Chapter 18
Generative Trees: Architectural Modelling of an Olive to Estimate Morphology and Radiation Relationship

Primo Proietti
Università degli Studi di Perugia, Italy

Marco Filippucci
Università degli Studi di Perugia, Italy

Luigi Nasini
Università degli Studi di Perugia, Italy

Luca Regni
Università degli Studi di Perugia, Italy

Antonio Brunori
Università degli Studi di Perugia, Italy

ABSTRACT

The research integrates the study of trees with the sciences of representation, in order to investigate the relationship between morphology and light interception in a tree, starting from the case study of an olive, modeled without using automation in survey. The representation of canopy architecture, manipulated for agricultural purposes by men, describes the action of sunlight in the tree, testing the potential of advanced digital design tools, especially the generative modeling. Through the design of a specific algorithm, the tree is interpreted like a fragmented photovoltaic panel, analyzed using 14,000 control points, corresponding to each leaves. The possibility of selecting these classes of elements becomes the instrument in interpreting the canopy structure, by finding categories describing and simulating the annual radiance and illuminance.

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INTRODUCTION

The objective of this study is to analyze the intersections between plant and representation, with the aim to discover new frontiers of knowledge where geometry is the starting point of creative and generative design processes. The chapter describes and quantify relationship between morphology and light interception in tree and its canopy structure, in order to understand environmental changes effects (Béland et al., 2013), and to acquire elements in the agricultural resource management (Proietti et al., 2008), both connected to photosynthetic activity of tree plantations.

The survey methodology and visual computing potential is transferred from the architectural field to trees studies. In the same way, the research is available for all the modelled plant, therefore it can be applied in other agricultural systems. Nevertheless, in accordance with the bottom-up approach already theorized by Hanan and Room (1996), it starts from a measureable data, hypothesis that allows to develop generalizable theses. The olive tree it has been selected among various plants, being one of the most popular and representative fruit trees in the Mediterranean area, whose anthropization allows to clearly describe the relationship between form and light (Proietti et al., 1988; Proietti et al., 1994). Human intervention, in particular in the pruning of the tree, is aimed to the uniform distribution of the solar radiation on all the leaves of the crown, a technique developed following empirical experience, which has only partly found a more analytical verification.

In order to describe tree with incredible levels of detail, using digital tools hold a great potential. The model conception, as well as survey technique, both represent essential steps, developed with a cross-disciplinary approach, able to deal with complex requirements and evolving data structures, also with simple activity and instrument.

The generic modeling developed and its purely theoretical significance forms the basis for a variety of applications in data interpretation and comparison between different models, evaluations, theories and operational concretizations.

Maybe a theoretical approach in this research could have hidden the operative reason of the study. At the basis of interpretative process is the analysis of relationship between form and light in the examined tree. On the one hand, in order to guarantee an uniform light distribution, through generative model it is possible to select part of the tree to understand its functionality: in this way, all the achieved results can help in selecting pruning choice, or opening to make a comparison among different cultivar, pruning options… on the other hand, starting from the tree representation the selected as generalized case study, all the issues connected to the optimization of sunlight could be simulated in the digital space, with the aim to generate economic advantages.

BACKGROUND

Trees, Light, Prunings

The photosynthetic activity of an olive leaf responds to changes in light intensity according to a typical pattern. Photosynthesis does not occur in the absence of light, but there is emission of CO_2 due to the leaf respiration process (as a consequence of the consumption of carbohydrates). During the growing season, the amount of CO_2 emitted is around 1.5 μmoles CO_2 $m^{-2}s^{-1}$. Increasing the light intensity, leaves start to photosynthesize; the point of compensation, that is equilibrium point between emitted (breath-