

Identification of Potential Crime Tactical Path-Finding Using Analytical Hierarchy Process (AHP) in Situational Crime Prevention Crime Intelligence in New Era

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Abstract— Most route guidance researches are mainly focused on route guidance for vehicles like Papago and Waze software. However, due to the recent spread of personal computing devices such as PDA, PMP and smart phone, route guidance for pedestrians is increasingly in demand especially in context of crime situation. The pedestrian route guidance is different from vehicle route guidance because pedestrians are affected more surrounding environment than vehicles. In this area of study which is situational crime prevention (SCP), pedestrian will try analyze the situation first before take any decision path. It satisfied goal of SCP in order to manipulate crime environment so that offender will seem harder and riskier, change criminal's ideas and reduce opportunities for criminal to commit crime. To solve this problem, we designed a model containing Multi Criteria Decision Making (MCDM) technique that is Analytical Hierarchy Process (AHP) to handle the uncertainty situations. Pedestrian path finding needs considerations of various factors affecting their safety walking. Factors affecting safety walking consists of 3 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 best path-finding.

Keywords—personal computing devices, route guidance, situational crime prevention (SCP), multi criteria decision making (MCDM), analytical hierarchy process (AHP), crime situation.

I. INTRODUCTION

Since 2009s, the statistic of crime has been start decreased after 6th Prime Minister of Malaysia make a new approach by developing National Key Results Area (NKRA). Growth of crime technologies are distributed well like CCTV or expert report and CPTED approach already set up at hot hotspots and seem many reduction of crime statistic were happened. However, it facing one problem which is not yet solved by government which is feeling fear towards crime still high among citizens [1]. By realize this problem, our members tried to educate citizens which path are the most preferable to pass through since this alternatives provided the best method than others [2]. As we know, lack of awareness towards crime also leads high percentage to crime itself [3]. This effort will help pedestrians to walk safely even enter to crime hotspot location. Examining the path finding which is a typical function, technologies have been emerged beginning with the shorted path finding considering an initial distance, the fastest path finding considering speed limits and classes of roads, the free road path finding

considering a toll, and the optimum (safety) path finding with the real-time environment information.

Recently, demands are focused to guide roads for pedestrians are increasing due to the popularization of portable mobile devices such as smartphones, PDA, PMP (Figure 1).

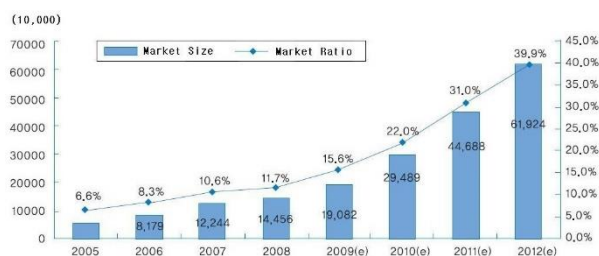


Fig.1 Trends and changes of smartphone markets (2009, Gartner)

All mobile devices nowadays can detect an IP address when someone surf an internet. This IP address can tell us someone location which clearly help us in this crime

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investigation. From these, we can calculate for the optimum path based on someone location. Therefore, it is required data and application programs specialized for pedestrian services. This clearly shown to us that crime prevention is not role from police only but rather seek help from others such as telecommunication company.

Based on characteristic of SCP itself, opportunity of a crime can be related to cost benefits, socioeconomic status, risk of detection, dependent on situational context, type of offence and access to external benefits. In addition, opportunities are dependent on the individual's current surroundings and consequential factors.

Emotions also play an important role in order to make this crime was failed or successful. It has three (3) important roles. First the people's state of emotionality is an important context on which rational conduct rests [4]. Second is the "sneaky thrill" of minor property crime also might operate more generally such that the anticipated emotional consequences of criminal conduct is one of the benefits or utilities ("thrills") that are weighed in the process of rational decision making [5]. Third as a sizable amount of research can attest, the anticipated emotional costs associated with criminal behavior might serve to effectively reduce the likelihood of such behavior [6]. Emotions are a central part of the psychological process of motivation as they heighten the saliency of certain desires, wants, and outcomes and thus energize people to pursue them [7]. If an victims gets panicked easily it is highly probable they won't think twice about making a wrong decision that will risk their life than an individual who is level headed.

This study analyzes factors having an influence on safety walking for data of environment setting constructing up to obstacles where pedestrians could pass through, and selects factors to be used for finding costs. Then, weights are assigned to the selected factors through the AHP (Analytic Hierarchy Process) method, and a path finding score is calculated using them. The path finding score is used to calculate a final path finding score for pedestrians through operations with a distance which is the existing finding cost.

Chapter 2 stated definitions for each keyword means. Chapter 3 derives factors having an influence on safety walking through an analysis on the existing studies. Chapter 4 proposed integrating AHP and Google Map, and Chapter 5 carries out detailed architecture of research framework. Finally, Chapter 6 discusses about conclusions and the future study subjects.

II . DEFINITIONS OF EACH KEY WORD

They have several keywords that readers will see in next section. To make understanding going smoothly well, this section will elaborate some keyword meaning in detailed.

A. Tactical Path Finding

In every company in this world have their unique business intelligence (BI) that drove to successful and profitable company. This business intelligence is made up from two (2) important components which are strategic plan and tactical plan.

Strategic plan or strategic intelligence is future-oriented, allowing a company to make educated decisions regarding future conditions in its particular marketplace or industry. It also permits the company's decision makers to visualize the future direction of the business and helps it recognize emerging trends and patterns within the particular industry and subsequently predict potential problems that may affect the current operating environment. In crime field, this strategy plan can included reducing the rewards that come from committing a crime, increasing the risk associated with offending, removing excuses for offending behavior and so on.

Whereas tactical plan means practical way that implemented to make sure our strategic plan is achieved. Tactical information was looked as involves a thorough and systematic analysis of current and emerging crime problems such as their causes and risk factors that is based on accurate, wide-ranging sources of information and has analysts with the capacity to interpret the data. In this research, tactical attributes are seemed important to bring our goal to tactical path-finding. Distance, visibility and obstacles can classify to tactical attributes.

B. Situational Crime Prevention

Situational Crime Prevention (SCP) is a prevention act that took opportunity as core elements in this area. It is chosen because this SCP has rarely been accorded attention in policy debates about crime control and also whether offenses are carefully planned or fueled by hate and rage, they are all heavily affected by opportunity [8]. This is strong by [9] that mentioned SCP capabilities are to change criminals' ideas about whether they can get away with a particular crime when opportunity are well manipulated by victims.

In real, SCP means to modify contextual factors to limit the opportunities for offenders to engage in criminal behavior [10]. It also involves identifying, manipulating and controlling the situational or environmental factors with certain types of crime [11]. This theory will be clearly understood when we go through to chess simulation study.

C. Analytic Hierarchy Process

The analytic hierarchy process (AHP) is a structured technique for organizing and analyzing complex decisions, based on mathematics and psychology. It was developed by Thomas L. Saaty in the 1970s and has been extensively studied and refined since then.

It has particular application in group decision making [12], and is used around the world in a wide variety of decision situations, in fields such as government, business, industry, healthcare, and education. Rather than prescribing a "correct"

decision, the AHP helps decision makers find one that best suits their goal and their understanding of the problem. It provides a comprehensive and rational framework for structuring a decision problem, for representing and quantifying its elements, for relating those elements to overall goals, and for evaluating alternative solutions.

Users of the AHP first decompose their decision problem into a hierarchy of more easily comprehended sub-problems, each of which can be analyzed independently. The elements of the hierarchy can relate to any aspect of the decision problem—tangible or intangible, carefully measured or roughly estimated, well or poorly understood—anything at all that applies to the decision at hand.

Once the hierarchy is built, the decision makers systematically evaluate its various elements by comparing them to one another two at a time, with respect to their impact on an element above them in the hierarchy. In making the comparisons, the decision makers can use concrete data about the elements, but they typically use their judgments about the elements' relative meaning and importance. It is the essence of the AHP that human judgments, and not just the underlying information, can be used in performing the evaluations [13].

The AHP converts these evaluations to numerical values that can be processed and compared over the entire range of the problem. A numerical weight or priority is derived for each element of the hierarchy, allowing diverse and often incommensurable elements to be compared to one another in a rational and consistent way. This capability distinguishes the AHP from other decision making techniques.

In the final step of the process, numerical priorities are calculated for each of the decision alternatives. These numbers represent the alternatives' relative ability to achieve the decision goal, so they allow a straightforward consideration of the various courses of action.

D. Chess Simulation Study

Chess game is widely well-known game and its characteristic more towards many-to-many attributes meanwhile in our focus research is more towards to one-to-many approach. In chess environment, each pieces will play a role in strategy games whether defense or attack enemy pieces. But in crime environment, victims play an important role to manipulate the situation effectively.

When the chess pieces in dangerous state, we need to safe our pieces from died or can develop strategy to eliminate enemy. But problem comes, mostly human will face disruption feelings caused by increasing an adrenaline hormone and leads them to make a wrong decision. This wrong decision is a big factor why our games always lost. This issue is not done yet; chess features also have do not provide a guide tool for a novice player. So, the percentage to winning a game was limit or none.

Next, we try to mapping out between chess case study and real crime case study, and both of them are very close relationship each other. For example, novice player in chess, we can assume it as foreigner people who do not familiar with

path. It also happen to expert people about path but cannot choose path well when the original path are blocked by construction or other else. Without a proper tool, it was impossible for them to choose a best secure path when facing crime situation or enter crime hotspots.

From perspective of adrenaline hormone also, researcher already stated our psychology balance will disrupted around 50% when facing a real crime situation [14]. This will lead them to a wrong and risky decision that leads them to crime's victim. Media also always show a seriousness crime in television or newspaper which makes public peoples always feeling fear and haunted with their own imagination.

Finally, after we understand enough how human decision works, we will go through to choosing a best secure path. This choosing approach will touched about closed list and open list that always being used in path-finding approach. In normal situation, people always have eight (8) decisions to choose. This choosing path will determine by closed list and open list of tactical path-finding. Closed list are used as a slightly best secure path which means, this path may contribute more to secure path meanwhile open list is list that not be checked from algorithms yet. In this process to choosing a possible closed list are controlled by pruning method. This pruning method will makes our system works efficiently and ease.

III. EXTRACT FACTORS AFFECTING SAFETY WALKING

The safety walking factors are divided into physical environmental elements and human subjective elements. The physical environmental elements are the ones for walking facilities, which are used as indexes for evaluating the walking environment and the human subjective elements are ones that could be differently represented depending on individual preferences and walking purposes etc. Handy S. [15] proved that the physical environment was an influence factor of safety walking by conducting a survey targeting pedestrians in different criteria's after classifying the safety walking purposes into leisure and movement means, and Moudon A. V. [16] analyzed on an influence factor of walking and cycling with evaluation indexes used in each field. And Lee C. [17] derived the importance of elements evaluating the walking affinity through a statistical analysis. Seo. H. L. [18] classified elements having an influence on walking into street environment network environment, and regional environment to analyze them, and Park S. H. [19] carried out a study to make them as indexes. Hieronymus C. Borst [20] classified elements having an influence on walking of the elderly and infirm into 25 items to make them as indexes and used them in path finding, Lee J. E. [21] classified the walking influence elements into physical environmental elements, changes of direction, visual field and accessibility to use for path finding through arbitrary weights.

Through these existing studies and distributed questionnaires, we finally came out with the classification for safety 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 whereas in Table 2 shows the abbreviation meaning that listed in Table 1.

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 |

TABLE 2: Abbreviations meaning that listed in Table 1

| Abbreviation | Meaning |
|--|---|
| C1-C10 | Cell-1 till Cell-10 |
| V1-V10 | Visibility-10% till Visibility-100% |
| OS, OM, OH (Size) | Obstacles Small, Obstacles Medium, Obstacles Huge |
| OL, OA, OML (Light Emission) | Obstacles Less Light, Obstacles Average Light, Obstacles More Light |
| OFM, OSM, ONM (Ability to move) | Obstacles Fast Move, Obstacles Slow Move, Obstacles No Move |
| O1-O10 | Obstacles-10% till Obstacles-100% |

From the Table 1, we derived sub-criteria with quantitative measurement where crime hotspots are identified from 10 x 10 arrays. If pedestrians approach area where crime hotspot radius is 10-cell array from initial place, then system will alert pedestrian to make decision. Similar to visibility and obstacles criteria representatively. They will measure through quantitative scale. However for obstacles criteria, it have slightly different measurement since this criteria can be sliced to favorable characteristic such as size, light restriction, ability to move and number of obstacles. This four (4) characteristic will framed the final result for obstacles criteria. If score is high, means, these obstacle criteria was important though which give advantages to victim in order determine safety path-finding.

A. 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 took alternative path to run from it compare cell below than 5. However, it still depends to obstacles and visibility of offender.

B. Visibility

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 disturbed by obstacles that constraint them.

C. 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 pedestrians 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.

IV. THE PROPOSED INTEGRATING AHP AND GOOGLE MAP

Based on the observation made in previous section, we present the idea of tactical path-finding and IP address where we can use Google API to achieve this goal. The proposed approach framework is designed in a simple figure to make it clear.

Figure 2 shows the structure of proposed approach which consists of a data collection, data analysis from the distribution questionnaire, applying MCDM/AHP technique and integrating AHP and Google Map. Each phase contributed the output with each output from previous phase will then lead to the next phase. Finally, integration between criteria weights and maps is accomplished producing the suitability maps which have the potential area for crime.

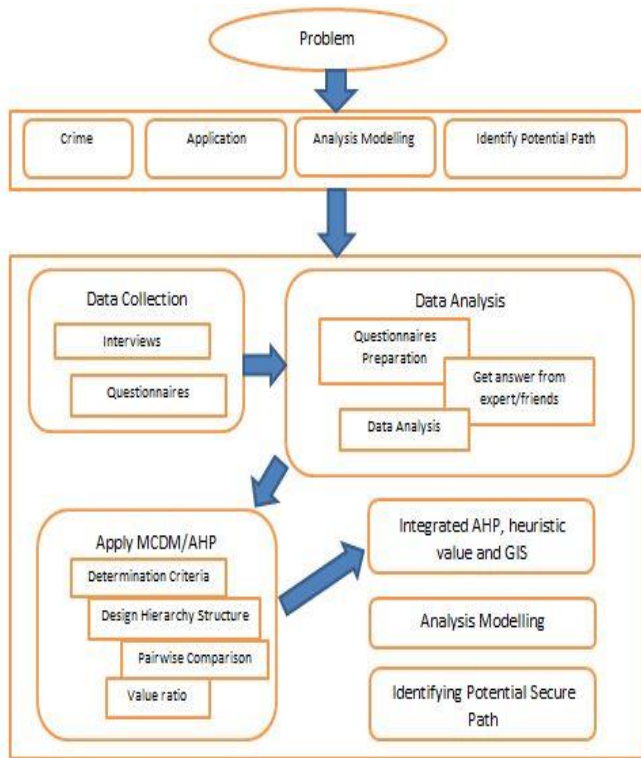


Fig. 2 Proposed Approach

A. Study Area

This study was conducted in Gong Badak, Kuala Terengganu. It is regional municipality located on the east side of Peninsular Malaysia and has population around 50,000 persons. Population is expected to reach 100,000 persons by 2020. Figure 3 shows the location of study area. Population increased occurred without proper controlling and monitoring has lead to several of problems such as criminal activity [22].

This region is the university area and busy street intersected by other university which is Universiti Sultan Zainal Abidin (UnisZA), where is the place with large pedestrian volume of people using surrounding facilities and willing to use public transportation.

From this, we can saw many crime hotspots that are spotted from PDRM file from January 2014 until December 2014. Most popular crimes that's happen was snatching criminal. It is because not 100% students are from Terengganu. Almost 70% are from outside Terengganu which is not very familiar with this place. So, with aid from our system, it could help students in taking a right path so that they can avoid from being crime victims.

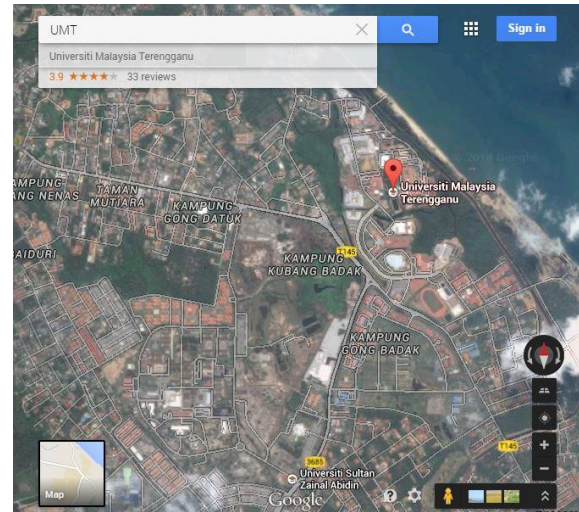


Fig.3 Universiti Malaysia Terengganu (UMT)

B. Data Collection

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.

V. ARCHITECTURE OF PROPOSED FRAMEWORK

This section briefly describes the detailed architecture in three phases which are crime hotspots radius phase, criteria evaluation phase, and mapping phases.

C. Crime Hotspots Radius Phases

This is first phase in order to alert citizen about near crime hotspots between them. In here, we will use collision detection technique which modelled victim and crime hotspots respectively. This technique is widely used in games application. It is important to know when objects in a game collide.

There are a lot of ways that collision detection can be done. The most obvious method is to take every single vertex in a model and check to see if any of them are inside of another model. This method, however, is very time consuming to do, especially if have lots of models, or models with a lot of detail in them. To deal with this problem, game programmers will use an approximation of the model that is easier to check for collisions. The two methods that are most commonly used are bounding boxes and bounding spheres. With these methods, it basically builds a box or sphere around a model that completely covers the model. There will obviously be area that is outside of the model, but still inside of the bounding box or sphere, but an ideal bounding region will limit this as much as possible.

In this study, we would like to use circle rather than box since it give more precise information. With circle models, it can give information about center of circle and radius of circle very well. The basic concept is to figure out how far the point is away from the center of the circle. If that distance is less than

the circle's radius, the point is in the circle. If it's more than the radius, it's outside of the circle.

Finally, in short, we know that two circles must have some overlap if the two centers are closer together than the sum of their radii (radiuses). If the distance is more than the two radii combined, then there will be an empty gap between the two circles. If the distance is equal, the two circles are touching at one point (we'll call that an intersection). If the distance is less, then the two circles *must* be overlapping.

Finally, when both circles are overlapping, system will give alert to end-user for be careful from any possibilities until system give final result to choose secure path. The result of the process must pass through criteria evaluation first.

B. Criteria Evaluation

According to studies conducted from questionnaires, the most important criteria used to determine the potential area of crime in Gong Badak were recognized. Based on questionnaires, distance; visibility; and obstacles were chosen as the potential factors.

Every factor derived above has a qualitative property. In order to approach as the GIS methodology when utilizing them in path finding, however, a quantitative analysis is needed. This study uses the AHP method for such a quantitative analysis.

The AHP is a method that Thomas L. Satty devised in 1980, which is a multi-criteria decision making technique to select the optimum alternative by understanding the evaluation criteria and the alternative as a hierarchical structure. This AHP was developed based on the fact that the brain uses gradual or hierarchical analysis process when human beings make decision. According to results of the study, it is said that human beings follow three rules (setting of a hierarchical structure, setting of relative importance, maintenance of logical consistency) when they solve a problem.

After three (3) processes are done, it will come out with pathfinding scores. It will be varying in value because each attribute give different value. The indicator for best secure path is referring by high AHP value. In conclusion, two attributes likes obstacles and visibility give more advantageous if the value was larger compared than distance attributes where it give disadvantageous when value are higher.

C. Mapping Phases Using Google Map

In this study, layers overlay to raster conversion, clipping processes using Google Map API function and calculating criteria weight using an application based on AHP technique makes out the manipulation of this study. Using Google Map capabilities, criteria maps were converted to raster then they were classified into several classes. Finally, suitable map for potential path-finding crime area will be generated. 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.

VI. DISCUSSION AND FUTURE WORK

This study extracted a variety of factors having an influence on safety walking in order to present a path finding method suitable to pedestrian path guidance which is recently issued. In addition, weights were calculated using the AHP to calculate the importance between the extracted factors, and these weight were used to assign scores of factors for each score. The logical validity was also proved using the consistency index when calculating weights for each factor through the AHP method. Finally, the finding cost was calculated for the pedestrian path finding by calculating these scores with distance values of the road network. The calculated finding cost applied to the road network in university busy street with large pedestrian volume, as a result, it was represented the result different from the path finding through a simple distance. It is analyzed because more suitable safety walking path was presented considering a variety of factors having an influence on safety walking.

However, a quantified verification for this is needed because it is only subjective view. In addition, a detailed study is needed for the criteria to distinguish attributes and the assigned scores also in the score assigning process.

The main cause affecting pedestrians in safety walking has many subjective elements. In other words, some people want a path having poor walking environment but faster way; on the other hand, some people want a walking path with longer way around but 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 through personal computing devices.

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REFERENCES

- [1] Program Transformasi Kerajaan, Laporan Tahun 2011, "Mengurangkan Jenayah Melalui Pelan NKRA", m/s 52-96.
- [2] Vienna. "Prevention: An Effective Tool to Reduce Corruption". Global Programme Against Corruption. Page 1-38.
- [3] Margaret Roper et al. "Khulisa Community-Based Crime Prevention Programme in Kwazulu-Natal 2006. Page 1-46.
- [4-6] Simpsons, S. (2000). Of crime and criminality: The use of theory in everyday life. Thousand Oaks, CA. Pine Forge Press.
- [7] Kaufman, B. (1998). Emotional arousal as a source of bounded rationality. *Journal of economic behavior and organization*, vol. 38, page 135-144.
- [8] V. Clarke, R., "Situational Crime Prevention – Successful

- Case Studies 2nd Edition. Library of Congress Cataloging, 1997: p. 1-43
- [9-11] Situational Crime Prevention Theory. URL: <http://crimeprevention.rutgers.edu/topics/SCP%20theory/theory.htm>
- [12] Saaty, Thomas L. Peniwati, Kirti (2008). Group Decision Making: Drawing out and Reconciling Differences. Pittsburgh, Pennsylvania: RWS Publications. ISBN 978-1-888603-08-8
- [13] Saaty, Thomas L. (June 2008). "Relative Measurement and its Generalization in Decision Making: Why Pairwise Comparisons are Central in Mathematics for the Measurement of Intangible Factors – The Analytic Hierarchy/Network Process". 102(2): 251-318. Doi:10.1007/bf03191825.
- [14] Cindy Dietrich. (2010). "Decision Making: Factors that Influence Decision Making, Heuristic Used, and Decision Outcomes. Vol.2 No. 2 page 1-3. URL: <http://www.studentpulse.com/articles/180/decision-making-factors-that-influence-decision-making-heuristics-used-and-decision-outcomes>
- [15] Handy, S. 1996 "Methodology for Exploring the link between urban Form and Travel Behavior." Transportation Research Part D 1(2): 151-165
- [16] Moudon, A.V. et al., 2003 "Walking and Bicycling: An Evaluation of Environmental Audit Instruments" American Journal of Health Promotion v.18 n.1 21-37
- [17] Lee, C. et al. (2006) "The 3Ds + R: Quantifying land use and urban form correlates of walking" Transportation Research Part D11 204-215
- [18] Hyeyoung Kim et al 2006, "An Accessibility-incorporated Pedestrian Routing Algorithm", Fall Conference on Geographic Information System Association of Korea 87-96
- [19] So-hynn Park et al, 2008, « Measuring Walkability in Urban Residential Neighborhoods:
- [20] Hieronymus C. Borst et al 2009, "Influence of environmental street characteristics on walking route choice of elderly people", Journal of Environmental Psychology 29, 477-484
- [21] Jongeon Lee et al 2008, "Department of Transportation Algorithm for Pedestrian in Shopping Area", Journal of Korean Society of Civil Engineers v.28 n.2D 147-154
- [22] Keith Harries. " Property Crime and Violence in United States: An Analysis of the Influence of Population Density". International Journal of Criminal Justice Sciences. Vol.1 Issue 2 July 2006.