A Computational Model of Tree Growth to Maximize Carbon Sequestration

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Global warming and increased CO2 emissions are becoming a large problem for the world. Tree plantations sequester carbon at up to 30 times the rate of old growth forests, and are a common way of reducing carbon footprints. We have created a computational model of tree growth that can determine optimal conditions for the planting of trees and significantly increase the effectiveness and viability of these plantations. In our model, leaves on the tree generate biomass for growth using photosynthesis. This biomass is used for, in order, root growth, leaf replacement, growth in width proportional to stress, and growing new branches and leaves. Stresses are computed based on forces due to gravity and wind. Branching is proportional to light availability at the branching site. Where possible, biological parameters are taken from naturally observed values and previous research. Extensive recursive algorithms and a voxel grid (3D index of space) are used to achieve efficient simulation and 3D visualization. We validate the model by confirming that generated trees exhibit allometric rules observed in nature, regarding leaf mass, stem mass, height, trunk diameter, and total mass. When exposed to varying light or wind conditions, statistical analysis confirms that the model successfully predicts characteristics of growth including phototropism and anemotropism. To our knowledge, our model is the first to exhibit these emergent properties without explicitly programming them into the model. We demonstrate one potential application of the model by determining the optimal tree spacing to maximize carbon uptake and timber production in a plantation.

Awards Won:

Third Award of $1,000