Utilizing Path Finding Algorithm for Secured Path Identification in Situational Crime Prevention

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***Abstract*—Crimes could happen anywhere and at any time. Most crimes happen when there exist opportunity for crimes to take place. Such crimes are categorized as situational crime. In this study, we are interested in this type of crimes because it focuses on the settings and pattern of crime, rather than upon those committing criminal acts. Crime prevention can be referred to as attempts made to reduce and deter crime and criminals. It is applied specifically to efforts made by government authorities and agencies to reduce crime, enforce the law, and maintain criminal justice. In this research, we propose a hybrid model, known as PCAHP that combine path finding algorithm, chess strategy and Analytical Hierarchical Process (AHP) to handle uncertain situations when approaching crime prone areas. In this tactical path finder, considerations need to be given to various factors affecting the best decision on alternative paths in order to avoid the risks of becoming the victims of crime. A support system adopting the PCAHP model will be developed to calculate the weights of the criteria for evaluating each crime factors and suggesting the safest possible path. The expected result of this research is to come out with a support tool that could help the public especially the pedestrian in choosing the safest alternative path either when passing through a crime hotspot or faced with uncertain situations to prevent crimes. The tool should also help to create awareness to the public on the status of crimes in their neighborhood.**

***Index Terms*—Analytical Hierarchy Process; Chess Game; Path-Finding; Situational Crime Prevention.**

I. INTRODUCTION

Nowadays, crime has brought serious problems to many countries in the world. Therefore, crime prevention is becoming one of the most important global issues, along with the great concern of strengthening public security. Crime prevention basically is everyone's responsibility. It is a complex social phenomenon and its cost is increasing due to a number of societal changes and the like, and hence, law enforcement organizations need to learn the factors that constitute higher crime trends. To curb this social criminal there is always a need for prudent crime prevention strategies and policies.

One of the primary prevention could be taken is situational crime prevention (SCP) that is stopping the crime before they happen. Clarke (1995) has proposed 25 techniques of SCP under five principal categories of action within an over-arching rational choice theory [1]:

i. Increase the effort (target harden, control access to facilities, screen exits, deflect offenders, control tools / weapons)
ii. Increase the risk (extend guardianship, assist natural surveillance, reduce anonymity, utilize place managers, strengthen formal surveillance)
iii. Reduce the reward (conceal targets, remove targets, identify property, disrupt markets, deny benefits)
iv. Reduce provocation (reduced frustrations and stress, avoid disputes, reduce emotional arousal, neutralize peer pressure, discourage imitation)
v. Remove excuses (set rules, post instructions, alert conscience, assist compliance, control drugs and alcohol).

In Malaysia, most efforts and resources are put into solving crime cases, which is aimed to improve public safety and reducing crime index as stipulated in one of the NKRAs (National Key Result Area) in the Malaysian GTP (Government Transformation Plan). Several measures have been taken such as installing CCTVs in selected crime hotspots, introducing omnipresence programs in crime prone areas, and adoption of CPTED (Crime Prevention through Environmental Design) in new town development. However, lack of awareness on the status of crimes in the community and little knowledge on ways to curb crime has resulted in little interest among the public and the respected parties to situational crime prevention. Without suitable tools and technology in detecting occurrence of crimes and disseminating this piece of information to the public have also created a challenge to situational prevention. With the wide spread use of personal computing devices such as PDA, PMP and smart phones, route guidance applications like Papago and Waze are increasingly popular and highly in demand, it will help people monitor easily in real-time. However, most of these applications focus more on finding optimal vehicle routes in order to avoid traffic congestions and may not contain enough details required to alert the authorities and the public at large in preventing situational crimes. The challenging problem in crime prevention area is determine the path that probably are made by a victim. More than 50% of crimes happen due to lack of awareness among the victim.

Due to the above problem, we propose a hybrid model, combine path finding algorithm (P) chess strategy (C) and Analytical Hierarchy Process (AHP) known as PCAHP. This model utilizing the Multi Criteria Decision Making (MCDM) technique, which is a technique under the Analytical Hierarchy Process (AHP), chess playing strategy and path finding algorithms, to handle uncertainties when faced with crime situations. Path finder such as pedestrian needs considerations of various factors affecting their safe walking. Factors affecting safe walking consists of three categories: distance between pedestrians and criminal, visibility of criminal view and obstacles frequency that exist in crime location. An application adopting the AHP idea was developed to calculate the weights of the criteria for evaluating each crime factors. The highest degree of AHP result will drive the pedestrians to choose the best optimal and secured path.

This paper is organized into four sections. In Section II, the related works of study is presented. The materials and methods included are elaborated in Section III. Discussion and the future study subjects are drawn in Section IV.

II. RELATED WORKS

Path-finding has long been an important research topic to determine the shortest or optimum path in decision making field. Successful applications of path-finding methods have been found in industry [2], navigation application [3], and game [4]. In a navigation application, most tools are focused on monitoring pedestrians and vehicles passing through road network safely [5]. According to a survey targeting at pedestrians in different criteria after classifying the purposes into leisure and movement, the findings show that physical environments were among the factors that influence safety walk [6]. Moudon (2003) on the other hand have employed evaluation indexes in order to analyze factors influencing safe walking and cycling [7]. A statistical analysis has also been used by Lee (2006) in deriving the importance of elements in the walking affinity [8]. In addition, Park (2008) has carried out a study to make influencing elements into street environment, network environment, and regional environment as indexes [9]. Another researcher has come up with classified elements for the elderly and selected 25 items as the indexes to be used in path finding [10]. A classification study by Lee [11] has categorized these influential elements into physical environmental elements, changes of direction, visual field and accessibility to be used for path finding through arbitrary weights. Another study, presented the influence safety walk factors are classified to traffic, sidewalk, network environment and safety facilities [5].

In gamer's application, several algorithms are used in order to implement tactical pathfinder techniques. These algorithms have their own advantages and disadvantages. For example, probabilistic pathfinder uses genetic algorithms as the engine to reach the goal. This technique uses simulation as their model to prove their pathfinder. This method was inspired by [12], where it could generate high-quality path plans by eliminating the low-quality ones. Fitness function was used to test the quality of the path plans. The path plans are generated by probabilistic path finding and the elimination is done by a fitness test of the path plans [12]. This path plan generation method has the ability to generate variation or different high-quality paths, which is desired for games to increase replay values [12].

Other studies use evolutionary algorithms for robot path planning. Most existing methods for evolutionary path planning require a number of generations for finding a satisfactory trajectory and thus are not efficient enough for real-time applications. A new method for evolutionary path planning which can be used online in real-time was introduced by [13]. It uses an evolutionary algorithm as a means for active learning of a route map for the path planner. Given a source-destination pair, the path planner searches the map for the best matching route. If an acceptable match is not found, the planner uses another evolutionary algorithm to generate an online path for the source-destination pair. The overall system is an incremental learning planner that gradually expands its own knowledge suitable for path planning in real-time. Simulations have been performed in the domain of robotic soccer to demonstrate the effectiveness of the presented method [13].

Furthermore, Tan et al., [14] have used personality cognitive in order to determine the best secure path. They model a generic cognitive framework in game agents to provide a tactical behavior generation as well as strategic decision making in modern multi-agent computer games. The core of their framework consists of two characterization concepts which are the tactical and strategic personalities where are embedded in each game agent. Tactical actions and strategic plans are generated according to the weights defined in their respective personalities. The personalities are constantly improved as the game proceeds by a learning process based on reinforcement learning. Also, the strategies selected at each level of the agents' command hierarchy affect the personalities and hence the decisions of other agents. The learning system improves performance of the game agents in the combat and is decoupled from the action selection mechanism to ensure speed. The variability in tactical behavior and decentralized strategic decision making improves realism and increases entertainment value. Their framework was implemented in a real game scenario as an experiment and shown to outperform various scripted opponent team tactics and strategies, as well as one with a randomly varying strategy [10, 14]. However, the two most commonly employed algorithms path finding in games are known as A* [4, 15, 16] and Dijkstra [17]. Another methods used pathfinding in games are BestFirstSearch, BreadthFirstSearch, IDA*, JumpPoint, Orthogonal and Trace [18, 19].

Meanwhile, Analytic Hierarchy Process (AHP) was used globally in different fields such as planning, selecting a best alternative, resource allocations, resolving conflict, optimization and numerical extension of AHP. Its ability to be integrated with different techniques like linear programming, quality function deployment, fuzzy logic and so on, make it a flexible and preferred approach. It enables users to extract benefits from all the combined methods, and hence, achieve the desired goal in a better way. The main function of AHP is to calculate the weight of each criteria involved in determining the correct decision. With the ability to select the optimum decision, it would be applied in crime field in order to determine the secure path to victims based on criteria derived [5].

III. METHOD AND MATERIAL

This section briefly describes the data and architecture of PCAHP model proposed in this study. The modelling of path-finding algorithm used is also presented in this section.

A. Data

Spatial data were obtained from PDRM supported by Universiti Malaysia Terengganu (UMT). Then, layers of the selected area were generated and new layers were created using Google Map as the software to do the operations.

B. Architecture of PCAHP Model

The PCAHP model proposed includes three phases which are data mapping, criteria evaluation, and path mapping phases. In data mapping phase, three criteria's having influences on safety walking safety are considered: path-finding criteria are distance between victim and offender, visual field of offender and numbers of obstacles exist as physical environmental and finally derived sub-criteria as Table 1. These criteria are also known as tactical attributes.

Path-finding algorithm is executed to analyze the tactical attributes. Then, weights are taken from the selected criteria's and sub-criteria's through the AHP method. AHP is a MCDM technique to select the optimum alternative by understanding the evaluation criteria and the alternative as a hierarchical structure. After two phases are done, it will come out with path-finding scores. It will be varying in value because each criteria (attribute) gives a different value. The indicator for best secure path is referring by high AHP value.

Finally, the suitable map for potential path-finding crime area will be generated by integrated AHP value and path-finding algorithm. This result will present a rank of best path to worse path. Then, suitability classification is divided into three classes to get the accurate result.

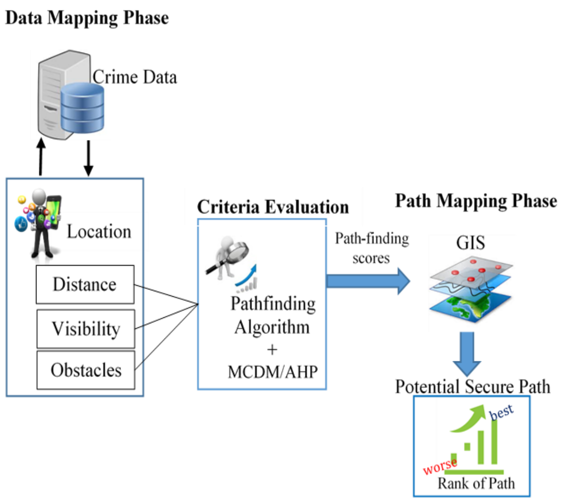

Figure 1: Architecture of proposed PCAHP Model

C. Modelling a Hybrid PCAHP

The path-finding algorithm would be at the core of the decision support tool that emulates the chess playing tactics in measuring variables surrounding crime hot-spots with the use of AHP. Normally in chess-game, a player have eight (8) possible movements where these movements are affected by number of obstacles and other variables. Each technique will determine the specific layers needed to be integrated for possible movements. Three different scenarios as described in the scope of the research will also be modeled, to represent (1) the victim in offender's view, (2) the victim in a crime hotspot but out of offender's view, and (3) the police making the arrest strategy. In modelling these scenarios, mathematical expression are required. The safe and optimum paths will be calculated based on the triangulation area. Each attributes in the path such as distance, visibility and number of obstacles will be set as the benchmark for the AHP calculation.

Let say, to calculate the score of distance number one or Cell1 (C1). The following mathematical notations were used.

$$\begin{aligned} C_1 &= (max - n)/(n-1) \\ &= (AVERAGE(16:18)-3)/2 \end{aligned} \tag{1}$$

where, C_1 is refers to $Cell_1$, n is the order of the matrix, Average (16:18) denoted cell rows (16) and columns (18).

After the optimum and safe paths have been determined, two lists of possible paths namely the closed-list and the opened-list will be created in the next phase. The paths with percentage score greater than 50% will be declared as closed-list while paths with percentage score below 50% will remain as open-list. These lists are derived from the path finding technique. Finally, the paths that are classified as closed-list paths will be recommended to end-users. However, if their destination is in the open-list category, then, additional time-dependent features will be added so as to ensure correct decision is made at the right time. To convert an opened-list path to a closed-list path, the value of sum of the exact cost with heuristic (expert choices) must have confidence value of greater than 50%. This final value are extracted from the path-finding formula such as:

$$F = G + H \tag{2}$$

where: G = the movement cost to move from the starting point A to a given square on the grid, following the path generated to get there.

H = the estimated movement cost to move from that given square on the grid to the final destination, point B. This is often referred to as the heuristic, since it is a guess. The actual distance can't be exact until it finds the path.

The decision is made through the AHP processes by calculating the summation of weight of each criteria (G and H). For example, given a situation where G comprises of C7, V8, OM, OL, OSM, and O7 with values of 0.03, 0.02, 0.09, 0.01, 0.21 and 0.21 respectively. To obtain the percentage score, the value of G needs to be added with H value and multiply the total sum by 100%. If the score is higher than 50%, then, it will be ranked as a secure path in the user list. The values are taken from the selected criteria's and sub-criteria's such as distance, visibility and obstacles as given in Table 1 [20].

1) Distance

Distance is an excellent measurement to determine the successful crime happens. It also close related with our velocity value. If the direction or path have a constraint in the middle, the velocity maybe slow compare than no obstacles in direction. The velocity also influenced by personal behavior such as heart rate, fitness, and strategy. This will guarantee that our path is varying from others. As logic, factor that lead to successful crime is the distance between offender and pedestrians was very near and numbers of obstacle is many so that criminal can hide himself from obstacle. Thus, in our research study, distance is assumed by number of cell between pedestrians and offender. If cell is below than 5, then the possibility to have a crime are higher otherwise if cell is above than 5, then the possibility to have a crime is lower because pedestrian can take alternative path to run from it compare cell below than 5. However, it still depends to obstacles and visibility of offender.

2) Visibly

One factor that led to lack of awareness is the visibility of human itself in tracking the existence of offender from behind. If criminal visibility already locked the position of pedestrians, then it will be advantages to criminal itself. However, visibility of human are defined as circular arc (geometry) where it just can view around 120 degree only.

This limitation degree was give advantage to pedestrians to escape from visibility area of offender. Furthermore, this visibility value also will be disturbed by obstacles that constraint them.

3) Obstacles

The obstacle is a third factor for successful crime. Obstacles have two (2) main functions which are first, it can be a weapon for offender to hide in order ambush a pedestrian and the second one, obstacle can be advantages to pedestrians to limit the visibility of offender and be a protection from criminal's attack. However, the characteristic of obstacles is difference since we can categorize it into four (4) characters which are size, light emission, ability to move and numbers of obstacle. The description for this character can view in Table 1.

The components of Table 1 can be described as follows:

i. The value of distance with C1 to C10 means Cell1 till Cell10.
ii. The value of visibility with V1 to V10 means the percentages of visibility, start with 10% till 100%.
iii. The meaning value of obstacles with OS is, the size of obstacles is small, OM is the medium size, and OH is huge size.
iv. OL, OA, OML are stands for obstacle light emission): obstacles less light (OL), obstacles average light (OA), obstacles more light (OML)
v. OFM, OSM, ONM are refer to ability to move: obstacles fast move (OFM), obstacles slow move (OSM), obstacles no move (ONM).
vi. The percentages of obstacles 10% till 100% are represent as O1-O10.

Table 1
Factors Having Influences on Safety Walking

Components	Description
Distance	C1,C2,C3,C4,C5,C6.C7.C8.C9.C10
Visibility	V1,V2,V3,V4,V5,V6,V7,V8,V9,V10
Obstacles	OS,OM,OH (Size)
	OL,OA,OML (Light Emission)
	OFM,OSM,ONM (Move)
	O1,O2,O3,O4,O5,O6,O7,O8,O9,O10

IV. Discussion and Future Work

This study presented a hybrid model, PCAHP that combines path finding algorithm, chess strategy and Analytical Hierarchical Process (AHP) rules in order to present a path finding method suitable to pedestrian path guidance. In this area of study, the criteria's of situational crime and situational crime data will be analyze in recommending alternative secured paths to the public. In addition to guiding the police in making tactical arrest strategy. Three main factors affecting safe walking considered are distance between pedestrians and criminal (distance), visibility of criminal view (visibility) and obstacles frequency that exist in crime location (obstacles). An application adopting the AHP idea was proposed to calculate the weights of the criteria for evaluating each crime factors. The highest degree of AHP result will drive the pedestrians to choose best path-finding. The consistency index will be used to validate the logically while calculating weights for each factor through the AHP method. Finally, the finding cost is calculated for the pedestrian path finding by calculating these scores with distance values of the path network.

In addition, the main cause affecting pedestrians in safety walking has many subjective elements. In other words, some people require a path having poor walking environment but faster way; somehow, some people need a walking path with longer way around with comfortable environment. The AHP method presented in this paper could be utilized for such personalized services. The AHP for decision making of public purposes should gather the major opinion, however for personal purpose such as safety walking, weights could be calculated according to a personal preference. Therefore, it could be utilized for personalized services such as application personal computing devices. This research will help police in tackling crimes to achieve the goals set for GTP's NKRA on reducing crimes. It will also help the public in deciding on the best alternative routes that are secured when faced with crime situations as well as triggering alerts about any crimes occurrences in their areas. Many application domains will benefit from this, in particular the forensic and crime prevention.

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