Chapter 5

Visualization Procedures and Results

This chapter describes the visualization procedure and the result of the soybean experiment and another plants which is constructed by this prototype.

5.1 Visualization Procedure

The visualization of this thesis consists of three algorithms. There are *Draw scene*, *Draw tree*, and *Perform Node* Algorithm. The *Draw scene* algorithm is the main part. It is *While loop* for plant animating following *GlobalBigT* time variable.

Draw Scene Algorithm

The *DrawScene* algorithm variables is described as following:

GlobalBigT	: It is the global time variable of animation.
AnimShow	: It is the flag of animation condition. It is true value for showing animation.
DrawLand	: The procedure draws the floor of the plant model.
ShowXYZ_Axis	: It is the flag of XYZ axis. It is true value to show XYZ axis.
DrawXZ_Axis	: The procedure draws the XYZ axis.
DrawTree	: The procedure draws the plant corresponding to *GlobalBigT* variable.

The *DrawScene* algorithm is given below.

```
DrawScene
Begin
    1. GlobalBigT := 0;
    2. While AnimShow Do
       Begin
          2.1 GlobalBigT := GlobalBigT + 1
```

```
        2.2 DrawLand
        2.3 If showXYZ_Axis then  DrawXYZ_Axis
        2.4 DrawTree(GlobalBigT)
        2.5 If GlobalBigT > Animation Time then
                GlobalBigT := 1
    End
End.
```

Draw Tree Algorithm

The *DrawTree* algorithm is consisted of two subprocedures, there are *SetTree* for setting the properties of plant component with null value of its child, and *PerformNode* for setting the properties of each component. The argument *bigTime* is the global time time step. The argument 1 of performnode procedure is the initial internode with the first internode of plant.

```
DrawTree(bigTime)
Begin
    1. SetTree properties and set the initial the child of plant
    2. PerformNode(1,bigTime)
End.
```

Perform Node Algorithm

The *PerformNode* algorithm is a recurrence procedure. It consists of three steps. First, it computes the properties of each component such as internode, petiole, leaf, apex, flower at the current time *t*. Second, it draws the plant components with the appropriate angle following the L-system symbol string such as internode, petiole, apex, leaf, and flower. Third, the *PerformNode* is called by itself using the current component number and the time *t* to its arguments. The arguments are described below

Treenode	: The current component is initialized by root component. That is the first node.
T	: It is the current time *t*, it is varied from 1 to the global time of the system with the appropriated time step.
Child of Treenode	: It is the child number of *Treenode* component.

PerformNode(Treenode, t)
Begin
1. Compute the properties of each component at current time t
2. Draw plant components with appropriate angle
   - Internode
   - Petiole
   - Apex
   - Leaf
   - Flower
3. PerformNode(Child of Treenode, t)

End.

5.2 Visualization results

The visualization of a soybean is shown in vegetative state. Cylinders are used to represent internodes and petioles segments. Spheres are used to represent jointed internodes. Triangular polygons are used to represent leaves and flowers. Figure 5.1 shows some selected stages of the development of a soybean shoot controlled by the production rules defined in Section 4. The developments in Figure 5.1 begin at time $t = 1$ according to the sigmoidal curve in Figure 4.20.

Figure 5.2 shows various plant structures with the same topology of L-system under different parameters. The L-system code of Figure 5.2 is given below.

```
Plant1{
    Iterations=8
    Angle=15
    Diameter=0.8
    Axiom=I[-1][+1][/2][\2][^1][^^1][^\-1][^^\-1][^2][^^2]
    1=I[/iL][\iL]1
    2=I[-iL][+iL]2
    endrule
    1=IF
    2=IF
}
```

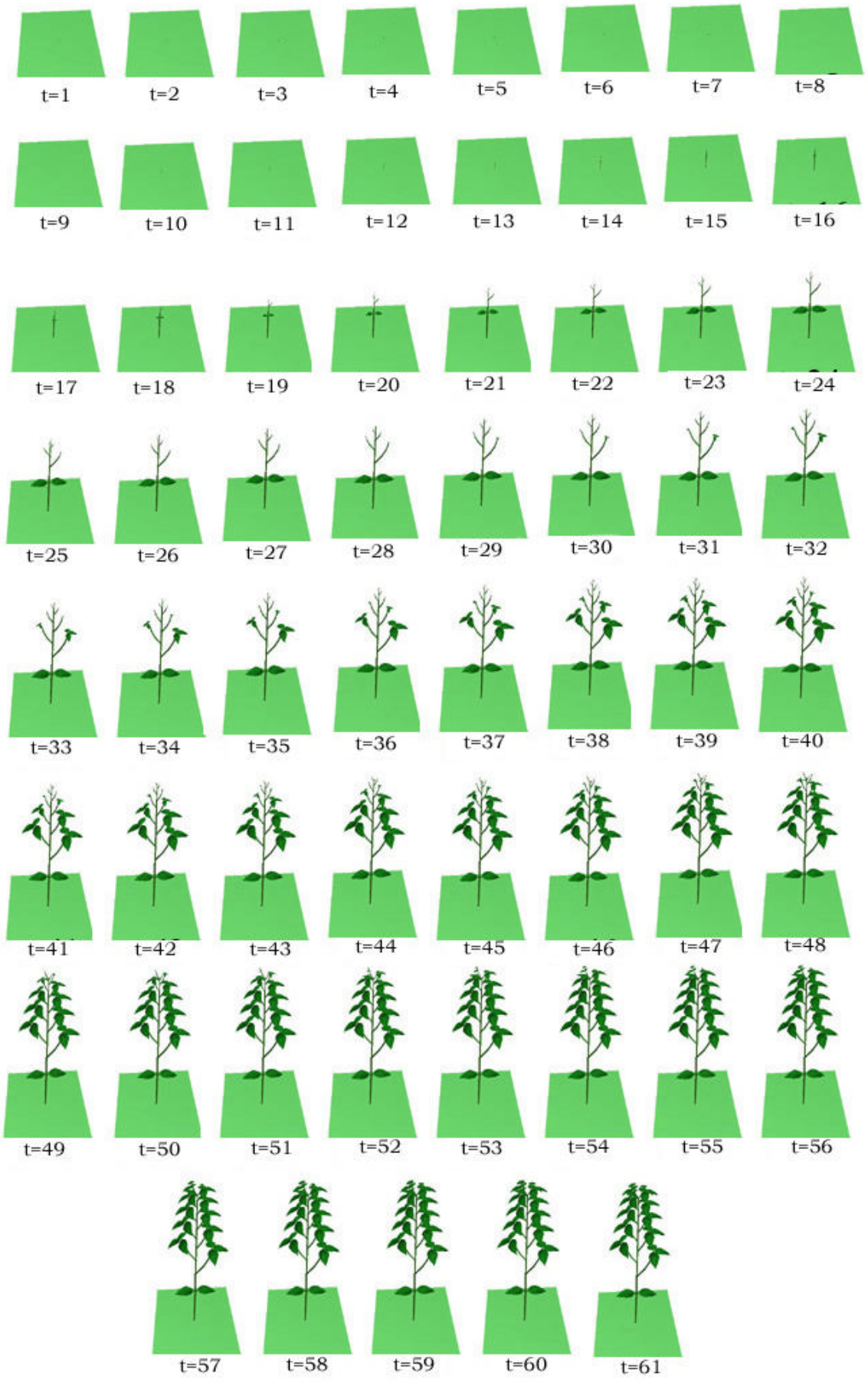

Figure 5.1: Simulation and visualization of Soybean shoots expansion over 61 days.

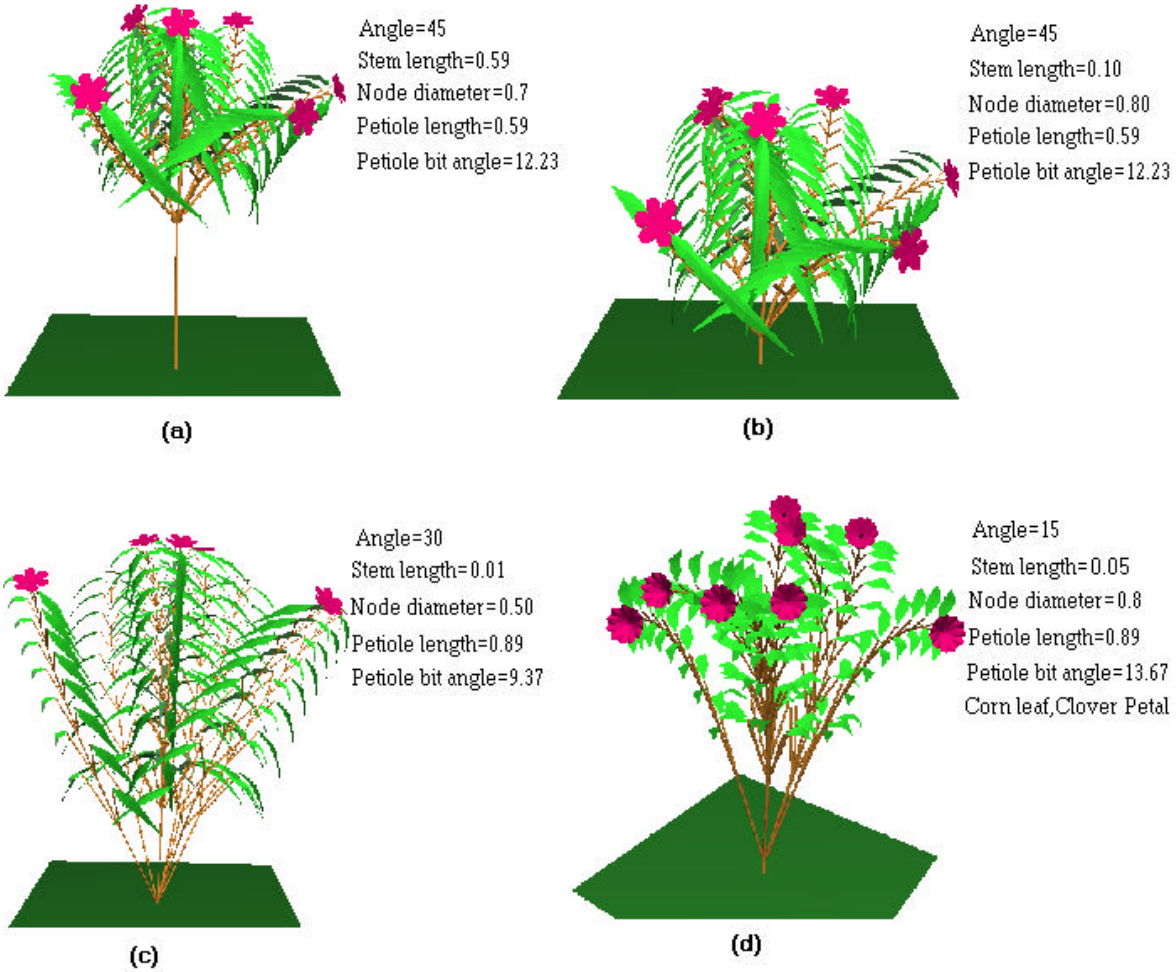

Figure 5.2: Different parameters of same topology of L-system.

All plants are generated using eight iterations. Although the same production rules are applied to the plants, it is remarkable that they look like different species. The symbol *L* and *F* are linked from our leaf and flower library which are created prior to the generation.

The PlantVR prototype can be used to generate any plant topology based on the Bracketed L-systems. The other plants example is given below. The spiral plant prototype is

```
SpiralPlant{
    Iterations=1
    Angle=45
    Diameter=2
    Axiom=IA
    A=I[^IP]I[^^IP]I[^^^IP]I[^^^^IP]I[^^^^^IP]I[^^^^^^IP]I[^^^^^^^IP]I
        [^^^^^^^^IP]IIAII[IIIIF]
    P=I[/IL]
}
```

The average data over 61 days are

Data
{

0	0.08993105
1	0.11488685
2	0.146561154
3	0.186634437
4	0.237129366
5	0.300433251
6	0.3792909
7	0.476747324
8	0.59601461
9	0.74023599
10	0.912127619
11	1.113500694
12	1.344707107
13	1.604106504
14	1.887703344
15	2.189117496
16	2.5
17	2.810882504
18	3.112296656
19	3.395893496
20	3.655292893
21	3.886499306
22	4.087872381
23	4.25976401
24	4.40398539
25	4.523252676
26	4.6207091
27	4.699566749
28	4.762870634
29	4.813365563
30	4.853438846
31	4.88511315
32	4.91006895
33	4.929681865
34	4.945065287
35	4.957112573
36	4.966535745
37	4.973899372
38	4.979649311
39	4.984136586
40	4.987636884
41	4.990366327
42	4.992494089
43	4.994152449
44	4.995444744
45	4.996451648
46	4.997236107

47 4.997847215
48 4.998323249
49 4.998694048
50 4.998982865
51 4.999207819
52 4.999383027
53 4.999519488
54 4.999625769
55 4.999708544
56 4.999773011
57 4.999823219
58 4.999862322
59 4.999892775
60 4.999916493
61 4.999934964
}

The growth function parameters are given below.

Bottom=0.0899, Top=4.9999, Slope=0.25, Tmid=16
For all component

The component parameters are given below.

Component
{
Leaf Library=Leaf,Bamboo, size=24
LeafScale x=0.60, y=0.8, 0.9
LeafAngle x=61, y=0, z=0
Flower Library=Petal, Canterbury bells, size=24, No.Petals=20,
LeafScale x=0.60, y=0.8, 0.9
LeafAngle x=61, y=0, z=0
}

The parameters are given below.

Parameter
{
Stem length=0.35
Node Diameter=2.0
Node Birth Rate=4.9
Petiole length=0.12
Petiole BitAngle=2.16
Internode Reduce=0.9
Petiole Reduce=0.9
Leaf Reduce=0.95
Flower Reduce=0.95
Short Internode Ratio=0.1
Short Internode Diameter=0.8
Short Petiole Ratio=0.1
Short Petiole Diameter=0.8
}

The visualized image of above prototype, data, and parameter are shown in Figure 5.3. The Figure 5.4 shows the spiral plant with new leaf and flower shape. The growth data are approximated by the same data for every component.

Figure 5.3: The spiral plant.

Figure 5.4: The spiral plant with the new different leaves and flowers.

The simple tree prototype is given below.

```
SimpleTree{
    Iterations=2
    Angle=25
    Diameter=2
    Axiom=I[-1][+1][/1][\1]
   1=I[-1][+1][/1][\1][&/IL][&///IL]iiF
   endrule
   1=I[-IL][+IL]IiF
}
```

The visualized image of a simple tree example is shown in Figure 5.5.

Figure 5.5: The simple tree.

The example plant is applied from Soybean prototype with one iteration. The L-system code is given below. The visualized image is shown in Figure 5.6.

```
AppliedSoybean{
    Iterations=1
    Angle=45
    Diameter=2
    Axiom=I[-P]I[+B]A
    A=I[/P]IL[\B]AF
    P=III[\IL][/IL][-IL]IF
    B=II[\IL][/IL][+IL]IF
    Endrule
    F=I[-IF][+IF][/IF][\IF]IF
    F=I[-IF][+IF][/IF][\IF]IF
    B=IL
}
```

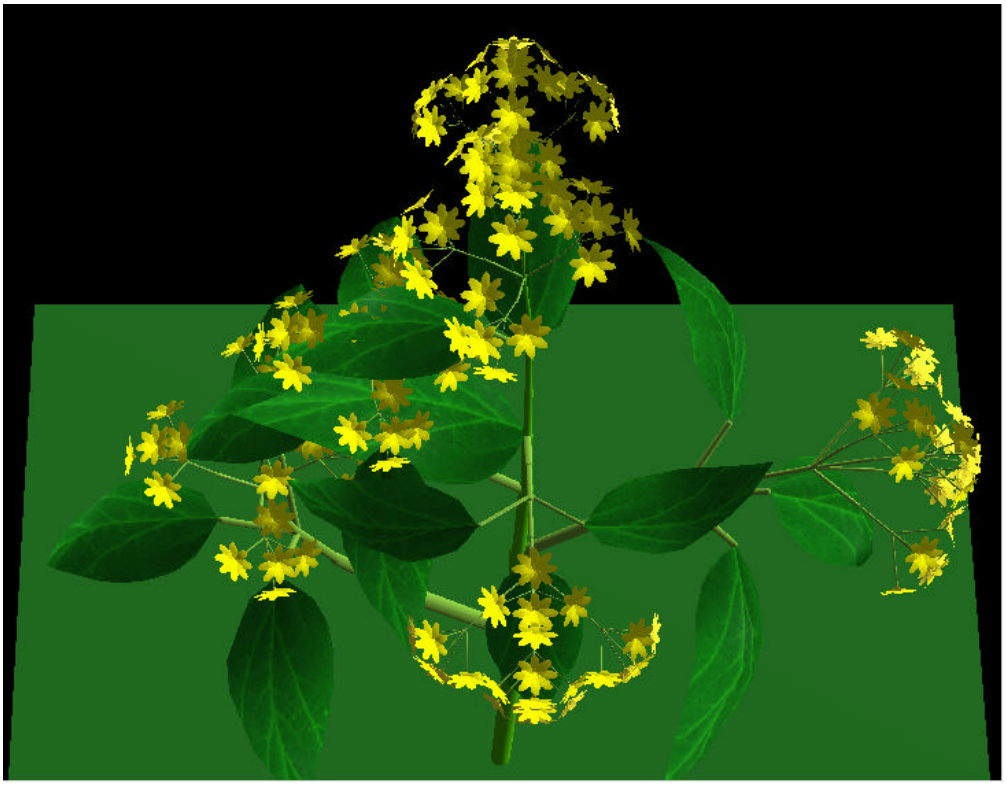

Figure 5.6: The applied soybean plant.