# **Appendix C**

This appendix presents how to use the *PlantVR* software. The *PlantVR* software is called the following icon.



#### Figure C-1: The main program icon.

The main program is shown as the following window. There are eight pages. First, the L-system page is used to create the physiology of plant. Second, the growth function page is used to set the growth function of each component, such as internode I, petiole P, apex A, leaf L, and flower F. Third, the component page is used to define the leaf and flower shape of plant. Fourth, the parameter page is used to adjust many parameters of plant shape and growing. Fifth, the animation page is used to set the



Figure C-2: The main program.

animated appearance and export the animation format to "GIF animation", and the frame of development. Sixth, the material page is used to set the color of each component. Seventh, the text editor is used to store the L-system code. Finally, the help page is user manual.

The description of Figure C-2 has six parts. The first, it is the main menu of the software. The second, it is the L-system editor, the L-system code will be entered in this editor. The third, the L-system result will be shown after compiling the code, the plant prototype. The number of iteration, the angle, the diameter, the production rules, and the endprodution rules are interpreted and writing in the third block. The fourth, the compiled result of L-system is shown in this block. If there are any errors of L-system code, the error message will be shown in this block. The process will be stopped. The fifth, the L-system string will be shown in this block after press the button "Generate Plant" at the main menu. The sixth, the visualization will be shown as three-dimensional plant in this window.

The L-system code is entered in L-system editor page in Figure C-3. It is compiled for the L-system symbol string. The *Soybean* prototype in Chapter 4 will be used for an example model. The L-system is given below.

```
Soybean{

Iterations=6

Angle=45

Diameter=1.5

Axiom=I[-iL][+iL]A

A=I[-P]I[+B]A

P=IIII[\pL][/pL][-pL]

B=IIII[\pL][/pL][+pL]

ENDRULE

B=IL

P=IL

A=IL

}
```

The *Soybean* prototype has six iteration, 45 degrees for the petiole angle, 1.5 centimeters for diameter of first internode, three production rules, and three endproduction rules.

# 1. The L-system page

L-System Gazeth Function Component P. Editor Show Complet-system Sensors Part	e Editor   Help		
L System Editor		Provi Vincolleverters im 1961	LON
Boybean( Iterations =6 Angle=45 Diameter=15 Asiom=1[-t,1[+it,]A Asi(=7)[+6]A P=111[(+6]A P=111[+6]A P=111[+6]A ENDRULE B=11 P=11 A=11 A=11 A=11	Cartech     Evension Paral     Argie Para     Logatere Para      Logatere Compiles		
Tice Result Input L-s	ystem		

Figure C-3: The L-system input.

The generated plant is constructed by the following step:

- 1. Input L-system code in the L-system code editor and set the appropriated iteration, angle, and diameter
- 2. Select the "Compile L-system" button to compile the code and check the syntax
- 3. Select the "Generate Plant" button to interpret the L-system string to the plant physiology

hoots Growth		_ 🗆 ×
ent   Parameter   Animation   Material   Tes ate Plant	xt Editor   Help	Exit
	Plant Visualization at 150	LOX
Controls Iteration 6 * Angle 45 * Diameter 1.5 * L-systems Soybean *		
Header Pass. Iterations Pass. Angle Pass. Diameter Pass.		
Lipping Log Manual Log	g	
	Interview     Animation     Material     Termination       abe Plant     Iteration     6     2       Angle     45     2       Diameter     1.5     2       L-systems     Soybean     2       Meader Pass.     1     2       Diameter Pass.     2       Diameter Pass.     2       Mone Pass.     2	Interview       Animation       Material       Text Editor       Help         abe Plant       Iteration       6       10       10       10

# Figure C-4: The result after generating plant.

The final of three steps for creating plant model in L-system page is shown in Figure C-4. If there are any error in each step, the user will edit the L-system code and recompile and regenerate the plant.

# 2. The growth function page

The growth function page consists of the growth function of the internode, the petiole, the leaf length, the leaf width, the apex, and the flower for the symbol I, i, P, p, L, A, F, respectively. The growth function page is shown in Figure C-5. The growth function of each component is selected as follow the symbol of L-system



Figure C-5: The growth function page.

string in L-system page.

The step of growth function is described the following steps:

- Select the function of symbol such as select the internode radio button for symbol *I* and *i*, the petiole button for symbol *P* and *p*, the leaf length for symbol *L*, the leaf width for symbol *L*, the apex for symbol *A*, the flower for symbol *F*, and all the button for every component.
- 2. Select the "Read data" button to open the data file, the data will be shown in the callout number three.
- 3. Select the "Fit Curve" button at callout number four to approximate the growth function of each component.
- 4. The four parameters of data will be shown at the callout number five. There are bottom, top, slope, and tmid value. Their meanings were described in Chapter 4.

5. The growth function of each component will be drawn in the callout number six

The internode component will be selected and open the data as Figure C-6. The data file of internode are shown in Figure C-7.



Figure C-6: Open the data file.

Select C Ini	Function lemode	C Led	Length	C Apex	C AI	Image Scaling
àch.	al Data	s lea	width	s move		
1	2.55	0.00	1.00	0.01 - 10.0	latin de	E-matrix (L.)
2	5.08	0.23	0.00	10.01	Intervide	Punction (1, i)
3	6.55	1.20	0.00	0.01		
4	7.32	1.97	0.00	0.00		
5	7.57	2.63	0.00	0.01		
6	7.35	4.70	0.00	0.01		
2	7.20	5.35	0.00	0.00		
8	7.20	5.60	0.90	0.00		1
9	7.20	5.85	1.40	0.25		13
10	7.20	5.85	1.75	0.41		12
11	7.10	5.85	2.15	0.61		
12	7.10	5.95	2.25	0.86	Patrola Fun	dan IP ol
13	7.00	5.90	2.45	1.30	1 00000 1 000	seen the 2 bit
14	7.00	5.90	2.45	1.60		100
15	7.00	5.75	2.25	2.10		
16	7.00	5.80	2.65	2.45		8
17	7.00	5.80	2.65	2.61		8
18	7.00	5.85	2.85	2.76		18
19	7.00	5.75	2.90	2.60		
20	7.00	5.75	2.50	2.55		
21	7.00	5.75	2.50	2.65		
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Figure C-7: Internode data.

The curve of internode growth function is shown in Figure C-8. The red line is the average of raw data, the blue line is the approximated growth function. The bottom, the top, the slope, and the tmid are 0.1275, 4.039, 0.65, 7.0, respectively.

Growth Function				
Select Function Internode Petiole	C Leaf Length C Leaf Width	C Apex C Flower	C AI	Image Scaling
Actual Data           1         2.55           2         5.08           3         6.55           4         7.32           5         7.57           6         7.35           7         7.20           8         7.20           9         7.20           10         7.20           11         7.10           12         7.10           13         7.00           14         7.00           15         7.00           16         7.00           17         7.00           18         7.00           19         7.00           20         7.00           21         7.00           22         6.43           Notion         Top           0.1275	0.00 0.00 0.23 0.00 1.20 0.00 1.97 0.00 2.63 0.00 4.70 0.00 5.35 0.00 5.85 1.75 5.85 2.15 5.85 2.25 5.80 2.45 5.80 2.45 5.80 2.45 5.75 2.25 5.80 2.65 5.75 2.50 5.75 2.50	0.00 ▲ 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.0	Petiole Funct	unction (I, i)
Growth Function pa	age			

**Figure C-8: Internode growth function.** 

The petiole data will be selected like the internode, that is, select the petiole radio button, and select the "Read data" button. The data file of petiole will be shown like Figure C-9. Then click the "Open" button to open the petiole data file.

Open				2 ×
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Files of type:	-			Cancel

Figure C-9: Open the petiole data file.

Select C In Pr	: Function terriode sticle	C Leal	Length	C Apex C Flower	C All	image Scaling
Aph	alData					
1	0.00	0.00	0.00	0.00.	Internede	Function II.0
2	0.00	0.00	0.00	0.00		CONCERNING .
3	0.00	0.00	0.00	0.00		
4	0.00	0.00	0.00	0.00	2200	
5	0.00	0.00	0.00	0.00	1	
6	0.00	0.00	0.00	0.00		
7	D. DØ	D. DO	D. DO	0.00		
8	0.63	0.00	D. DO	0.00		
3	123	0.00	D. DO	0.00	1	
10	177	D. DO	D. DO	0.0		
11	2.07	0.53	0,00	0.00	STORAGE AND	0004005/00
5	2.00	0.73	0.00	0.00	Petiole Fun	dian(P, p)
13	4.17	2.00	0.27	0.00	100000	depatcher
14	4.93	2.90	160	0.00		
15	5.33	4.10	0.93	0.00		
16	5.63	5.03	160	0.00		
W	5.60	5.93	2.40	0.32	18000	
18	5.97	6.33	3.30	0.60		
20	6.07	6.B7	5.00	1.85		
21	6.20	7.23	5,90	2.6.		
22	6.20	641	6.67	3.6.	L¥	
28	6.23	7.63	7.37	50.5		
41	_			<u> </u>		
Bollow	i To	P	Slope	Triid		
0	- 66	737	0.38	A A	Dend Data	Counteres
~	200		1.1.1.		ricau Diala - r	in correct povermoge

Figure C-10: Petiole growth function.

Then, click the "Fit Curve" button to approximate and draw the curve of petiole growth function in Figure C-10.

To open the leaf length data, click the "Read data" and select the leaf length data file and click "Open" button like Figure C-11, then click the "Fit curve" button to show the curve of growth function as Figure C-12.

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Figure C-11: Open the length of leaf data.

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( Inte	ernode	• Lear	Length	Apex	( All	
C Pet	iole	C Leaf	Width	C Flower		
Actu	al Data					
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7	0.00	0.00	0.00	0.00		
8	2.53	2.43	0.00	0.00		
9	3.40	3.23	0.00	0.00		
10	3.30	3.87	0.00	0.00		
11	4.27	4.23	0.00	0.00		
12	4.27	4.37	0.00	0.00		
13	4.27	4.43	0.83	1.07		
14	4.33	4.40	1.03	1.30		
15	4.47	4.43	1.37	1.93		
16	4.50	4.50	1.77	2.53		- 10-
17	4.53	4.53	2.33	3.13	Leaf Length F	unction (L)
18	4.53	4.53	2.73	3.63	Lear Lenguri	anction (E)
19	4.53	4.57	3.10	3.97		
20	4.53	4.57	3.37	4.13		
21	4.53	4.57	3.48	4.20		
22	4.53	4.57	3.48	4.20		
23	4.37	4.47	3.53	4.23		
24	4.37	4.47	3.53	4.23		
25	4.37	4.47	3.53	4.23		
26	4.37	4.47	3.53	4.23		12
27	4.37	4.47	3.53	4.23		
•						
Bottom	Тор	)	Slope	Tmid		
0	- 5.2	613	0.54 -	11 -	Read Data Fit	Curve Save Imag

Figure C-12: The leaf length growth function.

In a similar way, click the "Read data" button to open the leaf width data and click "Open" button as Figure C-13, and click the "Fit Curve" button to fit the growth curve of leaf width as Figure C-14.

Open			? ×
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•			F
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Figure C-13: Open the width of leaf data.

Select C In	Function	C Lea	Length	C Apres	C AL	Image Scaling
CR	diolo	@ Lea	Width	C Flower		1 🜲
Act	ualData					0. 1
1	0.00	0.00	0.00	0.00	LeafWi	dth Function (L)
7	0.00	0.00	0.08	0.00	1775.03	the second states and a second states and second states and second states and second states and second states a
8	1.43	1.10	0.00	0.00		18
9	2.37	2.27	0.00	0.00		18
10	2.10	2.53	0.00	0.00		18
11	2.63	2.77	0.00	0.00		18
12	2.93	2.87	0.00	0.00		
13	2.93	2.87	0.27	0.32		
14	2.97	2.87	0.30	0.52		1
15	2.97	2.97	0.83	1.1733		- N
16	3.00	3.00	1.13	1.67		k2!
17	3.03	2.97	1.53	2.02		
18	3.03	2.97	1.87	2.4788	Apex Fui	nction (À)
19	3.03	Z.97	Z.17	Z.67		31
20	3.03	3.03	2.33	2.77	8	-
21	3.03	3.03	2.43	2.50		
22	3.03	3.03	2.43	2.50		-
23	3.03	3.03	2.43	2.5000		1
24	3.03	3.03	2.47	2.90		1
25	3.03	3.03	2.47	2.90		
26	3.03	3.03	2.47	2.90		1
27	3.03	3.03	2.42	2.99		
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Batton	To To	p	Slope	Errid		
0	- Fr	· ener	0.45	11	Berry Date	The second second
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Figure C-14: The leaf width growth function.

The apex represents with the symbol *A*, therefore, we must select and set the growth function for apex growth function. Click the "Read data" button to open the data file, we assume that the apex growth curve as same as the internode function. Then click the internode file and fit curve, the result of apex growth function is shown in Figure C-15.

C Internode C Peticle	C Leaf Leng	h (C Apes r (C Flower	C AI	Image Scaing
Actual Diata				
1 2.05 2 5.08 3 8.95 5 7.57 6 7.20 8 7.20 8 7.20 8 7.20 9 7.20 9 7.20 10 7.00 10	0.00 00 0.23 00 1.29 02 2.63 02 4.70 05 5.60 0.5 5.65 1.7 5.65 2.1 5.65 2.4 5.80 2.4 5	0 0.01 0 0.01 5 0.01 3 0.01 0 0.01 0 0.01 0 0.01 0 0.01 0 0.01 5 0.21 5 2.01 5 2.01	LearWidth	Function (L)

Figure C-15: The apex growth function.

All of growth function, internode, petiole, leaf length, leaf width, and apex are summarized in Figure C-16.



Figure C-16: The growth function of internode, petiole, leaf length , leaf width, and apex function.

## **3.** The component page

The component page is used to define the shape of leaf and flower. To define the leaf and the flower component, the order of definition is shown in Figure C-17. First, Click "Open 3D Surface" to open the leaf and the flower library as Figure C-18. Second, click the radio button "Leaf Surface" to define the leaf surface. Third, select the leaf type at the combox box like Figure C-19 and the leaf shape will be shown in the callout number three like Figure C-20. If the letter F is appeared in the L-system string, we should define the flower shape. Fourth, click the radio button "Flower Surface" and select the flower type, the flower shape will display at the callout number five.

😹 Simulation and Visualization of Plant Sl	noots Growth	
L-System Growth Function Componen	nt Parameter Animation Material Text	Editor Help
Component Leaf Shape 2	Image: constraint of the state of the st	Plont Visualization at 1
Component page		

Figure C-17: The component page.

Open			? ×
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🗀 Bmp	🚞 PlantCap2	🖳 19-7-2000	省 brick
🗋 Flower1	🚞 PlantCap3	🔍 25-7-2000	🐹 clover
🚞 LeafDesigner	🚞 PlantFlow	🗐 25-7-2000	🗒 Data1
🗋 NewFlower1	🚞 PlantInterNode1	🛤 3DLeaf.sur	🗒 Data2
🚞 Paper_Cap2	🚞 TestInterNode	🗒 30 Seaf.sur	🗒 Data3
•			Þ
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Figure C-18: Open the leaf and flower library.



Figure C-19: Select the soybean leaf.

Leal Shape	Open 3D Surface New Surface
	C Leal Surface C Flower Surface Select Lear Type
Flower Shape	Lest Sizes 15 D Lest Scale X-Asis X-Asis Z-Asis
	Lest Angle X.Ass Y.Ass Z.Ass Z.Ass

Figure C-20: The part shape of soybean leaf.

#### 4. The parameter page

This page is used to set the plant shape and the plant growth parameter. The parameters are described as following.

- 1. The initial value of petiole angle is used to set the initial angle of branch and main stem.
- 2. Stem length is used to control the length of main stem.
- 3. Node diameter is used to set the diameter of internode and petiole.
- 4. Node Birth Rate is used to set the initial time of each component.
- 5. Petiole length is used to control the length of petiole.
- 6. Petiole bit angle is used to control the angle between the petiole and main stem.
- 7. Internode reduce is used to control the internode diameter.
- 8. Petiole reduce is used to control the petiole diameter.
- 9. Leaf reduce is used to control the leaf size.
- 10. Flower reduce is used to control the flower size.
- 11. Short internode ratio is used to control the length ratio between the short internode and the internode.

Simulation and Visualizati	on of Plant Shoots Growth n Component Parameter Animation Ma	sterial Text Editor Help
Parameter ]		Plant Visualization at 1
Initial value of Petiole Angle Stem length Node Diamter Node Bith Rate Petiole Length Petiole BitAngle Internode Reduce Petiole Reduce Leaf Reduce Flower Reduce Short Internode Diameter Short Internode Diameter Short Petiole Ratio Short Tetiole Diameter Short Petiole Diameter Short Petiole Diameter		
Wind Leaf Arrangement		
Parameter page		

Figure C-21: The parameter page.

12. Short internode diameter is used to control the diameter ratio between the short internode and the internode.

- 13. Short petiole ratio is used to control the length ratio between the short petiole and the petiole.
- 14. Short petiole diameter is used to control the diameter ratio between the short petiole and the petile.
- 15. Time stem is used to set the increasing time step.
- 16. Wind is used to set the bit randomness angle of leaf.
- 17. Leaf arrangement is used to set the arrangement of leaf angle.

All parameter is shown in the parameter page as Figure C-21.

## 5. The animation page

The animation page is used to control the animation of plant such as the rotation, translation, zoom, velocity of animation, scaling, capture image. The animation page is shown in Figure C-22.

L-System	and Visualization of Plant Shoots Growth Growth Function   Component   Parameter   Animation   Material   Text Edi ihow	tor Help
Animation Animation Translation		Plant Visualization at 1
Velocity Anir Scale	mation me Bar = 1 Play Pause Play Pause Play Pouse Start Frame 1 2 Capture Now	
Animation page	Animation Delay(x10 mS) 3 😨 for  5 😨 Bits Stop Capture Jpeg Compression (%) 80 🛫 (100% for Hight Quality) Capture Progress 0%	

Figure C-22: The animation page.

Simulation	and Visualization	of Plant Shor	ite Growth				5		
L-System	<b>Growth Function</b>	Component	Parameter	Animation	Material	Text Editor	Help	1	 
Animation	shQa								TIX

Figure C-23: The menu of animation page.

To show the plant model, click "Animation Show" button as Figure C-23. The plant model is displayed in the plant Visualization windows as Figure C-24.



Figure C-24: The first result of plant model.

To reduce the plant main stem, click the stem length to reduce the value at the trackbar as Figure C-25. The plant model is displayed in real-time showing.



Figure C-25: Set the length of main stem.

To rotate the plant model, click the animation page, and click the second trackbar of rotation to rotate about Y-axis. The plant model is shown in Figure C-26.

Compensation and Viewell and Personal Personality     Logistics Growth Function Compensation     Animatics Show	tion   Meterial   Test Editor   Help
Animation	
Potation Y = 94.7         Internation         Internation         Zoors         Velocity Antration         Scale         Animation Time Bar = 390         Cachine Image © Jpeg Fermat         Stat Frame         Animation Delay(k10 mS)         3 © Image Delay (k10 mS)         Jpeg Compression (%)         Data Frame         Displayers         Displayer         Displa	Ray Pause Capitare New Stop Copitue usity
Animetion page	

Figure C-26: Adjust the rotation on Y-axis.

To reduce the petiole length, click petiole length. The plant model is displayed as Figure C-27.

			Plant Visualization at 120
nitial value of Petole Angle Stemlength Node Dianter Node Dianter Node Bink Rate Petole Langth Petole Biolwagte Petole Reduce Leat Raduce Rower Raduce Short Internot Ratio Short Internot Biologister Short Petiole Rate Short Petiole Rate Short Petiole Dianeter Time Step		ţ	
	see provide a construction		

# Figure C-27: Adjust the appropriated parameter.

Simulation and Visualization of Plant Shoots Growth	
L-System Growth Function Component Parameter Animation Material Text	Editor Help
Animation	Plant Visualization at 390
Rotation ×= 62.7	
Translation	
Velocity Animation	
Animation Time Bar = 390	
Capture Image C Jpeg Format C Gif Format (256 Colors)	
Start Frame 1 🗲 Capture Now	
Animation Delay(x10 mS) 3 🗲 for 6 🗲 Bits Stop Capture	
Jpeg Compression (%) 80 🚖 (100% for Hight Quality)	
Capture Progress 0%	
Animation page	

Figure C-28: The top view of plant.

To show the top view of the plant model, click the animation page and click the rotation trackbar. The result will be shown as Figure C-28.

## 6. The material page

The material page is used to set the color of each component such as the internode, the petiole, front leaf, back leaf, front petal of the flower, back petal of the flower, the background, and the land. Especially, the used can design the leaf texture in order to map the leaf. The material page is shown in Figure C-29.



Figure C-29: The material page.

To set the leaf texture, click the check box "Set Leaf Texture" as Figure C-30. The material page will show the texture information. For example, select the leaf texture number two as Figure C-31. The result of texture mapping displays in Figure C-32.

C Front Lost C Back Lost C Lond	C Front Flower	
C BackLow C Land	C Baok Flower	
C Land	-	

Figure C-30: Select the texture of leaf.

Simulation and Visualization of Plant Shoots Growth L-System Growth Function Component Parameter Animation Material Text	Editor   Help
Material  Material  Material  Material  Color Setting  Color Green   Blue  Front Leaf  Front Leaf  Front Flower  Front Flower  Front Flower  Front Cand  Setted Texture  Setted Texture  Setted Texture  Leaf Texture	Plant Visualization at 300
Material page	

Figure C-31: Select the leaf texture 2.

Simulation and Visualization of Plant Shoots Grow	th	
L-System Growth Function Component Parame	ter Animation Material Text	Editor Help
Material Material Material Color setting Color Red Green Blue Green Blue Front Leaf Blue Green G		Plant Visualization at 390
Material page		

Figure C-32: The result of texture 2.

To open the soybean texture, click the texture image. Select the soybean texture as Figure C-33.

Open					? ×
Look jn: 🔁	29-8-2000	- 🖻 💆		(128x128)	
Y leaf5 Y leaf6 Y leaf7 Y leaf8 Y leaf9 Y leaftex1 Y longleaf	<ul> <li>Ymengleaf</li> <li>Ymouse</li> <li>YPicture</li> <li>YPicture</li> <li>YPiantVR</li> <li>Ymubber1</li> <li>Ymubber2</li> <li>Ymubber3</li> </ul>	Sovbean1			
File <u>n</u> ame:	soybean1		<u>O</u> pen		
Files of type:	Bitmap files (*.bmp)	•	Cancel		

Figure C-33: Open soybean texture.

Click "Open" button. The result displays in the Figure C-34.



Figure C-34: The result after selecting the soybean texture.

To change the internode color, click the radio button "Internode" and adjust the preferred color. The plant shows the internode color immediately as Figure C-35.

Material		Plant Visualization at 390
Material Color setting         Red         Color         Green         Blue         C         Internode         C         Petiole         C         BackGround	▶         80         ♥           ▶         150         ♥           ▶         50         ♥           ℃         Front Flower         ●           ℃         Back Flower         ●	
Set Leaf Texture	k,	
Material page		

Figure C-35: Set the internode to green color.

The petiole color will show in Figure C-36.

C Front Flower

Back Flower

C Internode

C BackGround

🔽 Set Leaf Texture

Leaf Texture 2

· Petiole

Material page

C Front Leaf

Back Lea

Land

-

Click the radio button "Petiole" and adjust the color of petiole like internode.



To adjust the perspective view as Figure C-37, click the animation page, and adjust the rotation trackbar.

rination	Plant Vienalla and at 200
Potation Y = 83.3 Trender torus and annuments of the second seco	

Figure C-37: Adjust the new perspective view.

To show the plant development at any time step, click the trackbar "Animation Time Bar". For example, adjust the animation time bar at 19, the plant development is shown in Figure C-38.

Animation	Flant Visualization of 13	
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Transision		
Zrom		
Volucity Animation Free control of the control of t		
Animation Time Bar = 19		
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Animator Delay(ri0 nS) 3 2 for 5 8 865 Stop Capture		
Capture Plogless 0%		
Animation page		

Figure C-38: The animation of plant growth at time 19.

animation					Plant Youring	dion of full	
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Turulation			2				
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Velocity Anias Scole	witten w Bar +53 Fr. Joeg Format (	Gil Formet (295 Colo		Perm		Y	T
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Veboly Aria Veboly Aria Scole	x Bar + 53	Gil Formel (255 Colo ∰ End Formel 1 Si 3 ∰ ror 6 10 ∰ 11003	ni Copiu ni Copiu ni Stopi ni Bito Stopi	Pause en Now Capture			T

At the time 53, the plant development is displayed as Figure C-39.

Figure C-39: The animation of plant growth at time 53.

At the time 75, the plant growth is shown in Figure C-40.

Animation	Stant Vinesteeline et /2
Rotation Y - 4	
	1×-
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Velocity Annation Scale	
Avenue for Time Bar = 70 Play Pauce	
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Start Flame 1 🚍 End Flame 1 🚍 Capture Now	
Animation Delag(x10m5) 3 🚊 for 6 🚔 Bits Stop Capture	
Jpag Compression (%) 👘 🏦 (100% for Hight Quality)	
Capture Program DN	
Azimaton Tros = 70	

Figure C-40: The animation of plant growth at time 75.

At the time 172, the result will be shown in Figure C-41.

Arimation	Plant Viruslinetion of 122
Rotelon Y = 4	教
Capture Image 17 Inter Except (1950 Calco)	
State Frame     1     End Frame     1     Capture Nov       Animation Data((x10mS)     3     tor     5     Bits     Stop Capture       Jpeg Compression (2)     60     (1005) tor Hight Quality)       Capture Progress     0%	
Anim elion page	

Figure C-41: The animation of plant growth at time 172.

To export the animation output frame and the animation output file like GIF animation, adjust the appropriated parameter such as the animation delay (set the value to one for fastest) and the quality of the animation file (set the value to eight for high quality of GIF animation). Set the capture image type JPEG format or GIF format and the JPEG compression quality (set to 100 for high quality).

، Capture Image	<ul> <li>Jpeg Format</li> <li>Gif Format (256 Colors)</li> </ul>	
	Start Frame     1     € End Frame     13     €       Animation Delay(x10 mS)     3     € for     日     Bits       Jpeg Compression (%)     80     € (100% for Hight)	Capture Now Stop Capture
	Capture Progress 0%	

Figure C-42: The capture setting.

Animation	Plant Visualization at 137
Rotation	
Translatio	Input Folder Name
Zoom	Prompt A
Velocity A	
Scale Animation	me Bar = 63
Capture In	🤗 🕫 Jpeg Formet 🕜 Gil Format (256 Colors)
	Start Frame 1 👮 End Frame 🔂 👤 Capture Nox
	Animetian Deleg(x10 m5) 3 🛣 for 9 🛣 Bits Stop Cepture
	Jpeg Compression (%)     80
Animation pa	

Figure C-43: Input the target folder of animation frames.

The animation is capturing using the plant visualization window. Don't open the other window that makes this window unclear. The user can set any parameter to include the changing to the output file such as rotation the plant model.

A snap short at sixty-nine percent is shown in Figure C-44. If you want to stop the animation, click the "Stop Capture" button.

Simulation and Visualization of Plant Shoets Growth  L-System Growth Function Component Parameter Animation Material Text Animation Show	Editor   Help
Animation	Plant Visualization at 43
Rotation Y = 4	
Zoom	it
Velocity Animation	
Animation Time Bar = 63	
Capture Image C Jpeg Format C Git Format (256 Colors) Start Frame 1 D End Frame 53 D Capture Now	
Animation Delay(x10 mS) 3 🛫 for 8 🕱 Bits Stop Capture Jpeg Compression (%) 80 😴 (100% for Hight Quality)	
Animation page	

# Figure C-44: Capturing at sixty-nine percent.

After the process has finished, the program shows the message "Capture Completed" as FigureC-45.

Translation   Zoom   Velocity Animation   Scale   Animation Time Bar   = 63   Animation Time Bar   = 63   Animation Time Bar   = 63   Animation Delay(x10 mS)   3   for   8   Bits   Start Frame   1   End Frame   3   for   8   Bits   Start Frame   1   End Frame   1   Start Frame   1   End Frame   1   Start Frame   1   Start Frame   1   End Frame   1   Start Frame   1   Start Frame   1   End Frame   1   Start Frame   1   Start Frame   1   End Frame   1   Start Frame   1   1   1   1   1   1   1   1   1    1    1   1   1   1   1   1   1   1   1   1   1 </th <th></th> <th></th> <th></th> <th><u>♦</u> _ →</th> <th>+</th> <th></th> <th>4</th> <th>ition Y =</th>				<u>♦</u> _ →	+		4	ition Y =
Zoom Capture Complet Velocity Animation Capture Image Capt	×	vr	Plants		-E1		<u></u>	slation
Velocity Animation Velocity Animation Scale Animation Time Bar = 63 Capture Image (* Jpeg Format (* Gif Format (256 Colors) Start Frame 1 * End Frame 63 * Capture I Animation Delay(x10 mS) 3 * for 8 * Bits Stop Cap Jpeg Compression (%) 80 * (100% for Hight Quality) Capture Decrement (* 100% for Hight Quality)	oleted.	ture Comple	Capt	<b>F</b>				n ,
Animation Time Bar = 63 Capture Image S Jpeg Format C Gif Format (256 Colors) Start Frame 1 End Frame 63 Capture 1 Animation Delay(x10 mS) 3 for 8 Bits Stop Cap Jpeg Compression (%) 80 for Hight Quality) Capture Image Compression (%) 80 for Hight Quality)		OK				· · · · ·	i	e it in the second s
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Animation Delay(x10 mS) 3 for 8 Bits Stop Cap Jpeg Compression (%) 80 (100% for Hight Quality)	e Now	Capture	] [	63 🚖	End Frame	1 🔹	Start Frame	株
Jpeg Compression (%) 80 🔮 (100% for Hight Quality)	apture	Stop Ca	Bits	for 8 🚖	3	elay(x10 mS)	Animation Del	15
100%		uality)	Light Qu	(100% for	80 🚖	ssion (%)	Jpeg Compres	
				100%		ress	Capture Progre	

Figure C-45: Capture complete.

In the folder, the system creates the new folder name "Soybean Capture" and shows the list of animation frames picture1.jpg to picture63.jpg for each development time as Figure C-46.

🔁 SoybeanCapture				- 🗆 ×
∫ <u>F</u> ile <u>E</u> dit <u>V</u> iew <u>G</u> o F <u>a</u> vorites	<u>H</u> elp			200
Back Forward Up	Cut Copy	Paste Undo	Delete Properties Views	
Address 🗀 G:\MyThesis_VR\29-8-20	100\SoybeanCapture			-
SoybeanCapture	Picture 12 Picture 12 Picture 16 Picture 23 Picture 23 Picture 23 Picture 23 Picture 30 Picture 34 Picture 34 Picture 41 Picture 45 Picture 45 Picture 45 Picture 52 Picture 56 Picture 66 Picture 66 Picture 63 Picture 63 Picture 63 Picture 63 Picture 64	Picture1     Picture1     Picture1     Picture20     Picture24     Picture28     Picture31     Picture33     Picture33     Picture42     Picture53     Picture53     Picture57     Picture60     Picture7     Picture7     Picture7	Image: Picture 10     Image: Picture 11       Image: Picture 12     Image: Picture 13       Image: Picture 13     Image: Picture 12       Image: Picture 13     Image: Picture 25       Image: Picture 25     Image: Picture 26       Image: Picture 25     Image: Picture 26       Image: Picture 25     Image: Picture 26       Image: Picture 25     Image: Picture 33       Image: Picture 26     Image: Picture 33       Image: Picture 36     Image: Picture 37       Image: Picture 36     Image: Picture 44       Image: Picture 43     Image: Picture 44       Image: Picture 50     Image: Picture 51       Image: Picture 50     Image: Picture 55       Image: Picture 51     Image: Picture 52       Image: Picture 54     Image: Picture 54       Image: Picture 54     Image: Picture 54       Image: Picture 54	
66 object(s)	1.80MB		🖳 My Computer	

Figure C-46: The list of animation frames and the animation file.

The file picture.bmp is the last frame at the time 63. The plant.gif file is the animation file is available show on the web browser, and the temporary file planttmp.gif for the backup of the animation file in the case of captured failure. The Figure C-47 shows the plant model after completed capturing.



Figure C-47: The plant model after capturing complete.

#### 7. Create a new plant

To create a new plant model, select the text editor page to copy the L-system code as Figure C-48, and paste to the L-system editor in the L-system page as Figure C-49. In the other way, type the new L-system code in the L-system editor.



Figure C-48: Copy a new plant prototype to create the new plant.



Figure C-49: Select all and paste to the soybean prototype.

Recompile and regenerate the plant, the old plant will active follow the diameter of new L-system code as Figure C-50.

Sinulation and Visualization of Plan L-System Grawth Function Compo Editor Show Comple L-system Gen	Shoots Growth nent   Parameter   Animation   Hatesial cole Plant	a] Test Editor   Help   Exit
L-System Editor		💽 Florit Visualization di 😒 📰 🔲
Plant( Iterations=1 Angle=45 Diameter=2 Axiom=1[-P]1[+B]A P=111(\1][/11][+1]F B=11[(\1][/11][+1]F A=1[-P]11[+B]AF Endrate F=1[-1F][+1F][/1F][\1F]IF B=11	Controls  Iteration  Angle  4  4  4  4  4  4  4  4  4  4  4  4  4	蒸
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an a	Gethelvetvetendendetvetvete Helvetvetvetendetvetvetendetvet Gethelvetvetendetvetvetvetendetvet Gethelvetvetendetvetvetvetendetvetvet	
L-system Editor		

Figure C-50: Compile and generate the plant prototype.

The new plant model will be shown as Figure C-51 after the "Animation Show" is activated.

i mabon	Plant Visualization at 150
Retation         Translation         Translation         Zoom         Velocity Animation         State         Animation Time Bar         State         Animation Time Bar         State Frame         Image Compression (2)         State Frame         Animation Delay(x10 m6)         State Frame         State Frame	19.55 IN A0

Figure C-51: The result after generating a new plant.

In the L-system string, there are the symbol "F" for flower component, the user must select the flower of plant such as select the petal of violet 2 as Figure C-52, but the flower are not shown.

Simulation and Visualization of Plan	a (densis lianed) Anna an Anna Anna Anna Anna Anna Anna A	
L-System   Growth Function Comp	onent   Parameter   Arnmation   Material   Lex	Exit
Component		Hani Visualization at 11th
Leef Shape Flower Shape	Open 3D Surface     New Surface       C Lead Surface     Plower Surface       Select Rows Type     Image: Surface       Image: Surface     Plower Surface       Select Rows Type     Image: Surface       Image: Surface     Plower Surface       Plower Surface     Plower Surface       VAsia     Plower Surfac	
Component page		

**Figure C-52: Select the flower from the library.** 

To check the flower growth function, read data and fit the curve of flower, the flowers are shown in Figure C-53.

rowth Function	1				Plant Vestalization of 200
Select Function C Internode C Petiole Actual Data	C Leal Length C Leal Width	С Арен Ф Flower	C AI	Image Scaling	
1 255 2 508 3 655 4 7.32 5 7.55 7 2.20 9 7.20 9 7.20 9 7.20 10 7.20 10 7.20 10 7.20 11 7.10 12 7.10 13 7.00 14 7.00 15 7.00 16 7.00 17 7.00 18 7.00 19 7.00 19 7.00 19 7.00 10 7.	0.00 0.00 0.23 0.00 1.20 0.00 1.27 0.00 5.61 0.00 5.61 0.50 5.65 1.75 5.65 2.75 5.65 2.75 5.65 2.75 5.65 2.75 5.60 2.65 5.60 2.65		Flower Funct	arr Fj	

Figure C-53: Set the flower growth function using internode data.



To reduce the flower size, adjust the flower size as Figure C-54.

Figure C-54: Adjust the size of flower.

To set the appropriated plant, adjust the parameter such as the petiole length, the node diameter. The result will be shown as Figure C-55.

Parameter	Plant Visuelization at 200
Initial value of Petiole Angle Stem length Node Daniter Node Birth Rate Patiola Langth Petiole BitAngle Internode Reduce Patiola Reduce Flower Reduce Flower Reduce Short Internode Diameter Short Internode Diameter Short Patole Ratio Short Petiole Diameter Time Step	
Wind Leaf Anangement	

Figure C-55: Adjust the appropriated parameter.

To zoom in or translate the plant model to the appropriated perspective view, set the appropriated parameter in the animation page as Figure C-56.

Arination	Plant Virtualization at 200
Arination Rotation Z = -12 Transistion Z = -12.7 Transistion Z =	Plen Vinisézston et 200
Avanation Time Bat + 200	
Capture Image G Upeg Format C Gil Format (255 Colors)	
Start Frame 1 🚔 End France 1 🚔 Capture Now	
Animetion Delay(x10 m5) 🤉 🏚 for 6 🚔 Bitz Stop Cepture	
Jpeg Compression (%) 🔹 (100% for Hight Quality)	
Capture Progress 0%	
Anmalion page	

#### Figure C-56: Adjust the appropriated perspective view.

To change the leaf shape, select the component page and select the leaf type as Figure C-57 such as "leaf long serrated".



Figure C-57: Change the leaf shape of plant.

Component Open 3D Surface New Surface Leal Shape C Leaf Surface C Flower Surface Select Leaf Type -Leaf, long senated -Leaf Size 17 Leal Scale X-Aois Y-Aois Flower Shape Z-Axis in markening Lest Angle X-Axis Y-Axis Z-Axis in adamanan paramahan paramahan Leef Size in X Axis = 1.39999997615814

The new shape of leaf is shown in Figure C-58.

### Figure C-58: The result after selecting the new shape of leaf.

To edit the new texture of leaf, click the texture image in the material page, and select the texture file as Figure C-59.

L-System	and Visualiz Growth Fund	ation of Plant Shoots G stion Component Para	owth ameter Animation	Material   Text E	ditor Help		Exit
Material				1	Plant Visualization	at 200	
Material Colo Color C Interno C Petiole C BackG	Open Look m	29-8-2000 Mangles M	「 E  Ø Y nubber3 Y soybean1		(64x128)	2×	
F Set Lea	File game: Files of type:	longleaf Bitmap files (*.bmp)		Qpen Cancel		/I.	
0pen Leaf Tex	ture Image		1				

Figure C-59: Change the new texture.

Material	Plant Visualization at 200
Material Color setting Color Green	
Material page	

The leaf shape is shown in Figure C-60 with the new leaf shape and its texture.

#### Figure C-60: The new texture result after.

To change the flower color, click the back or front of the flower radio button and adjust the preferred color as Figure C-61.



Figure C-61: Change the flower color.

To show the full screen of the plant model, click the maximize button of the visualization window or double click on the plant model. The result is shown as Figure C-62.



Figure C-62: The full screen of plant model.

To zoom in the flower, adjust the parameter on the animation page. The result will be shown as Figure C-63.



Figure C-63: Zoom in the flower.

To change the petal shape of the flower, select the flower surface such as "petal, clover". The result is shown as Figure C-64.

Component		Plort Visualization at 200	JOX
Leef Shops	Open 3D Surface     New Surface       Image: Surface     Image: Surface       Select Flower Type     Image: Surface       Flower Scel     Petal convert       Patal convert     Petal convert       Patal convert     Petal convert       Patal convert     Petal convert       Patal convert     Petal convert       Petal convert     Petal convert       Petal convert     Petal convert       Petal convert     Petal convert       Petal violet     Petal violet       Petal violet     Petal violet       Number of Petals     Image: Surface		
Component page			

Figure C-64: Change the flower shape.

Haterial Material Color setting 1 225 Red 4 \$ Green 4 -12 90 . . \$ Bke Front Flowe Internode Front Loal Periol BackGround P Set Leaf Textue Leaf Tedule 12 × Material pag

To set the flower color, select the material page and adjust the preferred color as Figure C-65.

Figure C-65: Change the flower color and perspective view.

In the similar way, to change the new petal shape of the flower, select the component page, and select the petal type as Figure C-66.



Figure C-66: Change the flower shape.

To change the number of flower petal, add the number of petal and the result will be shown as Figure C-67.



Figure C-67: Add the number of petals.

To change another petal shape, it will become the new plant in the same topology as Figure C-68, and Figure C-69.



Figure C-68: Change the flower shaper and the number of petals.



Figure C-69: Change the and six petals.

To show the new flower and the leaf color, Figure C-70 shows the new plant model.



Figure C-70: Change the flower and the leaf color.

To exit the software, click the "Exit" button on the main menu as Figure C-71.

Simulation and Florenzation of Flam Shots aromat							Lind 2		
L-System	Growth Function	Component	Parameter	Animation	Material	Text Editor	Help		1
[	and the second se							E	at 1

Figure C-71: Exit the program.