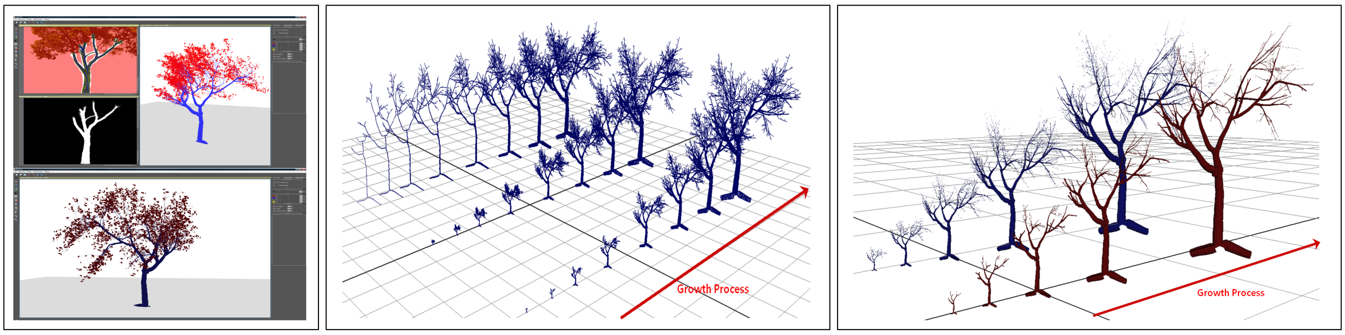
LiveTree : Realistic tree growth simulation tool

Jaehwan Kim, Il Kwon Jeong
Electronics and Telecommunications Research Institute*, Republic of Korea



(a) (b) (c)

Figure 1: (a) 'LiveTree' tool screenshots, (b) three different tree growth models according to the growth processes: allometric growth at the left without considering the scaling attribute; isometric growth at the middle; our proposed allometric growth at the right, and (c) first a few magnified results of isometric(dark blue) & ours(dark brown) growth models in (b).

1 Introduction

Natural 3D tree modeling and growth simulation as realistic as possible have been an important goal in a variety of areas such as computer vision and graphics. Hence, the creation of realistic looking 3D tree growth models is one of the most complicated and challenging tasks because of its inherent geometric complexity. As a consequence, computer representations of tree growth processes need considerable efforts to achieve high level of realism. Moreover, when describing the growth processes for a given whole tree model in most of commercial tools, only the scaling factor of overall tree size is considered so that the tree growth simulation has a limitation of having a simple isometric growth, that is the tree's shape is consistent through the entire growth processes. In reality, meanwhile, every parts of a tree grow at relative rates.

In this note, we present a novel, easy-to-generate solution that is capable of creating realistic-looking 3D tree models and growth processes from one given tree image. We are not only able to create a variety of similar models sharing the main trunk extracted from the given tree image through digital image matting [Levin et al. 2008] and skeleton-based abstraction [Bai and Liu 2007] of branches, but also generate all ages of young trees from the constructed mature tree by incorporating geodesic kernel [Kim et al. 2007] into a tree-growing mechanism, in order to preserve topologically stable paths for the visible branches' manifold, under pre-defined assumptions: (a) the new branch is the farthest away from a tree root on the branches' structure(i.e., branching orders); (b) branch which is thinner than others around the branch is more likely to be a branch of recent growth(i.e., branch thicknesses); (c) the global shape of tree is preserved through the entire growth processes(i.e., tree sizes).

2 Our approach

Once the visible branches consisting of the trunk with twigs have been extracted from the digital image matting procedure, we next build a tree and its allometric growth models about the given visible branches. We construct the tree skeleton as plausible as possible. However, for a complex tree branch consisting of lots of deformations and noise lead to redundant or shorten skeleton branches. To overcome such an instability, we employ a skeleton pruning method proposed by [Bai and Liu 2007]. The main idea of the current skeleton pruning method is to perform a topology preserving skeleton pruning based on a contour partition into curve segments, which makes it possible to extract the exact skeleton with the global topology. After getting the tree branch skeleton, we convert the skeleton into an undirected acyclic graph. Then, with the graph, we define a measurement of the i node's age $\mathcal{T}(i)$ which is in inverse proportion to the growth order, and a scaling control value of the whole tree size $\mathcal{M}(j)$, based on the addressed assumptions as following:

$$\begin{aligned}\mathcal{T}(i \neq r) &= w_p \|\phi(\boldsymbol{x}_i) - \phi(\boldsymbol{x}_r)\|^{-2} + EDT(\boldsymbol{x}_i)\\ &= w_p (K_{ii} - 2K_{ir} + K_{rr})^{-1} + EDT(\boldsymbol{x}_i),\\ \mathcal{M}(j \neq r) &\propto \mathcal{T}(j), \quad \text{s.t. } 0 < \mathcal{M}(\cdot) \leq 1,\\ & \quad j \text{ is an index of the latest branching node,}\end{aligned}$$

where we consider a nonlinear transform $\phi(\boldsymbol{x}_t)$ and kernel K as a geodesic kernel matrix. $\boldsymbol{x}_r$ is a tree root node and w_p is a weight value. We employ a euclidean distance transform, $EDT(\boldsymbol{x}_i)$, as a thickness measurement. As shown in Fig.1, our system is able to generate complex and realistic-looking tree growth models having distinct branching structures and sizes, but preserving their approximate shape through the entire growth processes, in a short time.
Our system also provides flexible user control for editing the output tree model by means of sketching(e.g., adding and deleting) branches on the intermediate result, alpha matte.

References

Bai, X., L. L. J., and Liu, W. Y. 2007. Skeleton pruning by contour partitioning with discrete curve evolution. *IEEE Trans. Pattern Analysis and Machine Intelligence 297*, 3, 449–462.

Kim, J., Shim, K.-H., and Choi, S. 2007. Soft geodesic kernel k-means. In *Proc. IEEE Int'l Conf. Acoustics, Speech, and Signal Processing*, vol. 2, 429–432.

Levin, A., Lischinski, D., and Weiss, Y. 2008. A closed form solution to natural image matting. *IEEE Trans. Pattern Analysis and Machine Intelligence 30*, 2 (Feb.), 228–242.

*e-mail: {jh.kim, jik}@etri.re.kr.
This work was supported by the Ministry of Culture, Sports, and Tourism (MCST) and the Korea Creative Content Agency (KOCCA) in the Culture Technology (CT) Research & Development Program 2011 [211A5020021098502001]

SIGGRAPH 2012, Los Angeles, California, August 5 – 9, 2012.
ISBN 978-1-4503-1435-0/12/0008