A Practical Plant Modeling

Using Xfrog

The web site to this book, found at "www.computerpflanzen.de" contains useful information, links to a collection of programs, and data and video sequences. Most of the content is related to our modeling system "Xfrog" which also can be downloaded there in a demo version usable with full functionality for 30 days. In the following, a practical introduction to modeling is given, which should help the reader create plants and other objects by him-/herself.

A.1 The Xfrog Modeling Environment

The basis of the program was designed in 1998 by the authors. During the years following, in cooperation with different coworkers and with generous support from the Intel Corporation and the ZKM Center for Media Arts and Technology, Karlsruhe, the program was further developed.

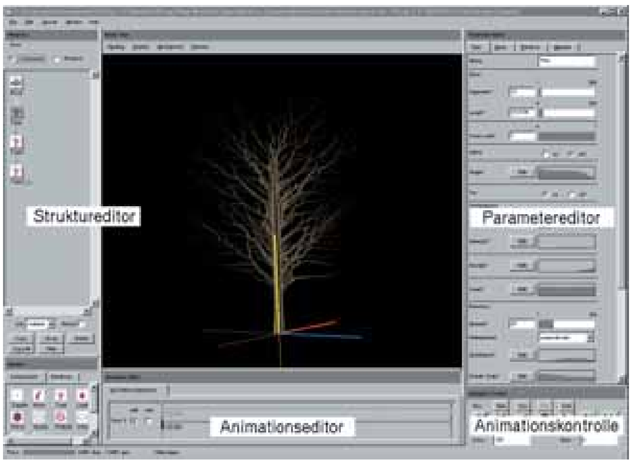
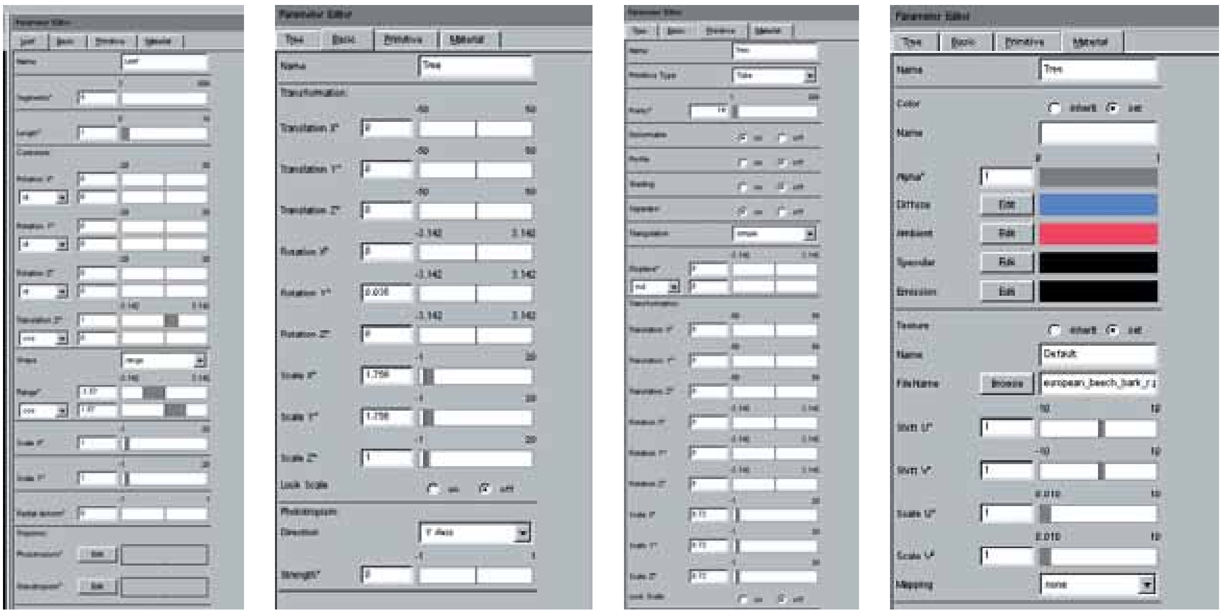


Figure A.1
Xfrog modeling environment, consisting of different dialogs

The program is an integrated modeling environment consisting of several dialogs (see Fig. A.1). In the structure editor the user constructs the structural description of the plant. The individual parts of the plant are generated with the components that were already introduced in Chap. 6. These components are activated in the field at the lower left through double clicking or by dragging them into the structure editor.

Connecting a component with the camera results in the creation of a geometry (if the component produces any), which is indicated in the large middle dialog window. In this dialog window, the 3D geometry can then be moved with the mouse, turned and scaled. The right, the left, and both mouse buttons are used, respectively, for these operations.

If a component is double clicked with the mouse button, the corresponding parameter editor appears on the right side of the dialog window. With this editor the individual parameters of the component can be changed. As already described, a basic parameter set exists for all components, as well as a number of individual parameters.



(a) (b) (c) (d)

Figure A.2
Editor for parameters: (a) parameters of the leaf component; (b) base parameter set, common to all components; (c) primitive parameters; (d) material parameters, also common to all components

Figure A.2 shows an example of a parameter editor. If the outer left marker of the four markers on the upper side is selected, the individual parameters of the component, here a leaf component in part (a), appears. In the second part, the base parameter as well as the scaling or rotation can be influenced. The third marker (part (c)) includes the primitive parameter, which appears when the component generates a geometric primitive. This is not activated for all components; however, if necessary, it can always be set by the user. In this context, also the material parameters (part (d)) are of importance, since they determine the appearance of the primitives, if the material parameters are not inherited by the components above in the structure.

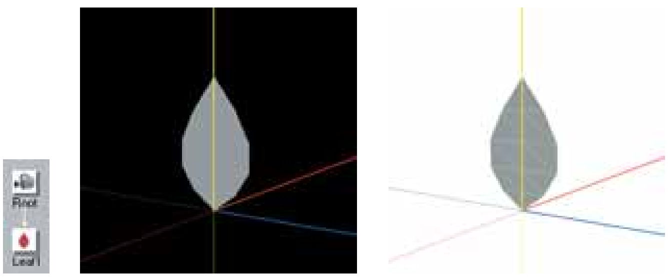
The last two dialogues of the program are used for animation. As already mentioned at the end of Chap. 6, in Xfrog a parameter-based keyframing is used. Here, at several time steps, the model is given an individual appearance by the user through modification of the parameters, which are then interpolated for the intermediate times by the system. In the animation editor, these keyframes can be created, while the playback of the animation is controlled using the animation control function.

A.2 Modeling a Flower

Although the rendering of trees requires a relatively small number of components, experience with the system is necessary. Thus, we suggest to first model a small flower. The final result was used for the interactive rendering of plants and can be seen in Fig. A.3. The description given here refers to the Xfrog Version 3.5, for the Version 4.0, which is integrated in Cinema4D, slightly different components are used.

Figure A.3
Final desired result for the plant modeling

After starting the program, a leaf component from the area at the lower left in the modeling environment is selected by double clicking. After it appears in the structure editor, it will be connected with the camera. The description for the structure and the view of the geometry are seen in Fig. A.4.

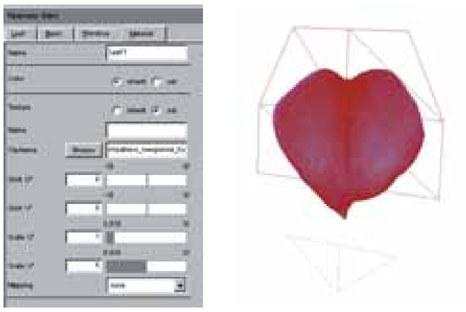


(a) (b) (c)

Figure A.4
(a) Initial structure; (b) geometry with black and (c) white background

For the following screenshots of the system, the background color (above the geometry dialog window) was set to white, and a wireframe rendition was chosen (menu “Shading”) for the triangle edges. The world coordinate system was also removed (menu “Display”). This then correlates with the appearance of the example that is shown further down.

The leaf should be textured in order to give it a realistic look. For doing so, the leaf component is clicked, and in the displayed parameter editor the subitem “Material” is selected. The texture menu appears. Now the provided texture with the name “impatiens_newguinea_hybris_petal.png” is selected. See the dialog and the strange-looking geometry in Fig. A.5.



(a) (b)

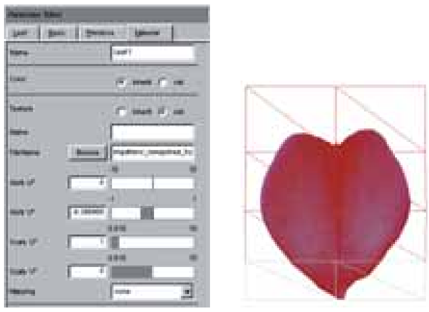
Figure A.5
(a) Material editor of the leaf component; (b) geometry, distorted by initial leaf component parametrization

The shape evolves from the initial shape of the leaf; the system was preset to display a leaf shape without texture. Thus, in the parameter editor under “Leaf” the parameter “Shape” is set from “Range” to “Spline”, and “Edit” is selected. In the appearing editor, all points except for the uppermost one, are dragged onto the edge, so that an square-like shape is created (see Fig. A.6).

(a) (b)

Figure A.6
(a) Form editor of the leaf component; (b) after setting

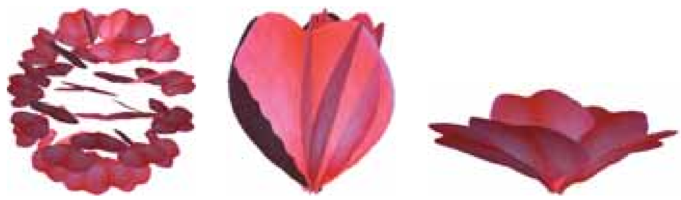
Now the texture only has to be moved on the lower side of the leaf geometry. For this, you have to return to the material editor. The move takes place through the changing of the U- and V-coordinates, which describe the positioning of the texture at the corner points of the leaf geometry. At the sub item “shift V”, you can set the possible minimal and maximal values of the control to -1 and 1 before changing the value in order to increase the accuracy of the control. Here you simply click on these values and enter the new value. Of course, you can also directly enter the value, as shown in Fig. A.7a; simply click on the number field. To stretch the texture, increase the “Scale V” to a value of eight.



(a) (b)

Figure A.7
(a) Material editor of the leaf component; (b) geometry after adjusting the texture

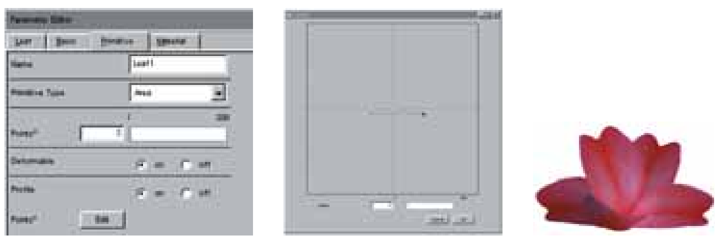
For modeling the flower, the leaf is to be multiplied through a phiball component. The component is selected and linked to the camera, then the leaf component is linked to the phiball. As a default, 50 leaves are created, which, according to the Golden Section, are arranged on a sphere. By changing the number to five, reducing the radius to zero, and changing the spherical section ("Fan") to the values of 0 and 0.3, we already get closer to completion of the flower. The leaves are now intersecting each other and must be arranged in a correct way. Here we click on the leaf component, and under the section "Leaf", the initial value of the "Rotation X" is set to two (see Fig. A.8c).



(a) (b) (c)

Figure A.8
(a) Standard arrangement of leaves; (b) refined arrangement; (c) introduced curvature applied to the leaves

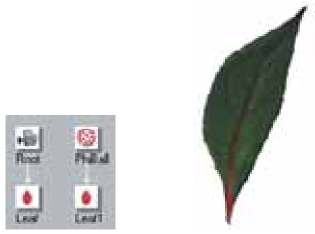
The operation causes a bending of the leaf along the main axis. The curvature perpendicular to the main axis is set at another place, since it relates directly to the rendered geometry primitives (in this case the triangulated point list). For doing so, in the "Primitive" editor, the entry "Profile" is set to "On", and in the respective editor the shape is set according to Fig. A.9.



(a) (b) (c)

Figure A.9
(a) Editor for primitive parameter; (b) editor to set profiles; (c) resulting flower geometry

In the next step we will create the normal leaves. To do this, the part of the plant defined so far is dragged away from the camera component, and a new leaf component is defined. Onto this, analogous to the above, the texture "impatiens_newguinea_hybris_leaf.png" is applied, and appropriately scaled. The components and the leaf geometry are shown in Fig. A.10.



(a) (b)

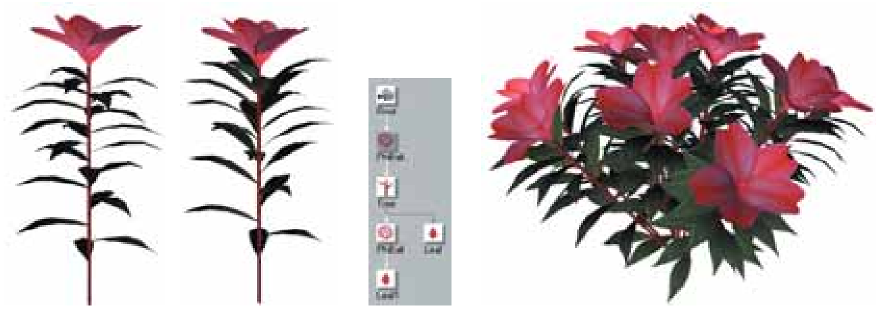
Figure A.10
(a) Components after defining the leaf; (b) leaf geometry

The leaf geometry is linked to a tree component, which in turn is linked to the camera component. At first look, the result is not very promising (Fig. A.11), since there are still some parameters to be changed. If the leaves should be smaller than in the image, the scaling on the primitive parameters of the leaf component can be changed. But let us return to the tree component. The diameter can be decreased using the "Shape" parameter. Now we apply the texture with the somewhat long name "impatiens_newguinea_hybris_bark.png" onto the tree geometry, and in the menu "Tree" the number of leaves is increased to 24 (see Fig. A.11c).

(a) (b) (c) (d) (e)

Figure A.11
Modeling of the branching, part I

In the next step the flower must be attached to the tree component. For this, the partial description of the blossom, which was laid aside, must be dragged onto the tree component. The link type for the connection between the tree and the phiball component now has to be set from "multiple" to "simple", i.e., the link itself has to be clicked and must be adjusted by the link type editor below the window. Finally, the scaling of the phiball component (in "Basic Parameters") is used to set the size of the flower. If the diameter of the tree component is changed accordingly, we have created a nice-looking branch. The still bothering jags in Fig. A.11e, shown below the flower, are removed using the leaf component in the part "Primitive" by adjusting the "Separator On". This prevents the triangulation of both geometries by the system.



(a) (b) (c) (d)

Figure A.12
(a) and (b) Modeling of the branching, part II; (c) combination of several branches to entire plant

Now the branching characteristic of the tree component must be changed, so that there will be more leaves at the top than at the lower part. The “Distribution” parameter in the tree component (“Tree”) is responsible for this. It will be changed so that, when moving to the upper part, the values increase (Fig. A.12a). There also the angles of the leaves are adjusted using the “Angle” parameter.

In the next step, these branches are to be connected to the plant. In addition, a phiball component is selected, and before it is linked to the camera the number of multiplications is set to 10. Additionally, the opening angle is reduced, as we did with the flower. Now the remainder of the structure can be linked to this component, and all components are linked to the camera. In Fig. A.12d we see the result, which, however, still has to be refined a little.

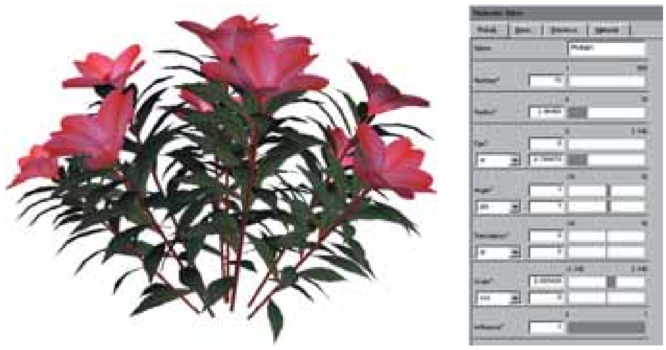


Figure A.13
Refinement setting for the Phiball parameter

For doing so, the radius of the ball is increased in the phiball component the branches are attached to. Also, using the “Scale”-parameter an individual size can be given to each branch. These sizes have to be adjusted in such a way that the outside branches are somewhat smaller than those on the inside. In Fig. A.13 an exemplary adjustment of the parameters and the result can be seen.

For the last step we return to the tree component. The branches should bend somewhat upward, toward the light. Such curvatures are implemented using tropisms. To do so, adjust the phototropism value of the tree component at the right end, this will bend the upper parts of the branches toward the light. You should receive a result as shown in Fig. A.14. If you want to achieve a still result more similarly to that in the first figure, then increase the number of branches and vary the "Scale"-parameter in the phiball component.

Figure A.14
Final result

In order to produce a high-quality image from the geometry, you must transfer the data to a rendering system. This can be done either by selecting a format in the menu "Export", and thereby storing the data, or by using one of the Xfrog plugins, to transfer the data into a rendering system such as 3D StudioMax or Cinema 4D directly. Different plugins are available on the Greenworks website (www.greenworks.de). Beyond that, diverse plants have already been premodeled, so that you can assemble more complex scenes. Doing so, we almost touch the borders of interactive computer graphics, if the LOD models already mentioned are not used. To implement a complex scene in the Xfrog modeling system, and to also adopt it to a rendering system will unfortunately only be possible in the future, at least for larger numbers of plants.

A.3 Modeling a Tree

In the second modeling example, a small tree is to be created. The basis for this example is a tutorial by Andreas Kathky which can be found also on the Greenworks website. The tree consists of four tree components that are linked together, and therefore has three branching levels. Here the structured creation of the geometry is especially important, since the parameter settings on the different branching levels might interfere, and thus the situation can easily become too complex when parameters on different levels have to be changed simultaneously.

In the first step, a simple component is attached to the camera. It serves to scale and move the geometry that has to be rendered later on. In the default setting it will not generate its own geometry. The name of the component can be changed in the parameter editor, for example, name it "Scale". In the next step, a tree component has to be attached to this component, this you name "Trunk". The geometry created so far is at first only a stem (Fig. A.15b). If the second tree component is attached to the first one, a default branching structure such as that in Fig. A.15d, is created. However, this only occurs if the connection between the two tree components is a “multiple” link. As already mentioned, this can be set in the line under the structure editor, when the link is clicked. Name the second tree component “Branch1”.

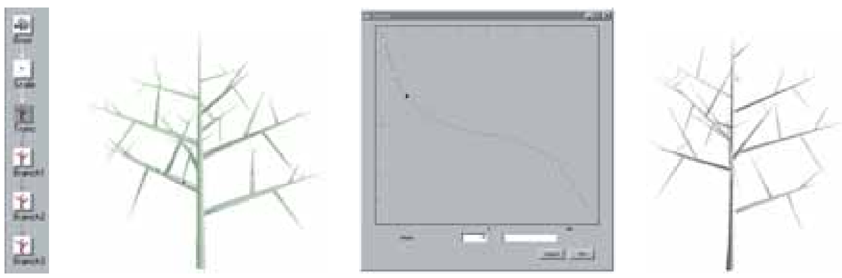
(a) (b) (c) (d)

Figure A.15
(a) Component for creating the tree trunk; (b) geometry; (c) first branching order; (d) geometry

Now two additional tree components are attached to the already-existing ones, and are named “Branch2” and “Branch3”. Again the link should be a “multiple”-link. In the following, the parameters for the components are set so that a young tree is created. We start at the “Trunk” component, and increase the number of segments to 70. This serves to more easily bend the trunk later on without the polygons becoming visible.

The modification of the geometry can best be controlled when a “wireframe” display is selected in the geometry window (Fig. A.16b). Up to now, the trunk had only three points per segment, and thus a triangular surface. This can be corrected by adjusting the number of points in the “Primitive” section; for example, select a value of 12.

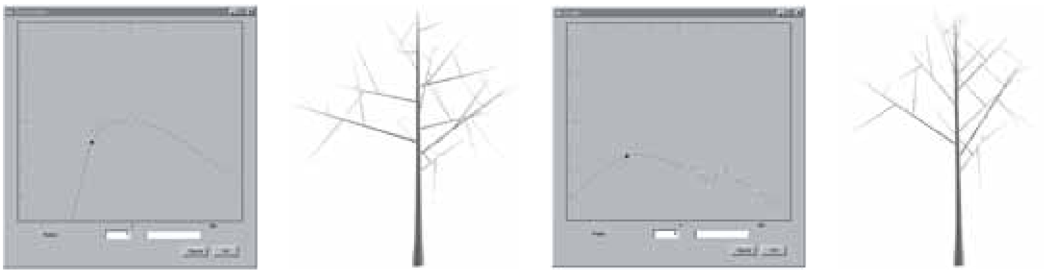
In the next step, the shape of the trunk is to be adjusted. In the parameter editor of the “Trunk” component, the field “Shape” is selected and set according to Fig. A.16c. Additional points can be produced by double clicking on the places where they should be inserted at the curves. Also, the branches of the first branching order have to be thinned out a bit. This happens in the same way as done with the “Branch1” component. Instead of calling up the editor, you can also change the approximated direct rendering in the menu by moving the points. Adjust each branch to be half the thickness of what it is at this moment. The changes will also affect all higher branching levels.



(a) (b) (c) (d)

Figure A.16
(a) All components of the tree skeleton; (b) geometry; (c) editor for the shape of the tree trunk; (d) geometry

We return to the "Trunk" component, and next we want to modify the angles and the branching characteristics. Both can be adjusted in the parameter editor under the column "Branches". The branching attribute "Distribution" is changed in the respective editor in such a way as to create fewer branches in the lower part than in the upper part (see Fig. A.17).

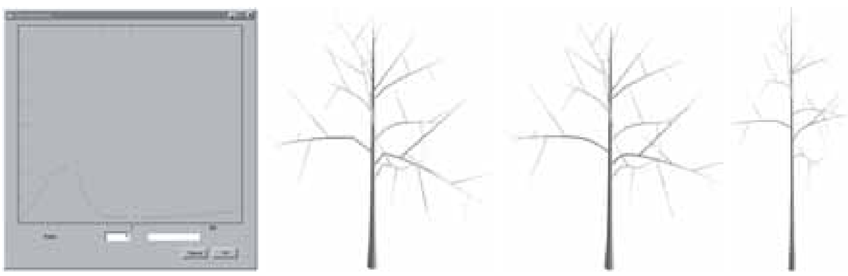


(a) (b) (c) (d)

Figure A.17
(a) Distribution editor; (b) geometry; (c) editor for branching angles; (d) geometry

In the same way, the branching attributes are entered under "Angle". Here the function is set as shown in Fig. A.17c; the jags in the function are important to achieve a lively appearance of the model, and at the same time avoid branches that are too uniformly shaped.

Actually, the branches should hang a little bit, meaning that a steeper branching angle has to be adjusted along the branch by bending. This occurs through the application of gravitropism, which affects the tendency of a structure to grow toward the ground. It can also be adjusted along the branch. For this you open the appropriate editor in the "Branch1" component, and set the curve similar to that in Fig. A.18a. Through bending, here the individual polygons of the geometry are becoming visible. This is avoided by simply increasing the number of segments in the "Branch1" component to about 70 (part c), if not already done.

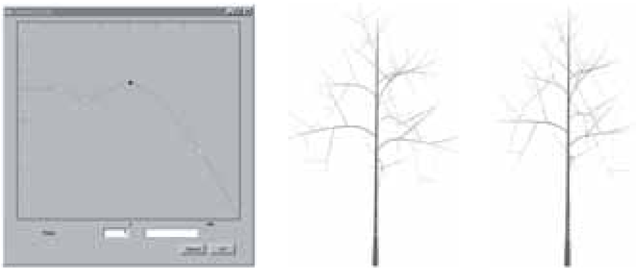


(a) (b) (c) (d)

Figure A.18
(a) Editor for gravitropism; (b) geometry; (c) editor for the branching angle; (d) geometry

Overall, the tree is still too compact. It is stretched by increasing the length of the "Trunk" component (all the way up in the "Tree" section). This should be set to about 35 (Fig. A.18d). If the tree has become too large for the screen, the its scale can be decreased to the desired size. This is done in the simple component named "Scale" just below the camera component within the "Basic" section. Alternatively, of course, the view can be modified by pressing the left and right mouse buttons while simultaneously dragging.

Now we can continue with the refinement of the branches in the first order. Aside from the geometric scaling, there is a parameter named "Growth Scale" in Xfrog for the tree components. We mean here a structural scaling that not only enlarges a geometry but also increases the number of branches.

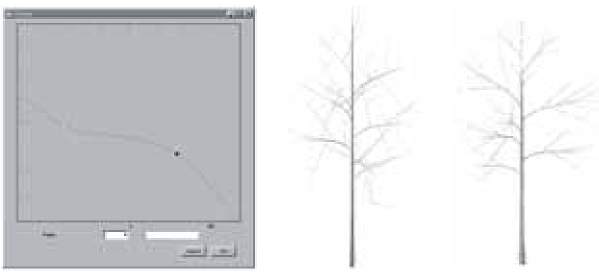


(a) (b) (c)

Figure A.19
(a) Editor for "Growth Scale"; (b) geometry; (c) shortened branches

This kind of scaling is increased by using the editor in the "Trunk" component, since this value should be assigned to all branches of the first order. Figure A.19b shows the amplified branches. Simultaneously, also the lengths of these branches should be decreased to create a more slender tree. For doing so, reduce the length parameter of the "Branch1" component to 16 (Fig. A.19c).

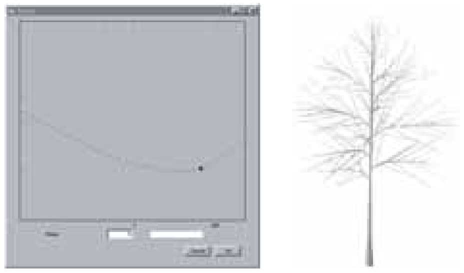
Now it is time to turn to the branching levels. Firstly the branches have to be shortened. Here we use the "Branch2" component and again the "Shape" parameter (see Fig. A.20a). Additionally, the angles of the branches are increased. This takes place by changing the respective parameters in the "Branch2" component: increase the angle in the upper area of the branches (Part c) to lower the curve.



(a) (b) (c)

Figure A.20
(a) Editor for "Shape" of the "Branch2" component; (b) geometry; (c) increase of the angle

Currently there are too few branches in the second branching order. If we simply were to increase the number in "Branch1", then they would only appear in the upper part of the crown. This is caused by the "Distribution" parameter in "Branch1", which does not permit branching at the beginning of the structure. While this is a good setting for tree trunks, the branches should however be distributed along the entire length. Therefore, activate the "Distribution" parameter of the "Branch1" component, and we see that there are actually almost too many branches; thus correct this by adjusting them with the "Number" parameter.

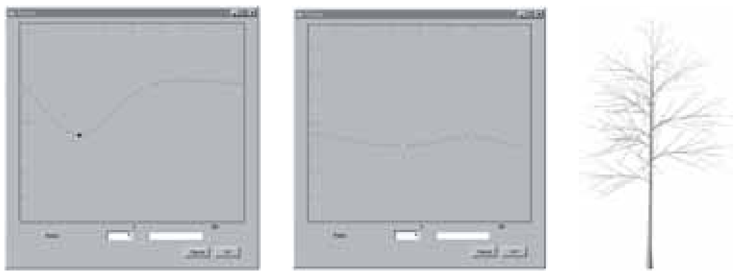


(a) (b)

Figure A.21
(a) Editor for "Density" in the "Branch2" component; (b) adjusting the parameter

There is a second parameter that influences the number of the branches; the "Density" parameter. This parameter indicates the density produced by the multipliers and thereby has a wide-ranging effect. Select this parameter in the "Trunk" component according to Fig. A.21a. Now we still have to adjust some other parameters: "Number" in "Trunk" to 13, and also in "Branch1" as well as "Branch2" to eight.

The "Screw" parameter controls the deviation angle, with which the branching deviates from a tree component. It can be used to realize typical tree branching or to render the model livelier. Set this parameter in the "Trunk" component as shown in Fig. A.22a, and set the same parameter for the "Branch1" component according to Fig. A.22b.



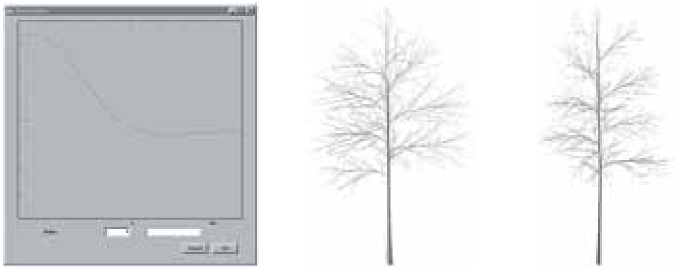
(a) (b) (c)

Figure A.22
(a) Editor for "Screw" in the "Trunk" component; (b) editor of "Branch1" component; (c) geometry

Let us now look at the last branching level. Here it is necessary to first apply a higher density, so that this level becomes more noticeable. Additionally, change the branching attributes in the "Branch2" component, so that more branches are created at the beginning (Fig. A.23a). Then lower the branches a bit in the "Branch2". The result should be similar to that in Fig. A.23b.

Now the branches of the second branching order ("Branch2") appear distorted because of their straightness. Correct this, i.e., bend them downward using gravitropism.

Actually the tree looks very nice so far, but it appears to be too straight. Natural trees often change their direction of growth, such as when branching out at a certain place. This process can take place using the deviation parameter: increase it uniformly along the entire length of the trunk and branch in the "Trunk" and "Branch1" components, respectively. The end result is shown in Fig. A.23c.

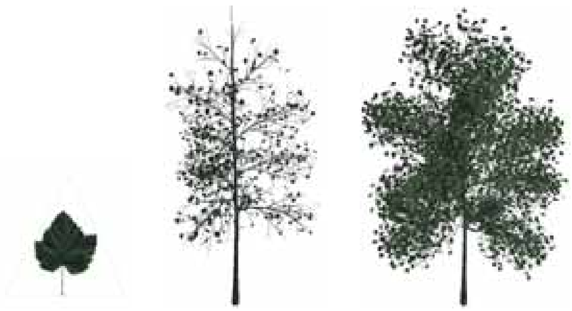


(a) (b) (c)

Figure A.23
(a) Editor for distributions in the "Branch2" component; (b) geometry; (c) final geometry of the tree skeleton, refined through application of gravitropism

Now attach the leaf component to the "Branch3" component. It is important that it is joined with a "multiple" link to the "Branch3" component. In the leaf, change the primitive to "Triangle up". Now, only a single triangle is produced; this is useful if many leaves have to be created. Apply the texture named "leaf.png" to this triangle and adjust the scaling so that the complete leaf becomes visible. Now apply the "bark.png" texture to the surface of the "Trunk" component.

In Fig. A.24a we show the leaf geometry, and in part b the complete model. If you have problems setting the texture parameters for the leaf, just attach it directly to the camera, and hide the rest of the geometry by selecting the "Scale" component and by activating "Hide" below the structure editor.



(a) (b) (c)

Figure A.24
(a) Leaf geometry with texture;
(b) geometry with textures;
(c) completed model

To enrich the model, select the "Trunk" component and carefully increase the "Growth scale" parameter until more leaves appear, especially in the upper part of the plant. Now increase the number of the branching in the "Branch2" and "Branch3" components to about a value of 12. Our version of the final result is shown in Fig. A.24c.