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**Synthesizing Agent for
Wumpus World**

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**Thesis submitted in fulfillment of the requirements for
Bachelor of Science (Hons) Intelligent Systems
Faculty of Information Technology And
Quantitative Science**

October 2004

DECLARATION

I certify that this thesis and the research to which it refers are the product of my own work and that any ideas or quotation from the work of other people, published or otherwise are fully acknowledged in accordance with the standard referring practices of the discipline

OCTOBER 11, 2004

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APPROVAL

SYNTHESIZING AGENT FOR WUMPUS WORLD

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بِسْمِ اللّٰهِ الرَّحْمٰنِ الرَّحِیْمِ

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ABSTRACT

The developing of intelligent agent has become a major research for many researchers currently. However, a little had focused on developing an agent synthesis. The domain of this thesis is traditional wumpus world that is enhanced and modified to be the synthesizing agent wumpus world. Therefore, this thesis objective is 'to identify the enhancement and modification needed and to create synthesizing agent algorithm that is sound for the synthesizing agent wumpus world. Agent synthesis is an automatic programming that will automatically deliver an agent into an environment, and will do the task given successfully in that particular environment. The major enhancement and modification have been made to the rules, actuators, and sensors of the traditional wumpus world. This thesis used a few approach in developing agent synthesis such as depth-first search and synthesis scheme. This technique is used by the agent synthesis to ensure that it will be synthesize into a right square and at the right time. As a result, the agents are able to achieve its goal in a shorter time and more accurately. This thesis would give ideas for future work in producing more quality agent syntheses. In conclusion, synthesizing agent could be a great solution to overcome the problem in an environment.

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CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

This chapter will describe the domain of this thesis. It will explain about the traditional wumpus world game, its' rules, and its' goals. Since this thesis is about the synthesizing agent, this chapter will be explaining about the agent synthesis including the objective, the scopes and the significance of this thesis. All of the objectives and the scopes were created appropriate to the wumpus world environment.

1.2 DESCRIPTION OF TRADITIONAL WUMPUS WORLD

The description of the traditional wumpus world is based mainly on the description given in Russell and Norvig book (Russell and Norvig, 2003). Wumpus world is a cave represented as a grid of squares surrounded by walls and connected by passageways as shown in Figure 1.1. It consists of four objects; wumpus, pit, gold and agent. Living somewhere in the cave is the wumpus, a beast that eats anyone who enters its square. Some squares contain pit that will trap the agent if it go into these squares.

The agent's goal is to get the gold without falling into a pit or being eaten by the wumpus. The traditional wumpus world is a 4x4 grid of rooms. The agent always begins the game in the lower left-hand corner of the grid, at (0,0) square. The location of the wumpus, pits and gold are chosen randomly other than the (0,0). The agent may move only vertically and horizontally in the direction in which it faces. The agent will do the

action grab if it picks up gold from the same square, and do the action shoot to fire an arrow and shoot the wumpus it facing. The agent has only one arrow.

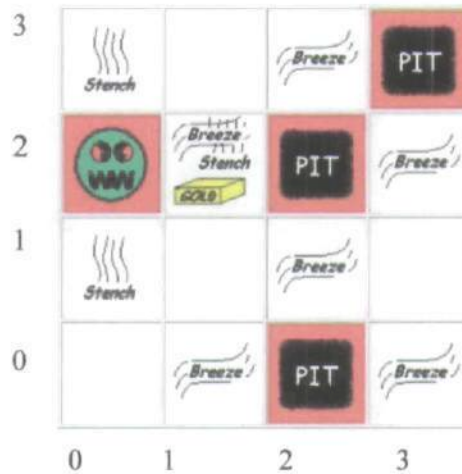


Figure 1.1 The wumpus world environment

In the traditional wumpus world, the agent has five sensors. Those sensors are stench, breeze, glitter, bump, and scream. In square adjacent to a wumpus, agent will perceive stench, and in square adjacent to pit, agent will perceive breeze, but in squares with gold, agent will perceive glitter. When the agent walks to the wall, it will perceive bump. In case of agent falls into a pit or eaten by wumpus, the agent will scream.

Specifically, below are the scopes of the environment, agent, wumpus, pits, and gold of the traditional wumpus world.

1.2.1 The Scopes of The Environment

The scopes of the environment for the traditional wumpus world are:

1. The size of the environment is 4x4 grids of squares.
2. The objects in the environment are:

- i. 1 agent
 - ii. 1 wumpus
 - iii. 3 pits
 - iv. 1 gold
3. The position of the wumpus, pits and gold are set randomly except at square (0,0) which is reserved to the agent starts square.

1.2.2 The Scopes of The Agent

The scopes of the agent in the traditional wumpus world are as stated below.

1. The agent is always starts at the beginning square (0,0).
2. The agent can move either vertically or horizontally by one-step.
3. The agent can grab the gold in the same square.
4. The agent can shoot the wumpus if the wumpus location is adjacent to it.
5. The agent has five sensors namely stench, breeze, glitter, bump, and scream.

1.2.3 The Scopes of The Wumpus

In the traditional wumpus world, the scopes for the wumpus are:

1. The wumpus cannot move anywhere.
2. The wumpus produces a smell called stench.

1.2.4 The Scopes of The Pits

The scopes for the pits in the traditional wumpus world are:

1. The pits are permanent in the squares.
2. The sign that there is a pit in a square is the breeze.

1.2.5 The Scopes of The Gold

For the gold, these are its scopes of it in the traditional wumpus world:

1. The gold cannot move anywhere.
2. The gold produces a glitter.

For the purpose of this thesis, some enhancement and modification have been made to the scopes of each objects and the environment itself. This is to ensure that the new wumpus world that has been created in this thesis is appropriate to the main objectives of this thesis. The changes of the scopes of the traditional wumpus world to the new wumpus world will be explained in Section 1.5.

1.3 SYNTHESIZING AGENT

According to Wooldridge (2002), agent synthesis is an automatic programming where the goal is to have a program that will take a task environment, and from this task environment automatically generate an agent that succeeds in this environment. Formally, agent synthesis is a function that can output an agent. This agent later is called agent synthesis. The agent synthesis can be categorized into two, those are sound and complete.

The agent synthesis is consider as sound if when there is exist an agent synthesis in the task environment, the agent is guaranteed can achieve it's goal. Therefore, only the agent that is guaranteed can be succeeds in the task environment will be synthesized into that task environment. This is to ensure that only the agent that is confident can do the task successfully will be synthesized.

In the other hand, the agent synthesis is consider as complete if it is guaranteed will exist an agent synthesis in the task environment but this agent is not guaranteed can

succeeds in the task environment. This means that, the complete agent synthesis is confirmed will be synthesis into the task environment but this does not mean that it could achieve its goal.

Between these two conditions, soundness is probably more important than completeness. Soundness and completeness will be discussed in detail in Chapter 3.

1.4 OBJECTIVES

The objectives of this thesis are as follows:

1. To identify the enhancement needed for the synthesizing agent wumpus world.
2. To identify the modification needed for the synthesizing agent wumpus world.
3. To create a synthesizing agent algorithm that is sound for the synthesizing agent wumpus world.

1.5 SCOPES

The synthesizing agent wumpus world consists of five objects. Those objects are agent, wumpus, pit, gold, and agent synthesis. The agent's goal is to get the gold and avoid from the wumpus and the pit. Besides that, the gold can move or change its position whenever an agent comes closer to it. The wumpus also will move to assist gold wherever and whenever the gold move. Wumpus acts as the guard for the gold.

Therefore, in order for both agent and gold to do these tasks, the scopes of the environment, agent, wumpus, pits, and gold have been modified. This is to ensure that an agent synthesis can be synthesized in the game logically to help the initial agent in

achieving its goal. Below are the scopes of the synthesizing agent wumpus world. The modification and enhancement of the traditional wumpus world's scopes will be highlighted (bolded) in the next sections.

1.5.1 The Scopes of The Environment

As already mentioned in Section 1.2.1, the environment of the traditional wumpus world only contains four objects. Differ from the traditional one, the synthesizing agent wumpus world add another object that is called an agent synthesis. Besides that, there is another rule has been added. The scopes of the environment for the synthesizing agent wumpus world are:

1. The environment is a 4x4 grid of squares.
2. The objects in the environment are:
 - i. 1 agent
 - ii. 1 wumpus
 - iii. 3 pits
 - iv. 1 gold
 - v. **1 agent synthesis**
3. The position of the wumpus, pits and gold are set randomly except at square (0,0) which is reserved for the agent starts square.
4. **If a square contain a wumpus or a pit, its diagonal square cannot contain either a wumpus or a pit. This is to ensure that the agent will not trapped especially at the corner the grid.**

1.5.2 Scopes of The Agent

The scopes of the agent in synthesizing agent wumpus world are not much differ from the traditional in Section 1.2.2, except the agent must co-operate with the agent synthesis in order to achieve the goal easily and quickly. The agent has the smell characteristic

that is called fragrant to give the sign to the gold that agent is closer to it. The new scopes of the agent are:

1. The agent is always starts at the beginning square (0,0).
2. The can move either vertically or horizontally by one-step.
3. The agent can grab the gold in the same square.
4. **The agent has a smell name fragrant.**
5. The agent has three sensors namely stench, breeze, and glitter.

1.5.3 The Scopes of The Wumpus

As stated in Section 1.2.3, the wumpus scopes had changed from the traditional wumpus world where:

1. The wumpus produces a smell called stench.
2. **The wumpus can move either horizontally or vertically by one-step.**
3. **The wumpus can only starts moves when the gold starts move.**
4. **The wumpus movement is around the gold only, where it guard the gold.**
5. **The wumpus has three sensors namely stench, breeze, and glitter.**

1.5.4 Scopes of The Pits

The scopes of the pits are not changed form the traditional wumpus world as mentioned in Section 1.2.4. The scopes are as follows:

1. The pits are permanent in the squares.
2. The sign that there is a pit in a square is the breeze.

1.5.5 Scopes of The Gold

In the traditional wumpus world, refers to the Section 1.2.3, the gold cannot move and have the glitter, but some modification and enhancements have been made. The modification is for the location of the gold where although its position is set randomly, but its location must be around the wumpus only. This is due to a reason where the wumpus acts as the guard for the gold. This will be explained in Chapter 3.

Besides that, some enhancements also have been made for the gold that focusing on its movements. These are the scopes of the gold in the synthesizing agent wumpus world:

1. The gold produces a glitter.
2. **The gold can move either horizontally or vertically by one-step.**
3. **The gold movement should be assisted by the wumpus.**
4. **The gold cannot move into the squares that contain the wumpus, pit or agent but can only move into an empty square.**
5. **The gold has three sensors namely stench, breeze, and fragrant.**

The modification and enhancements of the gold will be explained in detail in Chapter 3.

1.5.6 Scopes of The Agent Synthesis

This thesis is mainly focus on the synthesizing agent in the wumpus world. Thus, the scopes of the agent synthesis must be clearly stated in order to ensure that the design process goes smoothly. Actually, the scopes of the agent synthesis are not much differ from the agent but the different is the agent synthesis will automatically synthesized when the gold starts run but the initial agent starts from the beginning of the game. This will be discussed in greater detail in Chapter 3.

The scopes of the agent synthesis in the synthesizing agent wumpus world are as follows:

- 1. The agent synthesis can move either vertically or horizontally by one-step.**
- 2. The agent synthesis can grab the gold in the same square.**
- 3. The agent synthesis has a smell name fragrant.**
- 4. The agent synthesis has three sensors namely stench, breeze, and glitter.**
- 5. The agent synthesis can only be synthesized into an empty square.**

1.6 SIGNIFICANCE

The significance of this thesis is refers to the significance of agent synthesis in the synthesizing agent wumpus world. As mentioned before, the game objective is to let the agent grab the goal. For this purpose, the agent synthesis is very advantageous because it can help the initial agent by automatically synthesized in the environment to achieve the agents' goal. Therefore, the goal can be achieved much easier compared to the traditional wumpus world.

By synthesizing the agent, it will co-operate with the initial agent to encircle the gold until the gold cannot run anymore and finally the agent or the agent synthesis can grab the gold. That means, the goal can be achieved in just a short period of time. The co-operation between these intelligent agents is a positive significant where normally, the union can make a multi-agent team stronger and easier in completing their task.

Besides that, the significance of this thesis is, it is be able to create an automatic agent or a synthesis algorithm in an environment. This autonomous agent is the most importance section of mobility in the intelligent agents' aspects. It is become more importance if the synthesis algorithm that has been created is be able to produce the

agent synthesis that sound to the environment. This is because, a sound agent is guaranteed a success and will achieve its goal once it is synthesized in an environment.

1.7 SUMMARY

In this chapter, the domain, objectives, scopes and significance are described. The scopes of each objects and environment in the traditional wumpus world and synthesizing agent wumpus world are also described. The definition of the agent synthesis is completely described and discussed which the information is based on the research and knowledge acquisition processes, which will discussed in the next chapter.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

In developing this thesis, acquisition of knowledge from related topics is very important. Some technical terms need to be clarified clearly before proceeds with the thesis's design and prototyping. This chapter will discuss about what the previous researchers found relating to intelligent agent, agent synthesis, and wumpus world game. This chapter also covers about the definition of the task environment and its type, multi-agent, and agent program. The literature review framework is shown in Appendix A.

2.2 INTELLIGENT AGENT

There is no universally accepted definition of the term agent. However, some researchers viewed different definition of an intelligent agent. Wooldridge and Jennings (1995) presented that an agent is a computer system that is situated in some environment, and that is capable of autonomous action in this environment in order to meet its design objectives. They viewed this definition in a diagram as shown in Figure 2.1, where the agent takes sensory input from the environment, and produces as output that affect it. The interaction is usually an ongoing, non-terminating one.

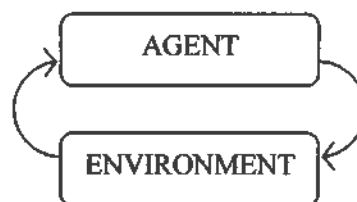


Figure 2.1 An agent in its environment by Wooldridge and Jennings (1995).

In the other hand, Russel and Norvig (2003) indicated that an agent is anything that can be viewed as perceiving its environment through sensors and acting upon that environment through actuators. This simple idea is illustrated in Figure 2.2.

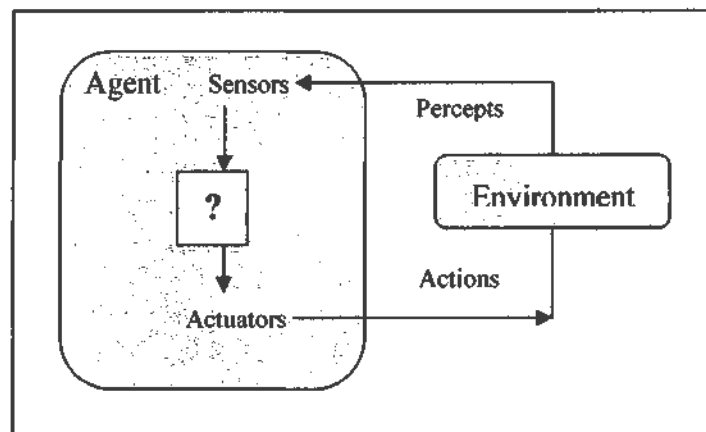


Figure 2.2 Agents interacts with environment through sensors and actuators.

Russel and Norvig's (2003) view about agent definition is quite similar with D'Inverno and Luck's (2001). D'Inverno and Luck (2001) suggested that agents are proposed as situated and embodied problem-solvers that are capable of functioning effectively and efficiently in complex environment. This means that the agent receives input from its environment through some sensory device, and acts so to affect that environment in some way through effectors.

These three definitions actually mean the same. An intelligent agent has a task in an environment and its actions in doing the task are based on the situation and the task environment. Agent is also a program that autonomously reacts to changes in its environment by taking appropriate actions. The most important feature of an intelligent agent is to perceive and to act according to the particular environment.

Wooldridge and Jennings (1995) have investigated about the issues that occur in the designing of intelligent agents such as agent theory, agent architectures and agent languages. In agent theory, they explained about what are exactly the agents, and the