Jake Douglass

Summary of:

Interactive Modeling and Authoring of Climbing Plants

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This paper describes a system that simulates the growth of climbing plants in real time. The system generates plants from seeds that grow like ivy or vines around objects. The system provides editing capabilities that allow the user to interact with and control growing plants.

This paper uses particle structures to represent plants. Particles know their position, orientation, parents, and children. The connections between the particles become the shoots or branches of the plant. Leaves can be represented either as single particles or part of a branch particle, depending on the data size of the plant structure. Most physics are applied to the entire plant using a shape matching algorithm that considers the entire structure and updates it in real time.

The user can set the following biological and physical variables to control plant growth. Surface adaption strength is the effect of nearby surfaces pulling on the plant. Weight is the physical weight of each plant segment. Branching probability is the likelihood that any growth will split into two branches. Maximum branch number is the maximum number of new branches that can be created at each split. Branch direction variance defines the possible rotation of new branches. Branch falloff modifies the thickness of new branches. Leaf growth angle determines the angle from the branch of leaves. Leaf step size determines the space between generated leaves. Stiffness controls flexibility of a plant during growth and interaction. Stress threshold determines the maximum stress between two particles before the plant breaks. Attachment strength controls the particles' connection strength. Phototropism is the plant's attraction to light. Density is used when the plant is subject to a fluid simulation, such as wind.

Plant growth occurs at each childless branch particle. For each branch particle, a predicted position is calculated from the particle's position, orientation, and position data collected from the shape matching. Next, the branch particle will move toward the predicted position but may be deformed by the effect of collisions or gravity on the plant. Particles that grow close to other objects will become anchored to that object, moving toward it during growth and it orients itself parallel to the object surface. The final position is computed from all changes by the prediction, shape matching, surface adaption, and phototropism.

Real time simulation allows the user to interact with the plant. The user can place a seed to start plant growth. The user can ‘grab’ sections of a plant and pull it in any direction. The plant will bend and break if pulled too far; branched under the most stress will detach and fall under their own physics. The user can ‘cut’ a branch, separating it from the plant. The user can manually grow branches and split them. The user can ‘paint’ regions to attract or repulse plants, adjusting the growth by pulling or pushing branch particles.

Plants react to three types of collisions in real time. When two plant particles collide, they are displaced along the normal of the contact point until they separate. Plants can be coupled with Lagrangian fluid simulations, such as wind. Fluid collisions determined by particle-cylinder intersection tests and effect local accelerations on plant particles. When a plant collides with an object, the plant particle will be moved away by computing the surface normal and the plant particle’s reflection vector off the surface. The system simulates friction and elasticity by adjusting the particle’s velocity as it collides. Plants will dynamically adapt to moving environment objects.

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