Applying Case-Based Reasoning to Spatial-temporal Analysis of Residential Burglary Crime Investigation: A Cloud Service Prototype

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Abstract

- A lot of researches have been done by applying the features of modus operandi, the influence factors of victims, crime prevention measures, and geographic profile of consecutive crime for the investigation of the residential burglary crime.

- The main objective of this research is to develop a decision support system by applying case-based reasoning (CBR) method for residential burglary investigation using the spatial and temporal evidences of crime case.

- A cloud service prototype is proposed for developing future collaboration mechanism between organizations.
The Spatial and Temporal Evidences of Burglary Crime and CSI

Spatial Distribution of Burglary Cases

Temporal Distribution of Burglary Cases

Habitual Thieves: Re-appear in certain Places, Periods, Time, and Pattern
Modus Operandi: Skill, Preference, Habits
Criminal Profiling: Evidences from Personality, Features, Field Response
The Limitations of Rules in CSI

- The success of rule-based expert systems is due to several factors:
  - They can mimic some human problem-solving strategies
  - Rules are a part of everyday life, so people can relate to them
- However, a significant limitation is the *knowledge elicitation bottleneck*
  - Experts may be unable to articulate their expertise
    - Heuristic knowledge is particularly difficult
  - Experts may be too busy…
Another Way of CSI from Past Experiences

- By referring how we solved similar burglary cases in the past.

- This is Case Based Reasoning (CBR)
  - memory-based problem-solving
  - re-using past experiences

- Experts often find it easier to relate stories about past cases than to formulate rules

- The main assumption is that:

  Similar burglary cases have similar patterns and evidences
R$^4$ Cycle

- **Retrieve** the cases from the case-base whose problem is most similar to the new case.

- **Reuse** the solutions from the retrieved cases to find the suspects for the new case.

- **Revise** the proposed suspect to take account of the evidences between the new case and the evidences in the retrieved cases.

- **Retain** the new case and its revised suspect as a new case for the case-base if appropriate.
The CBR Cycle and Computation/Service Needs

- Review
- Retain
- Adapt
- Retrieve
- Similar
- Suspects
- New Cases

Cloud Service (Queue)
Cloud Platform (Web Front-End)
Cloud Infrastructure (Billing, VMs)
Cloud Storage (Database)
Concepts of Case Base Reasoning and Cloud Service

CBR service is provided via Cloud service interface to a commercial CBR package.

A Service Factory supports the creation of multiple CBR instances:
- Permits many CBR processes to be executed in parallel from a single service access point.
The Conceptual Diagram for Cloud Service Prototype

- **Data Collection**: Microsoft Access
- **Computing Processing**: CSV Format
- **Analysis Methods**: Protégé + myCBR
- **Output**: MyCBR Case Base
- **Visual Analysis & Presentation**: Apache + PHP + MySQL With Google Map API
- **MySQL Database**
Similarity Value Measurement

\[
\text{Similarity}(f^I, f^R_j) = \frac{\sum_{i=1}^{n} w_i \times \text{sim}(f^I_i, f^R_{ji})}{\sum_{i=1}^{n} w_i}
\]

\text{Similarity}(f^I, f^R_j) : \text{Similarity Value with the j th case in case base}

\[f^I : \text{New Case}\]
\[f^R_j : \text{data of the j th case in the case base}\]

\[n : \text{number of feature indicator}\]
\[i : \text{total number of features}\]
\[w_i : \text{the weight of the i th feature}\]

\[\text{sim}(f^I_i, f^R_{ji}) : \text{the similarity value of the new case and the i th feature of the j th case in the case base}\]
Case Studies Results and Discussions

- 128 burglary crime case between 2007-2009 have been collected from the jurisdiction of 2 local police stations.
- 3 Categories (Spatial and Temporal, Convict Approaches, Field Characteristics) with 11 features and 82 factors are used for CBR.
Burglary Crime Case Processing

Step 1
Data in AccessTable format

Step 2
Import to Access DB

Step 3
Import to myCBR

Step 4
Finished in myCBR for further use
Burglary Crime Case Analysis

Step 1
New case input to myCBR

Step 2
Calculate Similarity Value

Step 3
Similarity Matrix

Step 4
Graphic comparison analysis
Burglary Crime Case Spatial and Temporal Analysis

Spatial location visual display and analysis on certain suspect derived from case base.

Temporal correlation visual display and analysis on certain suspect derived from case base.

All these analysis results will be shared in Intranet using cloud service.
Conclusions

- The considered methods and mechanism have been used to develop the cloud service prototype.
- Case studies show the reliability and validity of the prototype.
- The spatial and temporal analysis results sharing mechanism developed by using Google map API can improve the efficiency of burglary cases CSI among related agencies.
- Serious computation power and cloud service security mechanism are needed to be considered before further implementing the prototype to provide online service.
Future Studies

Comprehensive mechanism and technologies of Cloud Service are needed for further development.
Thank you for your attention

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