# Conclusion and Further Work

## 8.1 Introduction

The previous chapter reported the process followed to evaluate the approach proposed by this thesis. This chapter reports the overall conclusion of the projects and interprets the results of evaluation followed by achievements of each objective of the project. In addition, this chapter discusses the problems encountered and further work.

## 8.2 Overall Conclusion

In this thesis, we postulate that this emergent behaviour of multi agent systems can be used to design 3D game environments with emergence properties that were not visible in initial constituents. Based on that hypothesis we have proposed an approach to develop a common framework which is common to many types of environments. The proposed system has been designed with a multi agent systems based approach and a prototype is implemented to evaluate the proposed approach.

This prototype has been evaluated by measuring the time taken to generate 3D environments, extendibility of the system, adherence to industry standards, portability and cost effectiveness. After evaluating the time taken to generate a 3D game environment using prototype with the results obtained by capturing the time taken to design 3D game environment using coding approaches and manual world editor approaches, it is clear that the approach proposed in this thesis can be used to reduce the design time drastically. It was reported that the approach proposed in theses is about 40 times faster than using the coding approach to design a 3D game environment and about 6 times faster than using a world editor to design a 3D game environment. In addition, evidences are provided in evaluation chapter to ensure the adherence to industry standards, portability and cost effectiveness. The system provides a high level customizability and extendibility through the ability to configure 3D model definitions and agent rule sets. These features effectively addresses the issues of current 3D environment generation techniques being specific to one type of environment such as city environment and the lack of customizable frameworks which are common to many types of environments. In addition, the proposed approach is capable of generating a large number of previously unseen 3D game environment designs with a given input set, which have never been imagined by a designer.

## 8.3  Achievements of Objectives

Critically studying about 3D game development process was an objective achieved by studying the video game development process followed by the industry. Selection and use of open source game engine: jMonkey Engine as the software module to render 3D game environments and using the features of jMonkey Engine in prototype such as terrains, textures, lighting and 3D model loading provides evidences for the achievement of this objective. In addition Blender: open source 3D modelling software and GIMP: open source image manipulation software have been used which are widely used by open source game developers.

The current software solutions for 3D game environment design were critically reviewed by conducting a thorough literature survey on traditional procedural techniques for 3D environment generation. From the literature review of these traditional approaches we have identified that current 3D environment generation techniques being specific to one type of environment and the lack of customizable frameworks which are common to many types of environments as the main issue to be addressed. Also the top down and centralized approaches which are used in these traditional procedural techniques prevent game developers from using simple decentralized rules which are reusable in different environments. The chapter 2 of this thesis provides a summary of finding of this literature survey.

Studying about multi agent systems technology was another objective achieved by conducting a literature survey on "Using Multi Agent Systems for Problem Solving" as stated in chapter 2 of this thesis. According to literature, we identified that in multi agent systems surprisingly complex and interesting global behaviours can arise from simple rules that are followed by number of simple agents operate in an environment. In addition, the objective to investigate the use of multi agent systems to solve design problems achieved by conducting another literature survey on "Multi Agent System based Approaches for 3D Environment Design" and the finding of this survey are also reported in chapter 2 of this thesis.

The objective to design and develop a prototype multi agent system to assist the design of 3D game environments has been achieved by designing a multi agent system as described in chapter 5 of this thesis and implementing a prototype as reported in chapter 6 of this thesis. These 2 chapters provide evidences of the achievement of this objective with design diagrams, figures and detailed descriptions.

The evaluation of the proposed approach is another objective achieved by conducting an evaluation as stated in chapter 7 of this thesis and the results of evolution have been provided in that chapter. The evaluation was carried out using the prototype implemented by measuring the time taken to generate 3D environments and considering the extendibility of the system, adherence to industry standards, portability and cost effectiveness.

## 8.4   Problems Encountered

Loading and rendering a large number of 3D models in prototype 3D game environment was a major challenge in terms of memory consumption, CPU utilization and time taken to render the 3D view. After conducting various experiments with different 3D models, this problem was solved by converting high polygon 3D models to low polygon 3D models with the help of Blender open source 3D modelling software. At the same time the Blender software was used to make the orientations and sizes of 3D models consistent and it helped to solve the problem of making the appearance of the 3D models look natural in 3D game environment.

## 8.5   Further Work

At the time of writing this thesis, it was required to provide a height map image file as an input to define a preferred 3D game environment to be generated,. These height maps are created using an external image manipulation tool. Integrating a software module to generate height maps based on user requirements has been identified as a further work.

Also at the moment the generated 3D game environments are in a format which is compatible with jMonkey Engine which is a game engine based on Java programming language. This game engine was selected based on the compatibility with Java programming language which is used to implement the prototype. However by making few modifications it is possible to extend the system to support the more powerful and scalable graphic engine named OGRE (Object Oriented Graphic Rendering Engine). OGRE is a commercial quality open source graphic engine which used by many game industry projects with C++ and .NET programming language support. Therefore extending the prototype system to support OGRE has been also identified as an important further work.

## 8.6 Summary

This chapter concludes the project by providing an overall conclusion with and interpretation of results of evaluation. The achievements of each objective of the project have been discussed after that. Finally the problems encountered have been discussed followed by the further work of the project.