Development of a biomechanical toolbox – Acronym : PlantBioM.lib

Development of a toolbox for modelling and simulating feedback between plant growth and biomechanics

ABSTRACT

The PlantBioM project aimed to develop a toolbox to simulate the mechanical behavior of a growing plant on the basis of the beam theory. This toolbox, which comes in the form of a software library, is designed to be implemented in simulation platforms for plant growth, but also able to operate independently (stand alone version).
The project was divided into 4 main steps:
1 - definition of the structure of the library: it was mainly to distinguish the different core modules (reference materials, beam cross sections, mesh, loads, scheduler, solver, post-GPU) and associated data structures (representation of the topology, list of applied constraints, list of events, functional links between the different modules).
2 - Implementing the library under the platform Scilab, evaluation tests and coupling with the plant growth simulator GreenScilab (http://liama.ia.ac.cn/wiki/projects:greenscilab:home). The Scilab toolbox is operational and can calculate the bending of growing stems as well as the field of mechanical stress (see internship report of Miss Yang Ming, Ecole Centrale Pékin), through the implementation of the transfer matrix method. It was used to evaluate the risk of tree breakage within a forest stand submitted to strong winds, according to the allometry of each individual. This work was conducted in partnership with the Department of Wood Science and Forestry, Faculty of Forestry, Geography and Geomatics, Laval University, Quebec, Canada;
3 - development of the library in Java and of a "stand alone" simulator with a proper graphical user interface (see report of William and Benjamin Surroca Train, and site development http://amap-dev.cirad.fr/projects / plantbiom / wiki).
4 - interfacing with the software XPLO (http://amap-dev.cirad.fr/wiki/xplo), wich is devoted to the representation of plant architecture, via the data structure Architree. This work is still underway as part of a TER M1 internship at the UNiversity of Montpellier 2. Meanwhile, the library PlantBioM was translated in C language and implemented within the simulation platform for plant growth Qing Yuan, developed by partners LIAMA in Beijing (see visit of Dr. Mengzhen Kang and internship of Mr Haoyu Wang).

A modeling work has been carried out ahead of this development work, as part of Thomas Guillon's PhD thesis. It was proposed a new theoretical framework to explicitly calculate the mechanical response of a growing beam by defining a virtual reference configuration. An article describong this framework and giving examples of calculation has been submitted to the journal "Biomechanics and Modeling in Mechanobiology.

Keywords : Plant, Operation, Method/tool/technic, Model, Arabidopsis (species)

Year : 2008
Project number : 0803-024
Type of funding : AAP INRIA
Project type : AAP
Research units in the network :
Start date : 2008-10-01
End date : 2010-12-31
Flagship project : no

Project leader : Thierry Fourcaud Tancrede Almeras
Project leader's institution : CIRAD
Project leader's RU : AMAP

Budget allocated : 15609.59 €
Total budget allocated (including co-financing) : 21383 €
Funding : RTRA

PERSPECTIVES

The project PlantBioM continues in the form of a MASTER internship in Computer Sciences, which would achieved the integration of the library in the software XPLO.
The prospects in the short and medium term are:
- Implementing Thomas Guillon's results in a new PlantBioM solver. An algorithm has already been developed in Java and tested for solving equations of biomechanics ;
- provide a tool for training and expertise for the management of urban trees, based on the software XPLO-PlantBioM. This tool will allow testing the impact of different types of intervention (pruning, bracing, etc ...) on the tree mechanical factor of safety .
- the above point should also be developped with the METLA (Finland) and the University of Goettingen (Germany). A thesis proposal is being drafted and should be submitted in 2011 as part of a ITN European project supported by INRA on Virtual Plants.
- the PlantBioM toolbox would be used as part of research partnerships with LIAMA, China, if the cPlant project (EU INCO-LAB) submitted in early 2011 is accepted. This research includes modeling the architectural plasticity of plants and in particular dynamic feedbacks between bending of stems and development of branching.