

SIMULATION OF IDENTIFYING SHORTEST PATH WALKWAY IN LIBRARY
BY USING ANT COLONY OPTIMIZATION

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Report submitted in partial fulfillment of the requirements
for the award of the degree of
Bachelor of Computer Systems & Software Engineering
(Graphic & Multimedia Technology) with honors

Faculty of Computer Systems & Software Engineering
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JUNE 2012

ABSTRACT

A research is proposed based on Ant Colony Optimization for solving the shortest path problem in library. This is a research that the algorithm is aim to implement on a robot. The robot is used to walk around in the library to collect books from all the tables and put on book shelves. However, command prompt window will use to shows the result which is the shortest path. People nowadays are more concern about the efficiency of work, this may happen in library as well. Therefore, by determining the shortest path will help in reducing the time consume problem. This project is developed by starting with designing the workflow diagram as well as the design of the output interface. The work flow is the guide for the process of development. In between, Heuristic Approach is used to determine the entire possible paths at first, then Ant Colony Optimization algorithm will be implemented to search for the final and the shortest path. The system is used to be error free and the algorithm can effectively solve the shortest path problem.

ABSTRAK

Penyelidikan yang dicadangkan berasaskan Ant Colony Optimization adalah untuk menyelesaikan masalah laluan terpendek di perpustakaan. Algoritma dalam penyelidikan ini adalah untuk melaksanakan pada robot. Robot ini digunakan untuk berjalan di sekitar perpustakaan demi mengumpulkan buku-buku daripada semua meja-meja dan meletakkannya ke atas rak buku. Walau bagaimanapun, hasilnya akan menunjukkan laluan yang merupakan laluan terpendek. Pada masa kini, orang ramai lebih prihatin tentang kecekapan kerja, hal yang demikian berlaku di perpustakaan. Oleh yang demikian, dengan menentukan laluan terpendek akan membantu dalam mengurangkan masalah penggunaan masa. Projek ini mula dibangunkan dengan merekabentuk gambarajah aliran kerja seperti reka bentuk hasilnya. Aliran kerja tersebut merupakan pembimbingan kepada proses pembangunan. Di antaranya, Kaedah Heuristic digunakan untuk menentu keseluruhan laluan yang berkemungkinan pada permulaan, kemudian, algoritma Ant Colony Optimization akan dilaksanakan untuk mencari laluan terpendek dan yang muktamad. Sistem ini bebas daripada ralatan dan algoritmanya dapat menyelesaikan masalah laluan terpendek dengan berkesan.

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CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

Generally, optimization has been use for several purposes till nowadays. Optimization is considered as a procedure that used to reduce complex problems to a more simple way. It can also define as modifying a system to make it work to be more efficiently or use fewer resources. The studies of optimization are now implementing widely, it also a command field that will mostly explore by researcher.

While shortest path problem is one of the fundamental problem that used to find a short and minimum distance to reach the destination, with the minimum time consume as well. People nowadays are more concern on time consuming and efficiency of work. Therefore, by finding the shortest path, destination can be reached faster and result in saving time. There are several technique that used by researchers to determine shortest path, such as Ant Colony (ACO), Genetic Algorithm (GA), Particle Swarm Optimization (PSO), Dijkstra's algorithm and so on. Besides shortest path, all of these algorithms have been used in some other combinational optimization problem, for example, scheduling, travelling salesman problem, robotic motion planning and so on.

In this project, a system develops by using the optimization method to find the shortest path walkway in library. The technique that use in this project is Ant Colony Optimization which is an idea that comes from ant behavior. The concept is that, when ants search for food and return to the nest, they will discover many path in the area. The more times the ants go and back between the food and nest, the more times the trails will be evaporated. From the trails that discovered, the shortest path

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can be determined by comparing among it. Therefore, the longer the time those ants used to go and back from the food, the higher the probability for the ants to discover the shortest path. This is because ants will follow the largest pheromone concentration, while shortest path is the highest probability, since shortest path can reduce the time of returning to nest.

In addition, in the library there is a need to have librarian to collect books from tables to put back to the bookshelves that prepared. But unfortunately, human energy may not greater than robot. Since robot does not need to rest and can work up to the duration of battery. By implementing Ant Colony Optimization (ACO) in shortest path, robot will able to determine the shortest path between two locations and manage to bring the books to the bookshelf in short period. It will consequently saving time and human energy. Besides, it may increase the efficiency of work as well.

1.2 PROBLEM STATEMENT

Library is a place that people used to study and borrow books. There are some people that like to stay at the library to pass their reading time. Therefore, for each day, they may have some books that will leave on the table and need to be collected.

Nowadays, most of the libraries are using men power, librarian to arrange and collect books from tables. As for some other places, there may have robot to replace the men power, since robot can bring lots of the benefits to human being. Although human being are more intelligent than robotic, but still there are some constraints that we can see from human being, such as human may not afford to work for a day, 24 hours, as human will feel tired. Therefore they may need rest and take meal so that they have the energy to continue their work. This will consequently reduce the efficiency of work. Therefore, robot may more useful in this situation.

Besides that, it is hard to hire a librarian nowadays. Since most of the people wish to get a job that is more professional and paying wit high salary. So that there is lack of people that willing to sit in the library, arrange books and collect books. They

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will think that the job is boring yet low salary. In this situation, robot may replace human resource, as robot is program is program to help people in any situation.

Salary is another reason for replacing men power with robot. People work is to get salary to go on their live. Therefore, the higher the salary, the more people will interview to be a librarian. But the problem is, not all the library can afford the high salary and it is paying month by month. The amount may consider a huge number. Therefore, this will result in the creature of robotic.

On the other hand, although robot is more convenient and helpful in library, there are several things that need to be considered. Firstly is the cost of the robot. Robotic can be considered as a costly technology that creates to help people. Therefore some library may not afford to prepare a large number of money for few robots to increase the efficiency of work. Besides that, the monthly electric fee has to be concerned, as the robot need to be charged.

The faster the work can be done, the more the works can be finish up, and then the reputation of the library can be upgraded. This can be helped by applying shortest path on robot. The more the robot move, the more the battery will used. Therefore, battery is an important part that user needed to be always concern. If the power duration is 8 hours, then the robot needs to finish up work within 8 hours. If the robot moves a lot, then the duration may decrease. Therefore, the less the robot move, the more duration of the power and result in more work can be done.

Robotic is a technology that programmed by human being and controlled by human being. What the programmer wish the robot to do, he will program and implement in it. Some of the robots are able to move, but the problem is to determine the shortest path from the origin of the robot to its target destination. This will result in wasting the power duration, and then less work will be done, efficiency of work will decrease. If the robot able to determine the shortest path to reach a bookshelf, this will save the time consumed and increase the work performance even with 1 robot in a library. Therefore, there is a need to do a research on this topic.

1.3 OBJECTIVES

The objectives of this project are:

- i. To study Ant Colony Optimization technique in shortest path for library use.
- ii. To develop a shortest path using Ant Colony Optimization for library.

1.4 SCOPE

The scopes of the project are:

- i. A library that arranged with minimum 9 tables with 2 book shelves and maximum 25 tables with 3 book shelves.
- ii. Microsoft Visual Studio will be used to develop the system.
- iii. The system using C programming language and implement Ant Colony Optimization concept.

1.5 Thesis Organization

This thesis consists of six chapters and each chapter is to discuss the different issues in the project. Below that is the summary of the content for each chapter.

- i. Chapter 1 – Introduction
 - This chapter provides background information about the project which includes problem statement, objectives and scope.
- ii. Chapter 2 – Literature Review
 - Some literature and research which related to this project will be review and discuss in this chapter.

- iii. Chapter 3 – Methodology
 - Data analysis, method and the procedure of this project development will be discussed.
- iv. Chapter 4 – Implementation
 - The implementation of the system using Genetic Algorithm will be explained in this chapter.
- v. Chapter 5 – Result and Discussion
 - This chapter will present the testing result of the system and result on the discussion.
- vi. Chapter 6 – Conclusion
 - A complete summary of the project will be present in this chapter.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

This chapter briefly explains about the review for Identifying the Shortest Path walkway in Library by using Ant Colony Optimization. There are 3 main sections that will be discussed in this chapter. Firstly, we will discuss about the type shortest path problem that exist with different algorithm. Then will follow by the definition and the history of Ant Colony Optimization. Lastly, the usages of Ant Colony Optimization will be discussed.

2.2 SHORTEST PATH PROBLEM

Shortest path problem is one of the fundamental problems that studied in computational geometry and other areas including graph algorithm, geographical information systems (GIS), network optimization and robotics [21]. Shortest path problem is a problem of finding a path between two places that having the minimum length in order to minimize the time consumes and cost [18, 20]. In graph theory, shortest path problem is to find a path between two nodes or vertices in a graph by calculating the sum of the weight if the edges and define the shortest distance.

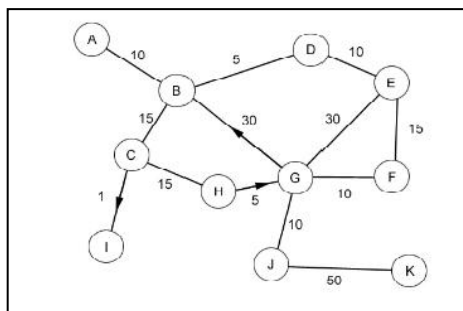


Figure 2.1 Model shortest path. Source from [21]

The purpose of finding the shortest path is to minimum the distance to reach the destination and result in saving the time consume, as well as saving cost. Besides that, the efficiency of job can be increase. These are the benefits of finding the shortest path. These had leaded some of the researcher to propose their research on it. Therefore, nowadays, there are a lot research investigate their research on shortest path problems by using different algorithm as well as in different type of shortest path problem. The algorithms are such as Ant Colony Optimization [4, 6], Genetic Algorithm [19], Particle Swarm Optimization (PSO), Dijkstra's algorithm and so on. There are some others shortest path problems that proposed by researchers, for example, Traveling Salesman Problem (TSP) [8, 9], Robot Motion Planning [13], Scheduling [14, 16] and so on.

2.2.1 Type Of Shortest Path Problem With Different Algorithm

In this particular part, the different type of algorithms such as Genetic Algorithm, Particle Swarm Intelligent and so on, which use to solve different kinds of shortest path problems will be introduce. Based on some of the papers, each of the algorithms shows their effectiveness on solving the problems. Some of the algorithms have been improved by adding others technique, and it shows the advance of the improvement.

2.2.1.1 Traveling Salesman Problem (TSP)

Traveling salesman problem is the problem that tends to find a shortest closed path which visits all the cities in given set and return back to the starting point [1, 9, 11, 22]. It is one of the NP-hard problems in combinatorial optimization [7, 11]. The purpose of solving the traveling salesman problem is to find the minimal cost for visiting each of the cities. Besides that, there is always hope that the time consume can be minimize as well. Traveling salesman problem can e differentiate in 2 types, which are asymmetric and symmetric. Symmetric Traveling Salesman Problem means that the distance between two cities is the same in each opposite direction and this form an undirected graph. Asymmetric Traveling Salesman Problem is the paths may not exist in both directions or the distances might be different, this will form a directed graph [7]. There some researcher had did some research on traveling salesman problem by using some other algorithm, such as Genetic Algorithm, Dijkstra's algorithm and so on. These algorithms had successfully solved the traveling salesman problem.

2.2.1.1.1 Genetic Algorithm

Genetic Algorithm is considered as evolutionary algorithms. It is a probabilistic search algorithm which simulates natural evolution [24]. Basically, genetic algorithm is use for combinatorial optimization problems. Genetic algorithm is the idea of Charles Darwin, who proposed the basic concept that, genetic algorithm, is designed to simulate processes in natural system necessary for evolution [23]. In this recent years, there are several evolutionary optimization of NP-hard problems have been proposed, one of it will be Traveling Salesman Problem.

There is a paper [23], by Li-Ying Wang, Jie Zhang and Hua Li. They proposed a research which is about An Improved Genetic Algorithm for TSP. In this paper, they were tried to improve the Genetic Algorithm to solve Traveling Salesman Problem (TSP). In between, they had introduce a method of untwist operator to improve the performance of Genetic Algorithm. Generally, there are three operator is needed for the algorithm, which are selection operator, crossover operator and mutation operator. But there is the extra untwist operator that proposed by them.

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Mainly, selection operator is used to select the individual, means the chromosome from the last generation, to keep the quality based on the fitness value. Crossover operator is the method that combining those selected individuals into new individuals. For the mutation operator, it is use to maintaining the diversity of individuals in the population. According to this paper, when routing the cities, it may produces a diagram of twist route, this will result in increasing the length of route. In order to solve the problem, untwist operator is introduced.

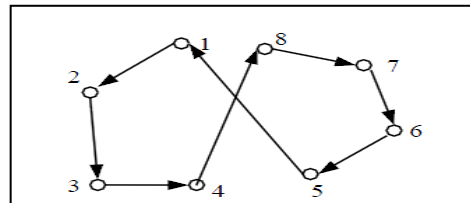


Figure 2.2 Twisted route

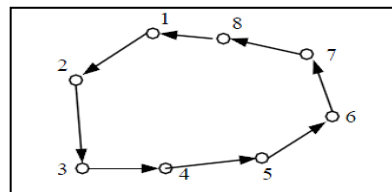


Figure 2.3 Route after untwisted. Source from [24]

The following is the algorithm that proposed by them [24]:-

Step 1: Generate p valid routes at random, where p is the scale of population.

Step 2: According to formula

$$f(X) = \sum_{i=1}^{n-1} D(X_i, X_{i+1}) + D(X_n, X_1)$$

calculate the fitness value of each individual.

Step 3: If the best route satisfies the request or the stop condition is met, then output

the best route and terminate the loop; otherwise go to step 4.

Step 4: Find the best route from current population and copy directly to new population.

As the result, they had proved that, untwist operator can break the knots if route and result in improve the genetic algorithm for solving traveling salesman problem.

2.2.1.1.2 Particle Swarm Optimization

Particle Swarm Optimization is first proposed by Kennedy and Eberhart in 1995 [26, 25]. It is a computational method that used to optimizes a problem by iteratively trying to improve a candidate solution based on the given measure of quality [25]. It also consider as evolutionary computation technique as it has common evolutionary attributes. Particle swarm optimization is concern of the position and the velocity. It optimizes a problem by having a population and moves the particles around in the search space, n-dimension according to some mathematical formulae [25]. The particles will represent the potential solution of the problem and it can remember the best solution it has reached [27]. In the search space, all particles will share their information, therefore there will be a global best solution. Since Particle Swarm Optimization is used to optimizes problem, therefore it can also been used for solving Traveling Salesman Problem that need to figure out a best path among the paths.

A paper of Modified Particle Swarm Optimization based on Space Transformation for solving Traveling Salesman Problems [26], is proposed by Wei Pang, Kang-Ping Wang, Chun-Guang Zhou, Long-Jiang Dong, Ming Liu, Hong-Yan Zhang and Jian-Yu Wang. This paper is discuss about a modified Particle Swarm Optimization is proposed to solve the Traveling Salesman Problem (TSP). In between, the algorithm is searched in Cartesian continuous space and space transformation is proposed to construct a mapping from continuous space to discrete permutation space.

The following is the description of the algorithm [26] that proposed:-

Step 1: Initialization

1-1. Parameters Initialization:

P_MAX, V_MAX, inertial weight ω , local search probability *TwoOptProb*, chaotic factors $C_v = C_l =$ DispitveProb, max iteration number MAX_GEN, and the population size MAX_NUM.

1-2. Population Initialization:

Initial the position and the velocity of each particle in the swarm randomly according to the parameter P_MAX and V_MAX.

Step 2: Iteration

If current number of iteration *IterNum* > MAX_GEN,
GOTO Step 4

For id=1 to MAX_NUM, id++

{

2-1. Exert chaotic operation with the probability of *DispitveProb*

if $\text{Rand()} < \text{DispitveProb}$, calculate the velocity V_{id} and position X_{id} of particle P_{id} according to formula (9),(10).

Else, calculate the velocity V_{id} and position X_{id} of particle P_{id} according to formula (1), (2).

2-2. Calculate the corresponding permutation π_{id} for position X_{id} according to GVP rule, and further

calculate the fitness of the particle P_{id} .

2-3. Local search for π_{id} with the probability of *TwoOptProb*, and restore the better solution to the search space according to the *LSR* strategy.

2-4. Update the local best of the particle P_{id} if we get a better solution.

}

Step 3: Finishing one iteration, update the global best of the swarm. *IterNum*++, GOTO Step 2.

Step 4: Output the best solution.

The formulae that need in the algorithm:-

$$V_i^{t+1} = \omega V_i^t + C_1 * \text{Rand()} * (P_i^t - X_i^t) + C_2 * \text{Rand()} * (P_g^t - X_i^t) \quad (1)$$

$$X_i^{t+1} = X_i^t + V_i^{t+1} \quad (2)$$

$$\text{IF } (\text{rand}() < C_v) \text{ THEN } v_{id} = \text{rand()} * V_MAX \quad (9)$$

$$\text{IF } (\text{rand}() < C_l) \text{ THEN } x_{id} = \text{rand()} * P_MAX \quad (10)$$

According to the paper, they found that, when the algorithm is operating, the swarm often falls into local minima too early, due to the introduction of local search, and the fast evolve of the swarm. To solve this problem, chaotic operation is introduced. At the end of the research, they found that chaotic operation and space

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transformation were effective for solving Traveling Salesman Problem by using Particle Swarm Optimization as the performance had been improved as well.

2.2.1.2 Robot Motion Planning

Due to the fast development of the technology, mobile robot is widely used in many sectors nowadays. To complete a mobile robot, there is a need of robot motion planning which it will help robot to perform a smooth action, based on the algorithm used. According to [12, 14], motion planning is to produce a continuous motion that connects the starting point and the goal point. In between, the collision that known as obstacles needs to be avoided. The objective of planning robot motion is to find an optimum path from the start to the goal without any collision in barrier area [13]. While planning the path for robot, there are two main thing that need to be consider, which are the time and the path that robot walk through is safe. This is because, nowadays, robots are mostly used to replace man power on every sector, therefore, robot is as similar as human being. They do need a safe path to walk through. The guidelines for the for robot path planning are shortest path, least energy consuming or shortest time [14]. Therefore, robot path planning is considered as constrained optimization problem. Since robot path planning is a NP problem, so, there are some of the algorithms or techniques that currently use to solve this problem, for example, Neural Network, Genetic Algorithm, Particle Swarm Optimization and so on.

2.2.1.2.1 Neural Network

According to [28], Neural Network is a mathematical model or computational model that is inspired by the aspect of biological neural networks. Neural network consists of an interconnected group of artificial neurons and it processes information using a connectionist approach to computation [28]. Neural network is consider as adaptive system that will changes it structure based on the external or internal information that flow through the network during the learning phase.

Figure 2.4 is the model of the Neural Network [28].

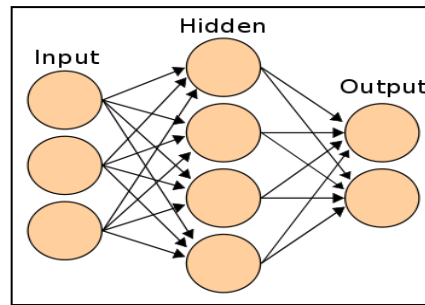


Figure 2.4 Model of Neural Network

In computational of robotic, neural network is from the wish of understanding principles leading in some manner to the comprehension of the basic human brain functions and then will build in the machine that are able to perform complex tasks [29]. It includes cognitive tasks such as learning, adaptation, generalization and optimization [29]. These will solve by using algorithm then will implement into robotic. Besides, recognition, learning and decision making are the need for a robotic, which robotic is used to replace man power in the future.

There is a paper of [30] Neural Network to Path Planning for two Dimensional Robot Motion by Christopher Kozakiewicz, and Masakazu Ejiri. The purpose of this paper is to propose a method for robot obstacle avoidance and path planning. The algorithm that used is based on camera image feedback loop utilizing Neural Network for image processing. Their research can be described in Figure 5 [30].

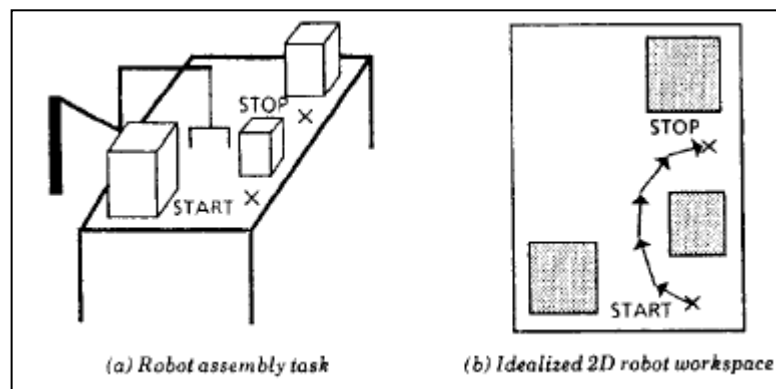


Figure 2.5 The block diagram of the Neural Network controller [30]

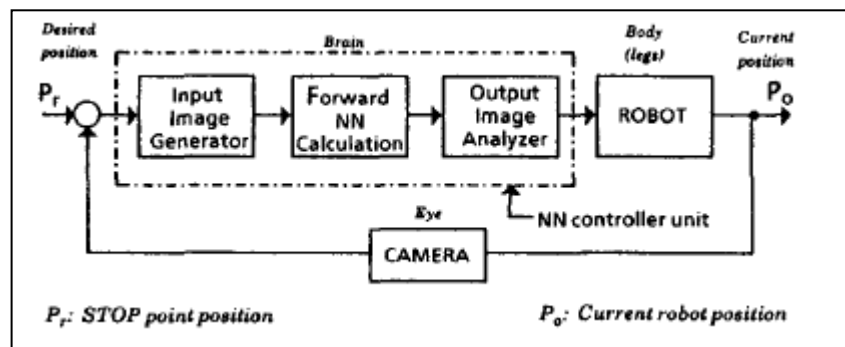


Figure 2.6 Block diagram of the Neural Network training algorithm [30].

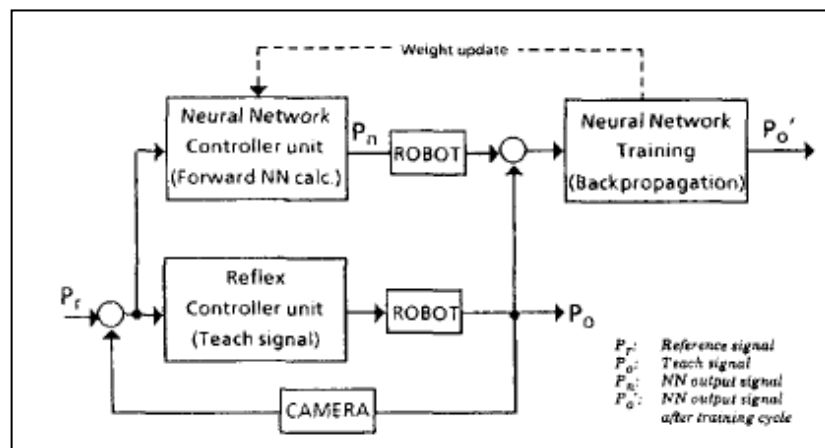


Figure 2.7 Neural Network Controller [30]

Reflex controller is depending on interaction of four low level instinctive behaviors:

1. Do not hit the obstacles
2. Get closer to the STOP point
3. Do not approach obstacles too closely
4. If no progress is made for several steps, take a short random walk.

Figure 2.8 is the block diagram of the Reflex controller:

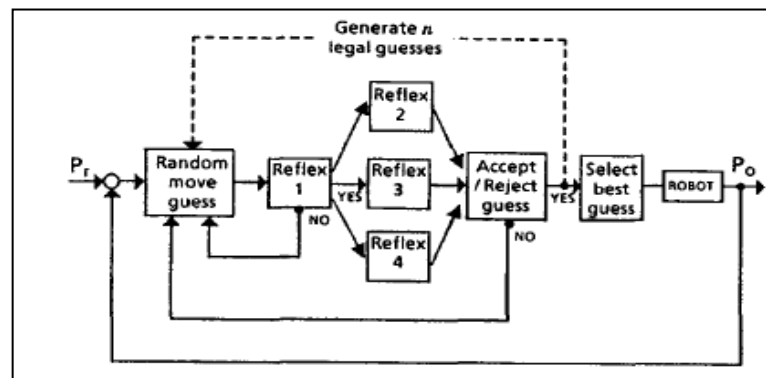


Figure 2.8 Block diagram of the Reflex controller [30]

Figure 2.9 shows the flow of finding the shortest path by using the Reflex controller [30]:

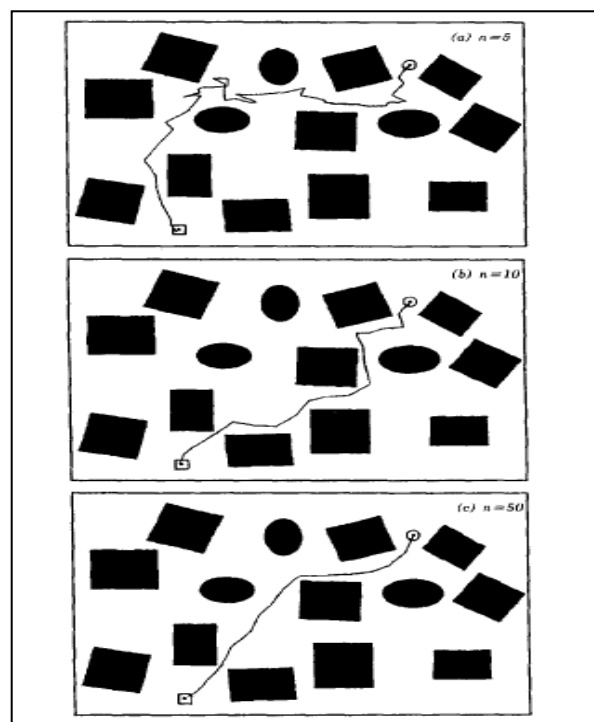


Figure 2.9 of finding the shortest path by using the Reflex controller [30]