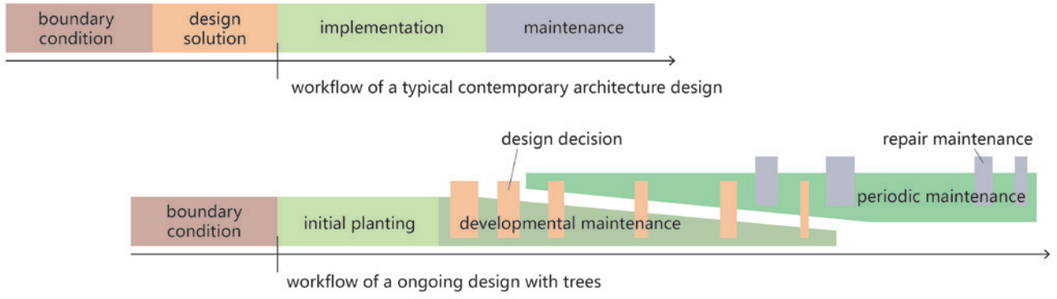
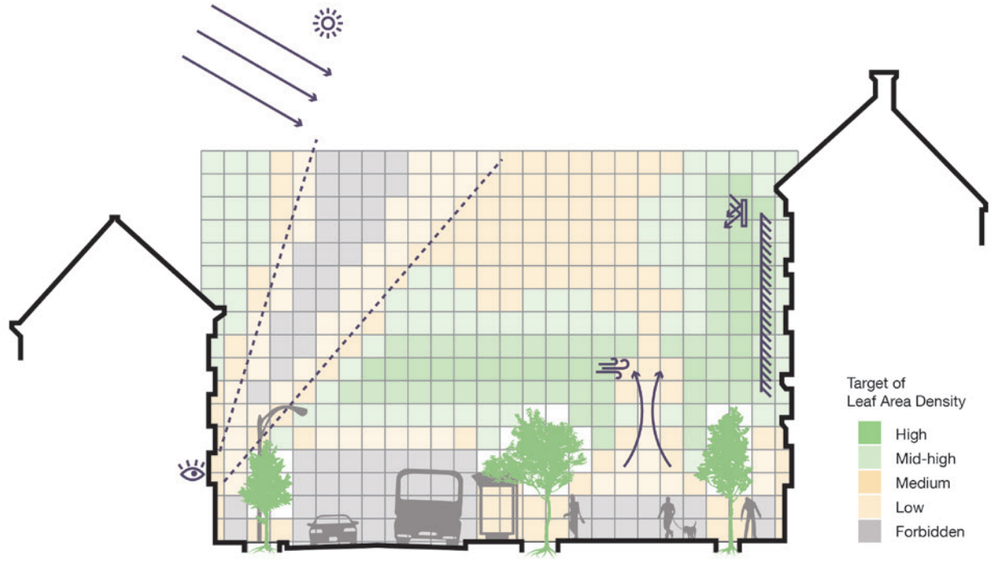




Designing and Managing Urban Green Systems

An iterative survey-simulation-manipulation procedure

Qiguan Shu

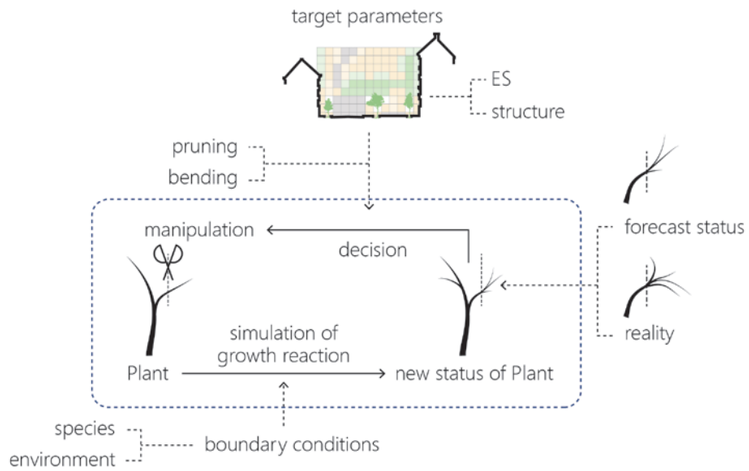
Comparison of a linear designing workflow and a proposed iterative workflow for designing with trees, whose growth is dynamic and thus requires adaptive strategies

Accelerated urbanization and consequent environmental degradation is drawing increasing attention to the value and delivery of ecosystem services that plants provide in cities. The role of woody plants, especially trees, in human settlements is becoming more and more important in this context. In the past, people invested much time in managing trees with different techniques for multifunctional purposes. For example, espalier trees are trained in geometrical forms for acquiring structural stability and increasing fruit yield in the city[1]; through pollarding and coppicing, trees were manipulated to produce firewood and building materials[2]; Devon hedges were built by injuring and laying down trees on earth banks to protect cattle or crops[3]; vite maritata systems use trees as supports for vines, whilst providing wind- and sun-protection for field crops and an ecosystem for diverse dependent species[4]; Hausschutzhecken are trees weaved into stable structures to protect buildings and gardens from wind[5]. These are historical cases where people's daily life interacts frequently with trees. At present, owing to the high cost of labor, trees in cities are designed with the aim of minimizing maintenance.

Today urban green infrastructure becomes a systemic approach to integrate plants in our build environment to solve urban and This approach includes new strategies to combine plants with technical elements and bring new ideas in species selection for targeted functional uses. However, tree management often remains being a standard procedure: mulching, watering and risk management[10]. In this context, designing with trees doesn't include a specific strategy for tree system management. Instead, it is almost a default deal that trees are treated with only a minimum care, aiming for a "natural growth form". This situation may change with the rapid development of machine vision and automatic robots. It is foreseen that urban trees can be taken care of by (swarms of) robots as a low-cost working force. Meanwhile the public might be interested in participating in tree management, which requires an appropriate knowledge base. To make this possible a computational approach to tree design is required to direct agents (i.e. gardeners, robots or none-professionals) in conducting tree manipulations. Such guidance must be in accordance with overall target parameters. Therefore, a survey-simulation-manipulation decision system must be developed.

In a traditional design workflow, designers do have all technical and visionary considerations in the first place to present a proposal. If unforeseen circumstances occur during the implementation, designers seek for minor adjustments in response to these cases. The form of the original design, at least, will be maximally preserved. This workflow is already challenging when the manufacturing and building process is dynamic and complex. In robotic fabrication for example, the behavior of the materials (i.e. cement flow or deformation of timber) is the result of the complex confluence of forces and material properties that occur during fabrication[11]. This is not accurately predictable beforehand. To address this, feedback loops are introduced, where design becomes an adaptive

top: An example of designing street green space with parameters of trees, the leaf area density are given in voxel space, where the sunlight of the north-facing apartments, shading over the motorway and south-facing façade, ventilation at the side walk are taken into consideration.
bottom: Structure of an ongoing study about the iterative survey-simulation-manipulation procedure for designing with trees



strategy throughout a dynamic process[12]. While the uncertainties of e.g. cement flow end with its solidification, the dynamic process of a living plant is life-long. This is the reason why previous Baubotanik projects[13] already follow an iterative, process based design approach. A precondition to such workflow is repetitively measuring and tracking trees' growth.
Key objectives to complete this iterative survey-simulation-manipulation procedure in our on-going studies are:

- efficient workflow for frequent tree scanning and high-quality skeleton abstraction
- simulations of tree's reactions to manipulations like pruning and bending using topological skeleton data and functional-structural plant models
- methods to approach a long-term growth aim of the plants with only short-term reactions of the trees to manipulation techniques predictable
- a computational design tool for designers and amateurs to design trees by target parameters
- practice of a dynamic design procedure in real projects.

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