Chapter 1

Introduction

1.1 Problem Identification

In nature, the growth of the plants seems to grow in randomness, and it is very interested in their growing. Time-lapse photography reveals the enormous visual appeal of developing plants, related to the extensive changes in topology and geometry during growth. Consequently, the animation of plant development represents an attractive and challenging problem for computer graphics. We hypothesize that Lindenmayer systems (L-systems) and parametric functional symbols should be efficient for plant development look more realistic.

The L-systems code has been created by John Martin Carroll in 1998. His software supports the deterministic bracketed L-systems and simple L-systems in two-dimensional space.

```
plant2{
  ;from The Algorithmic Beauty of Plants
  #iterations = 6
  dirs = 16
  axiom = ----X
  X = F[+X][-X]FX
  F = FF
}
```

In above L-systems code, The iteration is six, the angle is 16, the axiom is *X*. The letter *X* is replaced by string *F[+X][-X]FX* to the first production, then the string *FF* will replace a letter *F* where a letter *F* represents a internode. The image is created from these parameters. Six frames of plant development from first iteration (n=1) to sixth iteration (n=6) are shown in Figure 1.1.

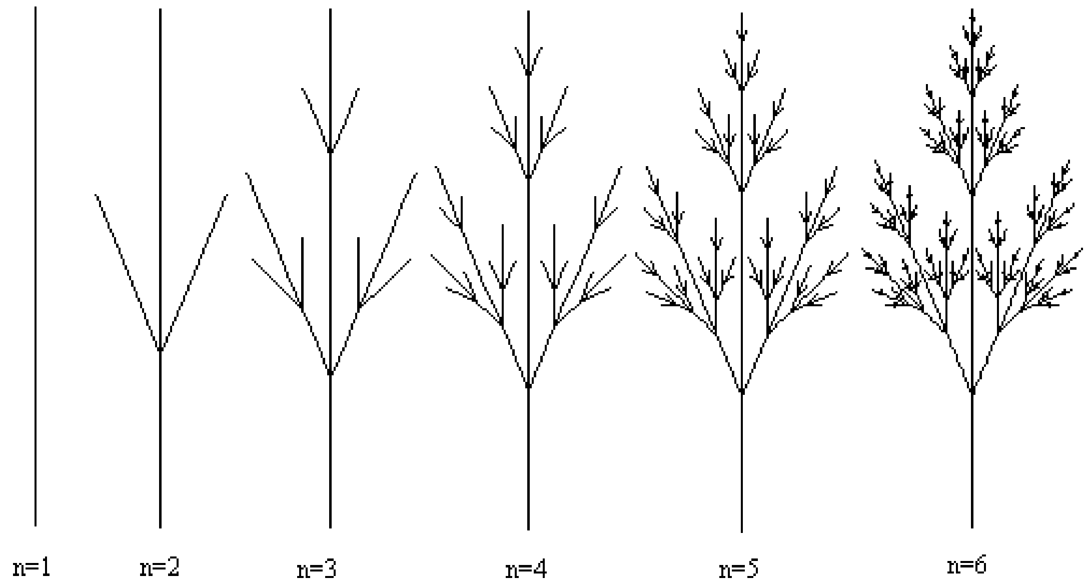

Figure 1.1: The development example of L-systems.

If we animate these six frames of plant development, the animation will not smooth and continuous, because the developments of some internodes are not shown for continuous frame. In order to solve this problem, the parametric functional symbols are applied in this thesis.

The iteration of L-systems has been used to animate the plant growth but at each time step of development the plant model was not smooth and continuous. This thesis presents a prototype to simulate and visualize the plant growth in L-systems by parametric functional symbols to the length, size and position of each component of plant, it can be seen that the plant model looks more realistic.

The parametric functional symbols are the symbols that added the parameter function to control the graphic form of plant development. It will be described in Chapter 4.

1.2 Objectives of the Research

The main objectives of this study are the following:

1. To develop an algorithm of plant development.
2. To simulate and visualize plant development by implementing in virtual reality form.

1.3 Scope of the Research

In the environment of plant development; light, carbon dioxide, water and soil are needed. The future plan of our project is to study how these factors are important and effective to plant development. This research will develop a prototype of plant development from data that are collected from some experiments which ignore all the factors of plant growing by using soybeans as case study. We measure the structural development of plants as individuals made up of components like apices length, internodes length, leaves width, leaves length, and diameter at different time steps in their life cycle. The mathematical model of soybean development will be simulated in virtual reality form. This prototype can be used to generate the realistic model of any plant based on bracketed L-systems.

This research presents a prototype for creating computer models that capture the development of plants using L-systems and mathematical model incorporating biological data. L-systems is used for qualitative model in order to represent the plant topology and development. There are six consecutive steps in this method, namely, (1) defining a qualitative model constructed from observations of plant growth in their life cycle, (2) measuring of key characteristics collected from actual plants, (3) converting raw data to growth functions based on sigmoid function approximations, (4) defining a quantitative model composed from the qualitative model and growth function, (5) visualizing of the quantitative model, and (6) evaluating model.

1.4 Details Schedule

The details schedule of this thesis are the following:

1. Search and study previous works about plant development and L-systems.
2. Collect data from soybean experiments.
3. Analyze the raw data to approximate soybean growth using growth function.
4. Study computer graphics, delphi programming, and OpenGL graphics library.
5. Write program to visualize the plant growing.

6. Experiment another plant to test the prototype and adjust the prototype for any plants.
7. Conclusion.

1.5 Expected Outcome

The usefulness of this work is to obtain an algorithm to generate and simulate the plant development which can be used to study how plant is develop.

This thesis is organized into six chapters. Chapter 2 reviews the literature. Chapter 3 is theoretical background about the classes of L-systems. The plant module and experimental design are discussed and illustrated in Chapter 4. The visualization procedure and results are shown in Chapter 5. Some final thoughts are summarized in Chapter 6.