OPTIMAL PLACEMENT OF SECURITY CAMERA

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My utmost dedication to my beloved family and friends.

Thank you always being there for me.

I love you.

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To fully acknowledge everyone who played a part in making this project a success would require more space that I have allocated. Bearing in my mind, I would like to mention a few key figures that played crucial roles in turning this project into reality.

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ABSTRACT

This research studies the optimization on the placement of security camera. We need to improve the field of view (FOV) coverage of a security camera by only adjusting the location of cameras with minimal numbers of cameras. Two dimensional of floor plan was designed in boundary nodes and internal nodes. Cameras were installed at boundary node in order to view the internal nodes. We propose Binary Integer Programming method which can efficiently find an optimal layout for each camera. Heuristic method of Particle Swarm Optimization (PSO) algorithm is applied on this problem. As a result of this optimization, the FOV coverage of the whole camera network is maximized. This study show that the proposed PSO method perform well and effectively applied in placement of security camera on any design of floor plan.

ABSTRAK

Kajian ini adalah untuk mencari kedudukan optimum kamera keselamatan. Kita perlu meningkatkan kawasan liputan dan menggunakan bilangan kamera keselamatan yang minimum serta kedudukan kamera yang optimum. Dua dimensi pelan lantai telah digunakan berserta nod sempadan dan nod dalaman dalam masalah keselamatan. Kamera akan dipasang di nod sempadan untuk melihat nod dalaman. Kami menggunakan kaedah "Binary Integer Programming" untuk mencari kedudukan optimum untuk setiap kamera. Algoritma kaedah heuristik "Particle Swarm Optimization" (PSO) digunakan untuk menyelesaikan masalah ini. Dengan hasil pengoptimuman ini, kawasan liputan kamera berjaya dimaksimumkan. Kajian ini menunjukkan bahawa teknik PSO mempunyai prestasi yang baik dan berkesan untuk menyelesaikan masalah kedudukan kamera keselamatan dalam reka bentuk pelan lantai yang berlainan.

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LIST OF ABBREVIATIONS

AGP	-	Art Gallery Problem
BIP	-	Binary integer programming
FOV	-	Field of view
gbest	-	Global best
MIP	-	Mixed integer programming
pbest	-	Personal best
PSO	-	Particle Swarm Optimization

LIST OF SYMBOLS

Π	-	Set of candidate camera
d	-	Dimension
GB	-	Global best
PB	-	Particle best
s	-	Sigmoidal function
v	-	Velocity vector
x	-	Position vector

CHAPTER 1

INTRODUCTION

1.1 Introduction

Mathematics in Industry Study Group (MISG) is a collaborative problem-solving workshop where applied mathematicians tackle real life problems shared by local companies. The workshop helps to rapidly determine the key scientific issues and mathematical challenges in the problems presented. MISG provide a unique opportunity for applied mathematicians to be exposed to industrial problems. It also helps to set up the link between industry and university, and in particular to encourage the greater use of mathematical modeling and analysis in industry. MISG is first held or organized in Malaysia with the collaboration between Oxford University, UTM and MIMOS Berhad in 2011 at UTM. MIMOS is a purpose-driven organization, tasked to enhance technological competencies of the industry, create new markets and help raise Malaysia's local, regional and international market competitiveness. One of the problems in MISG workshop is searching the optimal placement of security cameras.

In recent years, there is a hot research topic which is computer vision in video networks. The practical need for such systems is increasing, while the associated hardware costs are decreasing. In video sensor networks, the aim is to have as much coverage as possible within a pre-defined region, with an acceptable level of quality-of-service. The key scientific issues and mathematical challenges are determined on presented problems by the workshop rapidly. In this study, C Programming Language and MATLAB were used to solve the camera replacement problem.

The research of surveillance application is become important nowadays. This application very useful in monitoring the home security, industrial plant, an area for security reasons, supermarket, shopping center so on. Therefore, the visual sensor or cameras arrays are important for any surveillance applications. The aims are to gain maximum field of view (FOV) with good quality of service, minimum cost and minimum number of cameras used; proper placement of visual sensors is an important issue as these systems. The quality of the images is based on the position and poses of the cameras. The specific additional requirements may cause the required view in different. However, a camera layout which assures acceptable quality of image is required in all vision based applications. Placement of cameras depends on feasible location, dynamic or static objects shown in sensitive areas or the assigned priority of the area. Hence, the placement of cameras become an optimization problem with inter related and competing constraints.

The optimization of camera placement becomes complicated due to non-gradient property of the problem. In other word, only non-gradient based optimization can be used to solve the above problem. One of the non-gradient optimization is Particle Swarm Optimization (PSO). PSO is a robust stochastic optimization technique based on the movement and intelligence of swarms. PSO applies the concept of social interaction to problem solving. Number of agents (particles) keeps track of its coordinates in the solution space which are associated with the solution (fitness) that has achieved so far by that particle. This value is called personal best (*pbest*). Another best value called as group best (*gbest*) which is the value obtained so far by any particle in the neighborhood of that particle.

In the field of Computational Geometry, extensive progress has been made in solving optimal “guard” location problems for a polygonal area. For instance, Rourke (1999) gives a nice introduction to the family of static guard problems known as Art Gallery Problems (AGPs). In the AGP, the task is to determine a minimal number of cameras and their static positions, such that all points in the polygon are observed. The AGP and its variants employ unrealistic assumptions about the cameras’ capabilities that make these algorithms unsuitable for many real-worlds computer vision applicants: unlimited field of view, infinite depth of field.

In camera replacement problem, researchers simulate the observing region as a planar, for example, automated placement of cameras in a floor plan to satisfy task specific constraints. However, volumetric (3D) region is more realistic but we focus on problems that can formulate in terms of 2D in buildings. First we will decompose a given region into convex parts, and then approximate these parts by separator. These assumptions are valid since most of buildings consist of shapes in right prism form or can be approximated by a collection of right prisms. We also assume that cameras have pyramidal view with standard parameters and they are static which means they have a fixed position and orientation. Noted that it may not be necessary to observe the whole prism, but sufficient in observing some frustum of prism.

C programming combined intelligent and creative work. We must always have creative thinking in solving problem of cameras placement. Besides that, C programming is a widely used language which is also a general purpose programming language that is highly modular and structured. Two characteristic are vital in developing the applications:

- Modular is a programming style where a program involves in breaking down into several modules or way or function where each module represents a specific task and can get the solution of the problem by solving these modules.

Structured program is the instructions sophisticated flow from top to bottom to make it able to read and error when a program fails to run.

The aim of this study is the usage of C in solving the problem of optimal placement of cameras in two dimensional model (2D) layout. The number of cameras used is minimizing while the coverage of FOV can be increase as much as possible within a pre-defined region. Other than that, an algorithm of optimal cameras placement program will be developed and the configuration of problem is created or designed in two dimensional in detail.

1.2 Statement of the Problem

Nowadays, researchers simulate the observing of optimal placement of security cameras in door spaces. The cameras layout should satisfy with the task specific requirement or additional constraints since these will help in improving a vision algorithm's runtime performance. But, this remains a relatively under developed area of video sensor networks. The main reason of lack of interest may link to researchers' tendency to focus on the design of new algorithms for the problem. This may cause a clear lack of standard test beds to compare them. The lack of a standard test bed to evaluate and to compare the performances of different security camera setup may cause failure to capture or notice something and reduce the feasible region.

In addition, some even curious about how to get the optimal placement for security cameras and minimum numbers of cameras used. This study is designed to determine an optimal placement of the field of view and the number of cameras, given a specific task constraints, and the set of possible cameras may use in the layout. The minimum numbers of cameras are placing in door spacing. The interesting part is the area to be observed by cameras may be a specific polygon additional constraint. Besides that, there may include a number of dynamic or static objects and obstacles in sensitive area such as furniture, columns, walls and holes. Therefore, C programming was used to help find the minimum cameras to cover the whole region in 2D floor. Consequently, to provide effective scientific evidence to cover industries in selecting suitable places for cameras and save costs.

1.3 Objective of the Study

The objectives of this study are to:

- Determine the minimum number of security camera as well as their positions and poses in the space that maximum coverage is achieved.

- Minimize the blind area which is the place without secure by the cameras.

- Obtaining the maximum coverage while minimizing the total cost of security cameras.

1.4 Scope of the Study

This study is related the location of security cameras problem which will transformed into the problem of optimization. For this study, we have to determine the minimum numbers of security cameras used to cover the maximum field of view on a specific layout in two-dimensional floor plan. At the same time, we have to minimize blind area which is the area that cannot be viewed or covered by the security cameras. This study will also discuss about how to use the C programming and MATLAB on solving the optimization of the security cameras placement in 2D layout. C program and MATLAB are able to solve the problems in two-dimensional and three-dimensional securities cameras problems. The availability of fast and inexpensive computer programming allows solving the difficult and intractable problem mathematically. Methods of binary integer programming and binary Particle Swarm Optimization are used in the minimization problem. However, in this study, we will only restrict our scope of the camera placement problems in two-dimension.

1.5 Significant of Study

Through this study, there will be a benefit in increasing the level of awareness and costs saving among industries when installing the security cameras. Besides that, this study may help engineers to make reduction in the development time in finding the solution. Engineers cannot afford in sending too much of time to get the solution of the problem. So, C program and MATLAB is one of the important mathematical concepts in solving their problems. The used of programming on the data could be a good approximation for buildings on any specific layout in 2D. Using

these approximations, the optimal placement of security cameras in door spaces is chosen.

In addition, breakthroughs in technology have allowed the placement of high quality security cameras. The advance in technology video surveillance is an attractive and affordable security option for most homes and businesses which can help to prevent and reduce the criminal acts. Applied C program and MATLAB in the placement security cameras problem may capture surveillance footage virtually in any locations. The work can be performed fast and better by applying C program and MATLAB in the problem.

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