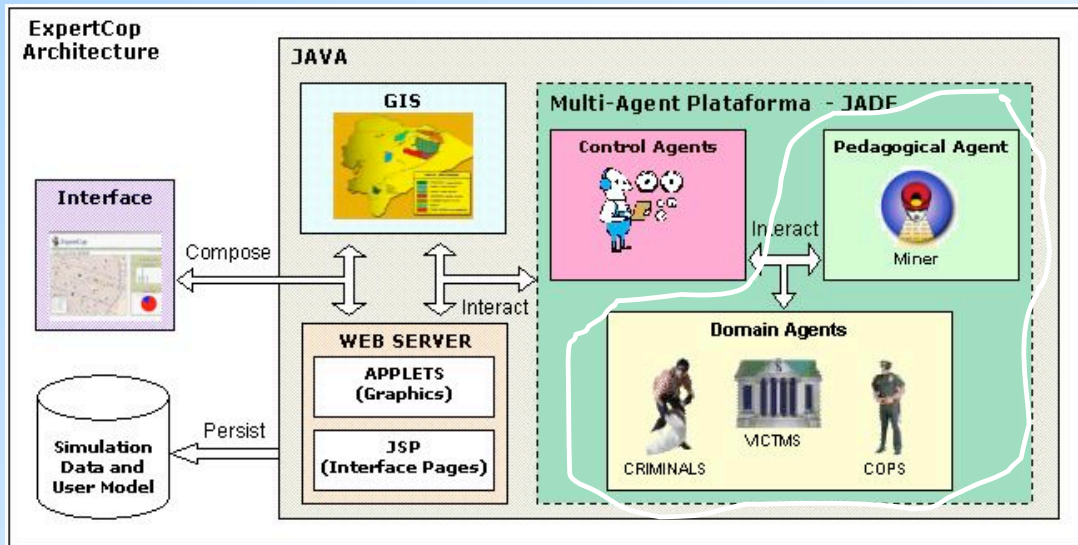
Foundations



- The simulation under games context
 - The “learn while doing” provided by the simulation
 - The playful aspect of games as a motivator
- The process adopted



ExpertCop Architecture



Domain Agents



- The actors of the studied domain.
- **NOTABLE POINTS:** Buildings that represent the targets of criminals such as drug stores, banks, lottery houses, gas stations...
- **POLICE TEAMS:** Created and characterized by the student, represent the resources to avoid crime by preventive policing. The student has to define for each team:
 - Work load
 - Work shift
 - Patrol areas (defined directly in the map)

Example:

Beta police team; Work shift: 8 x 16; Work period: 8 a.m. to 4 p.m. Area of patrol 1 (4hs): start 8 a.m. end 12 a.m. Area of patrol 2(4hs): start 12 a.m. end 4 p.m. The total work load is eight hours.

Domain Agents



CRIMINALS: Agents receives a mission of evaluating the possibility of committing specific crimes(based on crime database). The evaluation is based on:

- ✓ *Risk:* distance of police teams, target resistance capacity, public illumination, escape routes..
- ✓ *Benefit:* amount of spoils that the target can offer.
- ✓ *Personality:* Defines criminal "courage" level in the face of crime.

The criminal agents follow an assement Problem Solving Method(PSM) and use the inference machine of the JEOPS shell (Figueira and Ramalho 2000) to evaluate each possible crime by means of rules.

Example of evaluated rules:

IF police distance = *close* AND crime type = *robbery* AND target type = *bank*
THEN risk = *high*

IF target type = *bank* THEN benefit = *high*

IF benefit = *high* AND risk = *high* AND personality = *bold* THEN decision =
commit crime

Pedagogical Aspects in ExpertCop



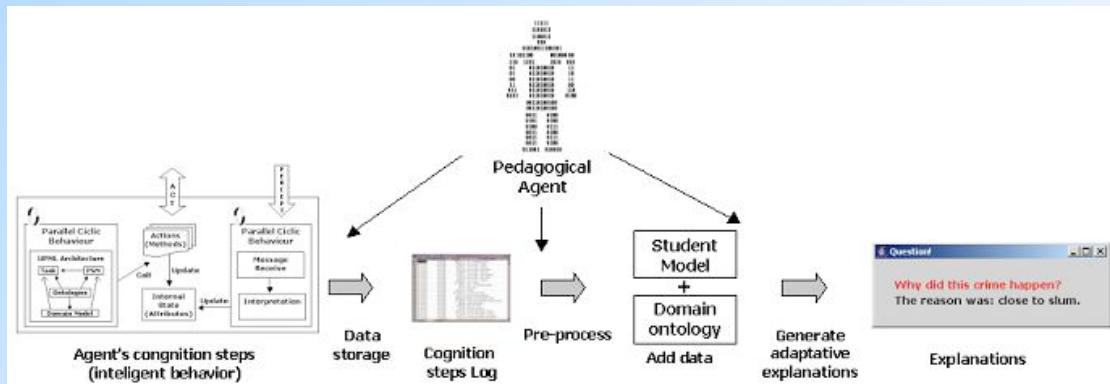
- Simulation isn't enough as a learning tool
 - It is difficult to understand the simulation model
 - it doesn't facilitates reflection about causes and effects
- The Pedagogical Agent - PA assists the students in the understanding of the simulation process and results generated.
- The PA has two specific strategies to assist the students:
 - ✓ The micro-level explanation
 - ✓ The macro-level explanation

Pedagogical Aspects



• Micro-level explanation – Event explanation

- The explanation of an individual event generated by the agents (the agent's reasoning process).

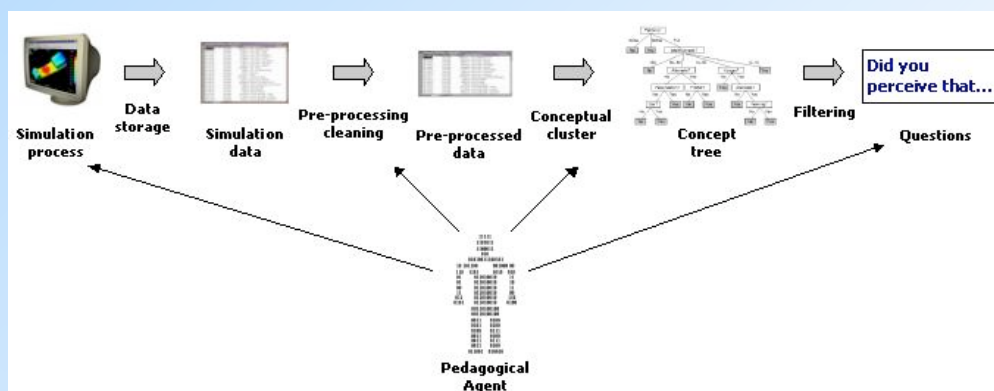


Pedagogical Aspects



• Macro-level explanation – Emergent behavior explanation

- We understand as emergent behavior, the effects of individual events in crime, its increase or reduction, criminal tendencies and seasonableness.
- For the explanation of the emerging behavior of the system, the pedagogical agent tries to identify patterns of behavior from the database generated in the simulation.



Demo ExpertCOP



Evaluation Context



- **ExpertCop was used as a pedagogical tool during a course at the Ministry of Justice and the National Secretariat of Public Safety - SENASP.**
- **The course was composed of an average of three classes of thirty students.**
- **The students were civil police officers (detectives), chiefs of police, and military police officers (uniformed police) with different levels of experience.**

Evaluation



- The acquisition or modification of beliefs can be considered as learning.
 - Hypothesis 1 ==> The system will make the students improve their understanding of the results (causes and effects), acquiring new beliefs or modifying old ones regarding crime and the allocation process.
- The percentile of crimes avoided in relation to the total of crimes attempted represents the participant's performance in a simulation.
 - Hypothesis 2 ==> The acquisition of new concepts and beliefs would make the students improve their allocation and consequently obtain better results in the simulations.

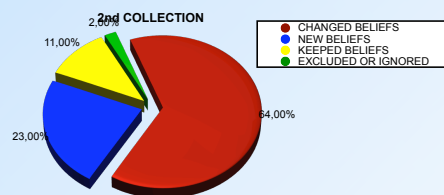
Result Analysis



1st hypothesis

Evaluation of collected beliefs

% Beliefs	% New	% Beliefs
64%	23%	11%



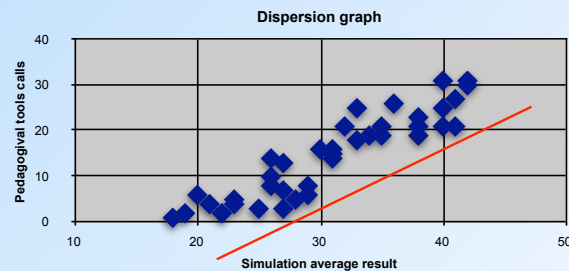
- 87% of students changed or included beliefs about crime motives and causes.
- We identified, in the evaluation, that more specific and practical beliefs replaced those initially observed, which were more generic.
- New beliefs about specific factors such as public illumination, patrol route distances, the existence of slums, work shifts were included by the students in the second collection.

Result Analysis



2nd Hypothesis

- Evaluation of the relation between the number of accesses to the pedagogical support of the system and the results of the simulations.
- In accordance with the dispersion graph, there is **a positive linear relation** between the number of accesses to the pedagogical support of the system and the results of the simulations.



Result Analysis



2nd Hypothesis

- The average results of the simulation with pedagogical support were 9,09% greater than the average of simulations without pedagogical support.
- Significant improvement (99%) following T-Test mean-pair
- Posterior simulations (small samples) keep the improvement, few students ran more than three but some of them ran until 7 simulation.

Results	D
n	89
Average	-2,60
Variance	48,93
Hypothesis test	
α	1,00%
gl	88
t observed	-3,510
p-value	0,04%
Decision	Reject Ho

1st SIMULATION RESULT AVERAGE	2nd SIMULATION RESULT AVERAGE	INCREASE
28,65%	31,25%	= 9,09%

More findings



- We also observed that although the students demonstrated more ability in handling the tool as time goes by, we verified that they spend more time during the allocation process. We think that this indicates a more reflexive allocation process.
- Another observation is that among the students an atmosphere of cooperation (or competition) was created, where they compared results and patrol routes seeking to identify similar strategies among themselves.
- Effectiveness of learning depends on the student profile
 - Debutant in computer science tends to concentrate on the tool instead of in the allocation process
 - Very experienced people in the allocation process improve less their performance

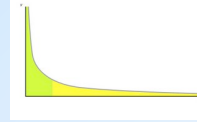


SIMPOL Project

Crime Simulation Model: Main Features



- Empirical studies of real data show that
 - Number of crimes in a geographic area follows a power law distribution;
 - Zipf law; few places with many crimes and many places with few crimes (hot spots)
 - Temporally, occurrence of crimes follows an exponential distribution for each type of crime depending on the period of the day
- Crime is usually brought about due to three factors: opportunity, benefits and risk (Felson 1979).
- Crime depends on social relations of criminals (Glaeser, 1996)



Challenge

- Defining a crime simulation model that reproduces real crime distribution

SIMPOL Goal



To reproduce crime distribution (both in spatial and temporal scales)

To represent crime tendency (evolution)

Understand, for a predefined scenario, which is the real impact of police patrol route strategies on crime behavior/contention



Geosimulation with Ant Colony Optimization

Methodology



- ❑ Analyses of crime real data for (i) identification of temporal and spatial distribution (ii) identification of real life strategies of police patrol routes used in urban areas (iii) identification of gateways.
- ❑ Use of bio-inspired models for modeling criminal behavior
- ❑ Modeling of criminal social networks
- ❑ Model refinement and validation by comparing simulation with real data

Simulation Model: Agents



- **TARGETS:** represent potential targets of criminals such as drugstores, banks, lottery houses, gas stations...
- **POLICE TEAMS:** represent the resources available for crime prevention by routine surveillance. Each team follows a route defined in terms of:
 - Number of targets to visit
 - Surveillance time in each target
- **CRIMINALS:** represent those who commit crimes. Criminal behavior is based on the following:
 - Criminals prefer targets close to a gateway (bus stops, slums, underground stations).
 - Crime is dynamic because criminals learn the best place to commit crime.
 - Criminals' learning depends on their social network

Simulation Model: Agents



Criminal Behavior



$$p_{cn} = \frac{[\tau_{cn}]^{\alpha} \times [\varphi_{cn}]^{\beta}}{\sum_{\forall p \in N} [\tau_{cp}]^{\alpha} \times [\varphi_{cp}]^{\beta}}$$

p_{cn} represents the probability of a criminal agent, c , choosing a crime target, n

τ_{cn} represents the learned experience of a criminal c with relation to crime target n , and

N is the set of all crime targets the criminal c is considering in his decision of where to commit the crime.

φ_{cn} is the inverse of the distance between the location of criminal c and the crime target n .

Demo SIMPOL



GAPatrol Project

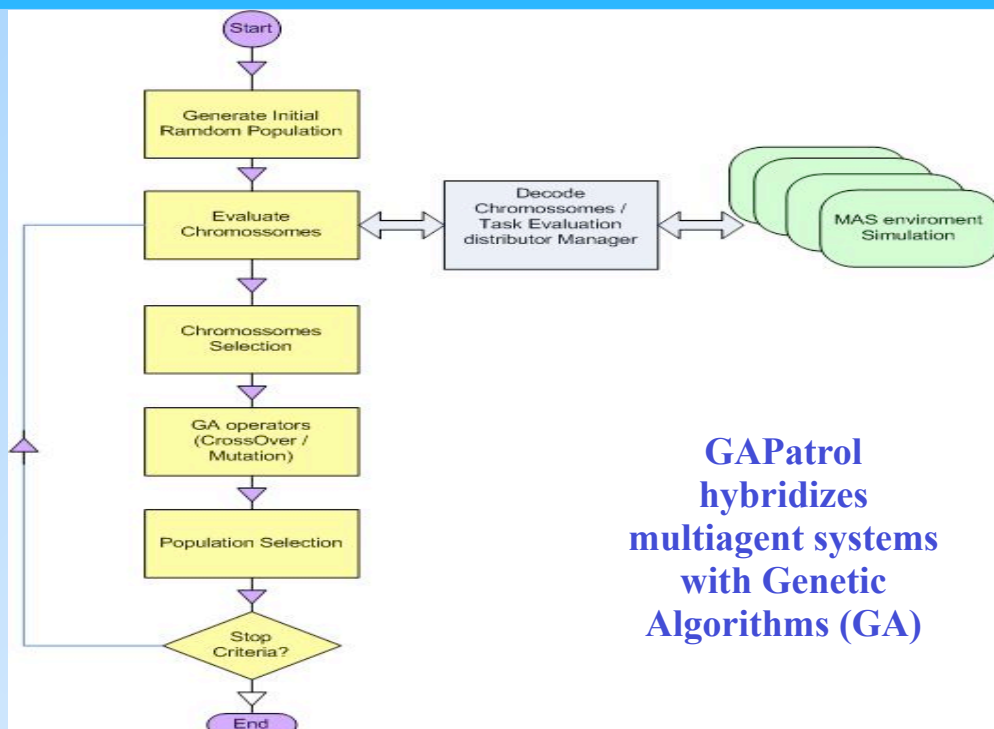


GAPatrol



- ❑ To explore the synergy between multiagent simulation and Genetic Algorithms
- ❑ Focus on police patrol route;
 - ❑ From a simulation model describing a scenario:
Identifying good police patrol routes
- ❑ Answer the question:
 - ❑ “What if I allocate ...”
 - ❑ The goal is to see what are the police patrol routes that lead to the crime reduction in a determined time?

GAPatrol Architecture



Some Publications



ExpertCOP was published in two International Journals (AI Magazine, 2006 and International Journal of Artificial Intelligence in Education, 2007)

Crime Simulation Model of SIMPOL was published in the book “Crime Analysis, Simulation and GIS”, Liu and Eck editors, 2007

GAPatrol was published and presented in the 3rd International Conference of Security Informatics in San Diego last year.

Ongoing and Future Work



- **A two-year grant of a local software house + Brazilian government for SIMPOL.**
 - **Ongoing research**
 - **When and how to reorganize the routes?**
 - **Participatory Simulation in ExpertCop**
 - **Conflict mediation and communitarian police**
 - **Commercial software in preparation**
- **International partners for new market**
 - **Informal agreement with Savannah Simulations (Switzerland) on ExpertCOP. Advertisement on the Web.**

Conclusion



- **Agent-based simulation with GIS comes to be a very promising approach for developing decision support systems in the law Enforcement domain**
- **Thanks for your attention**

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