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Break and Enter Expert System
1994 Progress Report

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TECHNICAL MEMORANDUM

August, 1994

**NOTE: Further information
       about this report can be
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EXECUTIVE SUMMARY

Police services throughout the world are mainly concerned with gathering and processing information in carrying out their responsibilities relating to solving and preventing crime. They represent a significant component of the information industry. This technical memorandum descibes the development and introduction of knowledge-based technology to one part of the operation of the Ottawa Police Service. While the focus of the current system is on a specific application, the goal is to demonstrate the potential of this technology for a broad range of the activities that make up the criminal investigation component of the police service.

In collaboration with the Ottawa Police Service, the National Research Council is developing an expert system to support the investigation of residential break and enter incidents. A major goal of this project is to demonstrate the effectiveness of knowledge-based technology in support of police operations and its potential for application throughout the Service. Particular attention has been given to the introduction of the technology into the operations of the Police Service and its impact on traditional procedures. The prototype system has completed its Alpha-testing in the Ottawa Police Planning and Research Section and is about to begin Beta-testing in the Break and Enter Squad.

In September 1994 a Canadian company has been selected to transfer the prototype into a commercial product. It is expected that by the summer of 1995 a product will be available.

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RÉSUMÉ

Dans le monde entier, les services de police s'emploient principalement à recueillir et à traiter des renseignements qui les aident à remplir leur mandat, lequel consiste à prevenir les actes criminels et à repérer les coupables de tels actes. Ces services occupent une place importante au sein de l'industrie de l'information. La présente fiche technique porte sur le developpement d'une technologie basee sur la connaissance qui sera utilisee par une division du Service de police d'Ottawa. Le systeme actuel ne remplit qu'une seule fonction, et nous voulons montrer que cette technologie peut servir à diverses activités associees aux enquêtes policieres menées par le Service de la police.

Le Conseil national de recherches du Canada collabore avec le Service de la police d'Ottawa à la mise au point d'un systeme expert qui facilitera les enquêtes relatives aux introductions par effraction dans les residences. L'un des objectifs de ce projet est de démontrer que la technologie basee sur la connaissance peut s'averer un outil precieux au cours des operations policieres et pourrait Qtre utilisee dans l'ensemble du Service. Nous avons accordé une importance assez grande à l'integration de la technologie aux operations du Service de la police et à l'incidence de ce changement sur les méthodes habituellement utilisees. Les premiers essais du systeme prototype ont été effectés à la Section de la planification et de la recherche du Service de la police d'Ottawa, et les essais pilotes debuteront sous peu à l'Escouade de des effractions.

En septembre 1994, un contrat a été octroyé à une entreprise canadienne pour transformer le prototype en un produit commercial qui devrait se trouver sur le marché d'ici l'été 1995.

Pour plus de renseignements, veuillez communiquer avec John Arnold, expert scientifique en chef, au (613) 993-3737.

The Investigator's Notebook*

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In collaboration with the Ottawa Police Service, the National Research Council is developing an expert system to support the investigation of residential break and enter incidents. A major goal of this project is to demonstrate the effectiveness of knowledge-based technology in support of police operations and its potential for application throughout the Service. Particular attention has been given to the introduction of the technology into the operations of the Police Service and its impact on traditional procedures. The prototype system has completed its Alpha-testing in the Ottawa Police Planning and Research Section and is about to begin Beta-testing in the Break and Enter Squad.

Introduction

Police services throughout the world are mainly concerned with gathering and processing information in carrying out their responsibilities relating to solving and preventing crime. They represent a significant component of the information industry. This paper addresses the development and introduction of knowledge-based technology to one part of the operation of the Ottawa Police Service. While the focus of the current system is on a specific application, our goal is to demonstrate the potential of this technology for a broad range of the activities that make up the criminal investigation component of the police service.

Background

In 1987, the National Research Council (NRC), as part of its program of research and development of artificial intelligence technology, initiated a study of machine learning techniques. The goal was to determine the potential for machine learning in applications to real-

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world problems and a search was made for appropriate data to use in the project. At the time, the Ottawa Police Service was investigating the use of database and graphics display techniques in crime analysis. They had available a large data set of residential break and enter (B&E) incident data that they were willing to make available to the NRC project. The goal of this project was to identify patterns in the data that would provide information of use in solving crime and in the deployment of resources to prevent crime. The results of the initial study indicated that, while patterns could be identified, they were coarse and primarily related to geographic location. Not enough information was available to identify detailed relationships between incidents. Nevertheless, a prototype system was produced that made use of statistical clustering and database technology. It permitted the selection of any incident in the database as a reference and the identification of similar incidents. In this process, weights could be assigned to each of the incident parameters. While the prototype aroused interest, the original project that had provided the database had been terminated and a review was undertaken to determine the next steps.

Up to this point, the project had been driven by the technology. The goal was to determine the potential of the technology. Interaction had been primarily with the Crime Analysis Unit. The emphasis now shifted to a more user-oriented approach. While crime analysis continued to be of interest to the Ottawa Police, systems to provide assistance to the investigator were considered of higher priority. **A** general review of information processing and use within the Ottawa Police was undertaken to determine where knowledge-based technology could make a significant contribution.

Requirements

The focus on residential B&E was maintained. Individual cases usually involve a low monetary value, there are rarely witnesses to the incident, and it is difficult to justify the expenditure of resources to carry out a detailed investigation of most of these cases. For the victim, the invasion of his or her dwelling can be a traumatic experience. It is further aggravated if the impression is given that there is little or no action to be taken by the police and the only reason for filing a report is to satisfy the requirements of the insurance company. Nevertheless, the total number of B&E incidents is high and impact on the economy is significant. This is clearly an area that provides a good opportunity to introduce knowledge-based technology and to illustrate its potential for other applications.

The identification of requirements for a system to support the B&E investigator began with a review of the flow of information within the Ottawa Police Service. We identified the sources of information, the processing that took place, the users of information, and the repositories (computer files, narrative report forms, officers notebooks, internal memos, . ..). Very little of the information had been accessible to the original crime-analysis project. The second step was to carry out a detailed review of several cases with an experienced investigator. This gave us an appreciation of the information that was used specifically for investigating residential B&E. **Again,** very little of this information was available in the computer. At this stage, we had identified a requirement to develop a data gathering process that would specifically address the B&E investigator's needs and to combine that with the investigator's knowledge in a system that

would help to identify possible suspects for a given case. The next step before embarking on the system design was to visit several projects where knowledge-based systems were being applied to crime investigation. In early 1992, the project team visited the FBI Academy, the Baltimore County Police Department, the U.S. Treasury Department, and the Jefferson Institute for Justice Studies. The Baltimore County Police had a system that was operational at the time. This was a B&E expert system (Ratledge and Jacoby, 1989) that had been developed by the University of Delaware and the Jefferson Institute in conjunction with several municipal police forces throughout the US. The system applied rules derived from experienced B&E investigators to data describing the crime scene to produce a profile of the suspect. This profile could be compared to a library of profiles to produce a list of possible suspects. The library of profiles was created over a period of years from cases that had been cleared by charge or otherwise. The system was used by a full time investigator and data from the crime scene were captured by identification officers using a form designed for the purpose. The system appeared to be of limited operational value due to the lack of resources and involvement, the limited database, and the incomplete validation of the rule-base. However, within the Baltimore County Police Department, there appeared to be general agreement that the system could become an extremely useful tool if these problems were overcome.

The U.S. visit proved to be an extremely valuable contribution to the project. It confirmed that the area of residential B&E was one that offered good potential for demonstrable success. It also alerted us to the problems that would have to be overcome to achieve technical success and organizational acceptance. Of particular importance was the identification of the need to involve in the development all those who would be users of the system, suppliers of data to the system, or involved with the system in other ways, such as its integration into the general information processing environment.

Project Objectives and Development Strategy

The overall objective of the project was defined as:

> *To develop a knowledge-based system that will assist the police in the investigation of residential break and enter incidents and that will illustrate the potential for other applications in support of police investigations.*

Initial functionality goals were established as follows:
1. Provide support for gathering and recording case data.
2. Generate suspect characteristics from case parameters.
3. Provide the investigator with easy access to the following information:
   - case parameters
   - other incidents in the vicinity
   - similar cases
   - patrol officer report narrative
   - witness information
   - sighting reports
   - investigators' notes.
4. Identify the modus operandi (MO) of suspects from cleared cases.

5. Generate a list of possible suspects.
6. Identify patterns in the data.
7. Generate reports as appropriate.
8. Provide a graphics display capability.

Five main criteria were identified as crucial to the success of the project. First, the system had to be robust. Failures should not occur more frequently than once per month and any system failure should not require re-entry of more than one case. Second, the system had to achieve user acceptance. The system must be perceived by the users as permitting them to carry out their tasks more effectively. Furthermore, users should have a sense of ownership in the system through contributing to its development and continuing evolution. Third, the system has to be acceptable to the organization. It must be seen to have tangible benefits to the organization in the form of productivity increase for those investigators using it. Fourth, the system must demonstrate future potential. It should be perceived by the user to be applicable to other areas of investigation and to offer a means of maintaining or increasing service in a period of limited resources. Finally, the system should be suitable for commercial deployment. The results of alpha and beta testing should demonstrate a commercial opportunity for potential distributors of the system.

The need to develop organization-wide ownership in the system strongly suggested an approach based on specification through an evolving prototype. This permitted users to contribute to the system and see their influence on the design.

Knowledge Acquisition

To produce an effective system, we had to determine from the available experts what information about a B&E incident was significant and what this information meant to the investigator. The process started with a brainstorming session in which we brought together a team of experts consisting of present and past members of the B&E squad as well as members of the Identification and Crime Analysis Sections. The goal was to identify all of the parameters that might be significant in describing a residential B&E. A residential B&E form being used by the Tucson Police (one of the departments participating in the US. project) was used as a reference guide. The session yielded approximately 260 parameters that could describe a residential B&E, such as glass *cut, glass broken, searched concealed compartment,* and *victim at home at time of incident.* Subsequently, each of the experts was provided with a list of the parameters and asked to identify, for each parameter, what they would conclude about the physical and/or behavioral characteristics of the suspect. They were also asked to indicate the confidence that they had in their conclusion. If there was no link identified between B&E parameter and a suspect characteristic by any of the experts, that parameter was eliminated. The result was a set of matrices of confidence factors relating B&E parameters and suspect characteristics. The original group of experts was reassembled to review the results and to come to a consensus on the relation between B&E parameters and suspect characteristics and the associated confidence factors. The result was the core set of rules representing the investigators' combined knowledge. Also created was a data gathering form that was to be used in reporting residential B&E incidents.

Data Acquisition

Members of the Patrol Division were critical to the success of the system. They would be asked to complete an entirely new type of report form that needed to be filled out with a high degree of accuracy for the system to be of any value. Traditionally, front line officers attached to the Patrol Division were the last ones to find out about any new form or procedure even though they were normally the ones tasked with doing the work. They were usually told that procedures or forms had been changed, given minimal training, and told to get to work.

For the project to be successful it would be necessary to convince the majority of patrol officers, of which there were approximately 200, to commit to the concept of the new form. To do this a two-hour lecture was prepared, which every member of the Patrol Division had to attend in small groups of no more than 10 officers. Of the two hours, approximately one hour and forty-five minutes was spent justifying to them why the system was being created and how it would be used. Only fifteen minutes was set aside to actually train them on the new form. The groups were limited in size in order to personalize the lecture and to limit the impact of a negative training session.

The training sessions had to be given, for the most part, at 5 o'clock in the morning because of the requirement to have more officers on the road at all other times of the day. This time of day had some obvious drawbacks. However, the ability to speak to the officers in small groups was very beneficial In addition, the trainers' willingness to get up numerous mornings at 4:00 AM for a couple of months gave a convincing demonstration of their belief in the project.

Before training began for all the patrol officers, a group of 20 officers was selected, four from each platoon, to complete a trial on the training pilot and implementation of the data reporting form. One of the primary messages we attempted to deliver to these officers (and subsequently to all patrol officers) was our belief in a need for an organizational change in the approach to the investigative process. The historical method of investigation in the Ottawa Police Service, as in most urban centres in North America, was to assign the patrol officers almost no decision making power in their report taking duties. It was believed that these officers did not have the time, or the training to do more than just complete a report form and send it through the investigative chain to the detectives. Therefore, in training the officers of the trial group, emphasis was placed on their role as preliminary investigators whose duty it was to gather as much information as possible from as many sources as possible. At the end of their investigation, their duty was to make a decision, based on what they had learned, as to whether or not this case required any further investigation by the B&E Squad. If it did, they were to note their conclusions and forward the file. If, on the other hand, they concluded that no further investigation was required, they were empowered to finalize the report and advise the complainant that, pending new information, no further action would be undertaken on the case.

This group of trial officers used the form for three months starting in the summer of 1992 and reported their findings in a meeting in November. This meeting was positive and showed an unexpected level of enthusiasm for the new form. All the officers in attendance indicated that

the form was easy to fill out and that once they had completed a few it only added a few minutes to the time spent at a residential B&E.

Several officers indicated a sense of accomplishment in that they believed that they were achieving more during their preliminary investigation, not just filling in the standard form and leaving. In addition, a number of officers stated that the victims appeared to be more satisfied than normal, due to the broad range of questions being asked and the fact that the officer was noting their responses.

Training of the rest of the Patrol Officers continued through the fall of 1992, and by the end of the year all residential B&E incidents were reported using the new form. During this process, a number of suggestions were made by the Patrol Officers and **many** of them were implemented in revised versions of the form, which is currently at release 2.

System Implementation

The system consists of two main components: Data Gathering and Input, and Analysis. As indicated in the preceding section, data gathering currently relies on a paper form, the data from which are verified and entered into the system by an analyst. Software is provided to support the entry of information from the form. Basic formats are checked by the system and addresses are checked against a city street tile which forms part of the system. Other inconsistencies must be detected by the analyst who may have'to contact the reporting officer or the victim for clarification of the data. Ultimately, the paper form will be replaced by a pen-based computer and the templates for the entry of data from the form have been developed with this in mind.

In addition to supporting the entry of data from the incident report forms, the system provides for the entry of information on suspects who are eventually charged with the offence. As the suspects file grows, it provides the means whereby the rules on which the analysis module is based can be validated.

The Analysis module is rule-based and has been implemented using the expert system shell Crystal, supplemented by C Language routines for access to data files. Of the functionality goals listed in Section 4, the current prototype incorporates the first two functions, most of the third, and a limited report generation capability. Suspect data that are currently being gathered will permit 4 and 5 to be incorporated and will support investigation of 6. A graphics display capability is provided off-line through use of a commercial GIS software package that can display file information generated from the Crystal implementation. The overall system structure is illustrated in Figure 1.
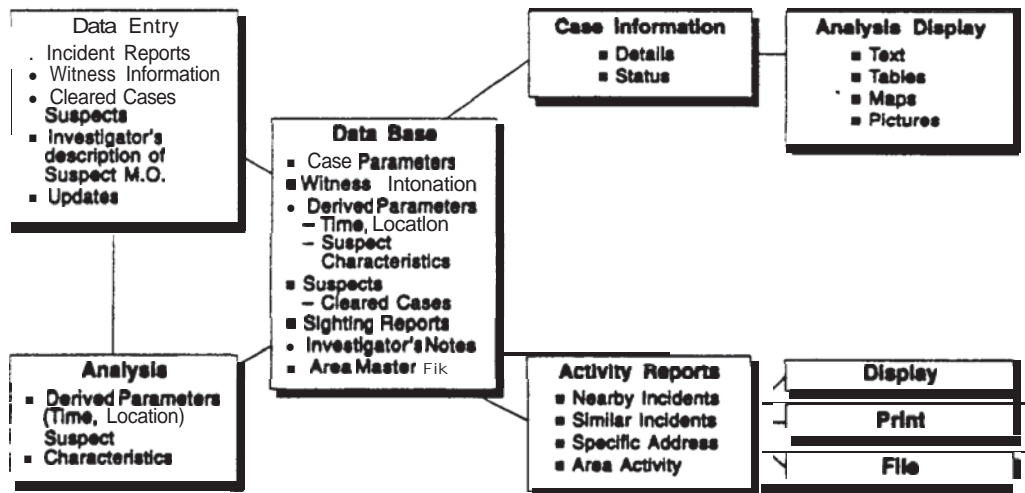
Figure 1: System Structure

System Status and Preliminary Results

The data entry system has been in operation since the fall of 1992 and continues to be used to record all residential B&E incidents in the city of Ottawa. The Analysis system was installed in the Ottawa Police Planning and Research Section in October 1993. It has been in use since then in an Alpha test mode with evolving functionality. The focus has been on verifying the rule base and using the prototype to help define required functionality. In early October, the system will be installed on two laptop computers for use in the B&E Squad in a Beta-test mode.

While the Beta-test is not scheduled to start until October 1994, there have been a number of times investigators or the officer in charge of the B&E Section have asked for information from the system There have also been a number of times we have approached them to point out the possibility that a suspect(s) was responsible for a rash of B&Es.

One of these cases occurred when the analyst assigned to the system observed what she believed to be a trend occurring in the south end of the city. With very little effort, she was able to identify five B&Es in a smalI area that had a high probability of having been committed by the same suspect. Three of them were quite similar and two others, while in the same area at about the same time, were slightly less similar due to the method of entry. The analyst prepared a report for the officer in charge of the section including a computerized map of the area with the B&Es plotted on it (using a separate software package).

The following morning, by coincidence, a suspect was arrested at the scene of another B&E in the area in question. The officer in charge provided the assigned investigator with the detailed

analysis which the investigator took with him when questioning the suspect. The investigator, using his skills and armed with more information than he would normally have access to, was successful in having the suspect admit to three of the five listed B&Es.

In another case, which occurred shortly after the Alpha test began, a number of reports were observed where there was no sign of forced entry. Upon further investigation, it was noted that these incidents were occurring only in high-rise apartment buildings. Queries on the expert system produced a lengthy list of similar reports over a two-month period with incidents occurring all over the city.

As a result, a report was produced for the officer in charge of the B&E Section outlining the high probability that one person or a related group of persons was responsible for numerous B&Es in the city. Unfortunately, due to a lack of resources and no firm leads as to who may be responsible, all that could be done was continue to monitor the situation. It must be remembered that the module which identifies possible suspects had not yet been installed or tested.

A few months later information was received from an informant who indicated that a person he knew was going out every day and doing B&Es in high-rise apartment buildings. This person was apparently trained in the use of lock picks and was responsible for hundreds of B&Es. With this information, along with the corroboration from the expert system, investigators were soon successful in arresting the suspect.

Realized and Potential Benefits

The following are just a few areas where benefits or the potential for benefits brought about by the system have been identified:

A significant improvement has been achieved in identifying what data to collect. By looking at each piece of data and asking what information does this provide about the suspect, data are now being collected that are truly useful in the investigation of crime. If we cannot justify the utility of a piece of data, it should not be collected.

By changing the method of collecting data at crime scenes and changing the way database systems are used by the investigating officers, access has been provided to more of the information that was traditionally captured in narrative form but unavailable unless the report was read. A vast majority of any organization's information assets are locked, up in documents. The information in these documents has usually not been turned into fields and records, data for storage in a database. By improving the method in which documents are created, stored, accessed and exchanged, the effectiveness of the police operation can be dramatically improved.

By analyzing how the experts think and then capturing their thought processes in the form of rules we are creating **a** knowledge base for future investigators to use both in the investigation of crimes and in training. We will never be able to replace these expert investigators, but if we can capture even a small portion of their expertise we will have gained.

For some types of crime, data could be collected across large geographical areas, such as regions, counties, provinces or states, countries and internationally. In crimes such as commercial B&Es the suspects often travel hundreds of miles to commit crimes. Bank robbers regularly travel across countries. Art thieves cross international borders to ply their trade. By standardizing documents across these geographical areas and providing quick and easy access to current useful data, all police and/or security agencies would be vastly improved.

Internally, by removing the traditional barriers that hierarchial organizations have created, the flow of information is improved. At the same time, by changing the way the investigative process is viewed, by building on the teamwork required to start systems such as this, the entire organization can be affected. Patrol officers who may have seen themselves as only good for filling in forms, can see how they are an integral part of the investigative process. File clerks who could see no useful purpose in making hundreds of photocopies of reports now judge themselves to have been an important link in the team that created something new and special.

Externally, the communities that are served can see a positive change in the way that they are treated at the scene of a crime. Instead of simply tilling out a form and leaving, the police officer now is asking detailed questions and taking precise reports. Thus, there is a message being sent that the police care and want to help. In this age of community policing it is clearly the role of a police service to respond to the needs of diverse communities. Expert system technology offers a way of improving this response.

Conclusions

The introduction of a significant expert system into an information industry is likely to have an impact throughout the organization. If the system is a *foreign body* for many of the people who will be affected by it, rejection is a very likely outcome. In the introduction of the B&E expert system, we recognized that it would require changes in various procedures, investigative techniques and paper flow systems for the system to be successful. The key to success has been ensuring the early involvement of all who would ultimately be affected by the system. This has been accomplished through formal briefings to management and also to broad staff meetings. Training sessions have been provided as required. Input has been encouraged from all involved, from clerks to experienced investigators. Expertise has been solicited on a group basis wherever possible through brainstorming sessions and also through more structured team discussions. In this way, the expertise that has been built into the system is not identified with any one person but has broad ownership throughout the organization. At the same time, we have been careful not to oversell the system The proposed users realize that the system must build up its database of suspects and their MOs before it can start to make reasonable links between incidents and possible suspects. However, even in the Alpha-test mode, the system has produced information of value to operational personnel. Technical success is necessary, but it also requires a receptive environment if it is to survive within the intended organization.

Acknowledgements

References

Ratledge E.C. and Jacoby J.E. (1989). Handbook on Artificial Intelligence and Expert Systems in Law Enforcement. Greenwood Press, Westport, Connecticut.