Museum security enhanced using genetic algorithms and virtual reality

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1 Problem and Motivation

Interior intrusion detection design systems assimilate a number of technologies. Among these are cameras, motion sensors, and laser beams [Sec 2002]. In this paper, we concentrate on the automatic placement of stationary laser beams. This problem has never been tackled in this form because of the scope involved and also insurance companies who ask their customers to use specific methods (expensive walls of laser beams for example [Art 1993-1994]).

Here we present one (**RLM**) which can handle these two aspects. First, we use an approximation algorithm which produces close to optimal solutions and makes no assumption about the space under study : a genetic algorithm. Secondly, we submit these solutions to an expert who can analyse them in a virtual world we created. Thus, we take into account the three key points in the art of alarms paradigm : security, profitability and experts' knowledge.

2 A graphics based genetic algorithm (GA)

Genetic algorithms are search procedures based on the mechanics of natural genetics and natural selection [Goldberg 1989]. Encoding a potential solution to the problem, the fundamental data structure is an individual. They are composed of chromosomes. For example, here, a chromosome is a laser beam and an individual is a configuration of laser beams. The collection of individuals existing at any point in time is referred to as the population.

A **fitness function** quantifies the *level of effectiveness* of an individual. We simulate a robber in a gallery : he starts in the direction of one exhibit and goes on until he gets to all of them or walks too long, stopping and changing direction whenever he meets a laser beam. We consider him to be a simple polygon but his volume has been computed taking into account different possible postures. All movements are allowed so we had to develop a framework for fast and accurate collision detection with the environment [O'Rourke 1998]. The fitness result is mainly related to the number of laser beams touched, but also to the number of exhibits stolen and the distance covered. This metric allows us to differentiate good and poor individuals in terms of placement of laser beams.

Then we apply the three common genetic operators :

selection : each individual in the population has a chance to be selected in proportion to his fitness,

crossing-over : next generation individuals are created by swapping half of the ancestors' chromosomes,

mutation : one individual per hundred gets one more chromosome (here we optimize the number of laser beams needed).

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Even using genetic algorithms, the need for resources is huge. That is why we decided to use a **centralized parallel implementation** [Goldberg 1989]. The master processor executes the genetic operators and then distributes the fitnesses computation.

3 Virtual reality for an optimal decision

Coupled with a *Model View Controller* based architecture, our virtual world is a *JAVA 3D* application whose aim is to help experts in their final decision by using three functionalities.

First, they are able to navigate in the gallery in order to analyse the *GA*'s results. At the same time, we offer them the possibility to modify, delete or add a laser beam if necessary. At each moment, they can ask the system to evaluate the modified configuration.

Secondly, they can test the solution by being the robber : we notice them at each new intersection with a laser and give them a score, based on our fitness function algorithm. Experts are familiar with robberies, so they can test different well known approaches.

However, our fitness function may produce a new one. So thirdly, we make available the most efficient and atypical robberies. Different points of view are available; experts can stop the visualisation for considerations, restart it and so on.

4 Contributions, results and perspectives

RLM, the first semi-automated algorithm for museum security, results from the coupling of two robust approaches. First we compute a set of solutions using a parallel genetic algorithm based on a fitness function which simulates real robberies. Then, we submit these solutions to an expert, who, thanks to our virtual world, is able to analyse, modify and test them.

Based on our fitness function, improvements in terms of security are good : 40 %. At the same time, we managed to reduce the number of laser beams used by 15 %. These statistics have resulted from comparing manual and **RLM** configurations.

An important perspective is now to extend our virtual world by integrating haptic devices. This would allow experts to get inside the gallery in order to check it. This is the next step of our work.

References

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