Botanic Shell Structures

Michael Balz Dipl.-Ing. Freier Architekt, Stuttgart, Germany
Jens Gühring Dipl.-Ing. Inst. für Photogrammetrie Universität Stuttgart, Germany

1. INTRODUCTION

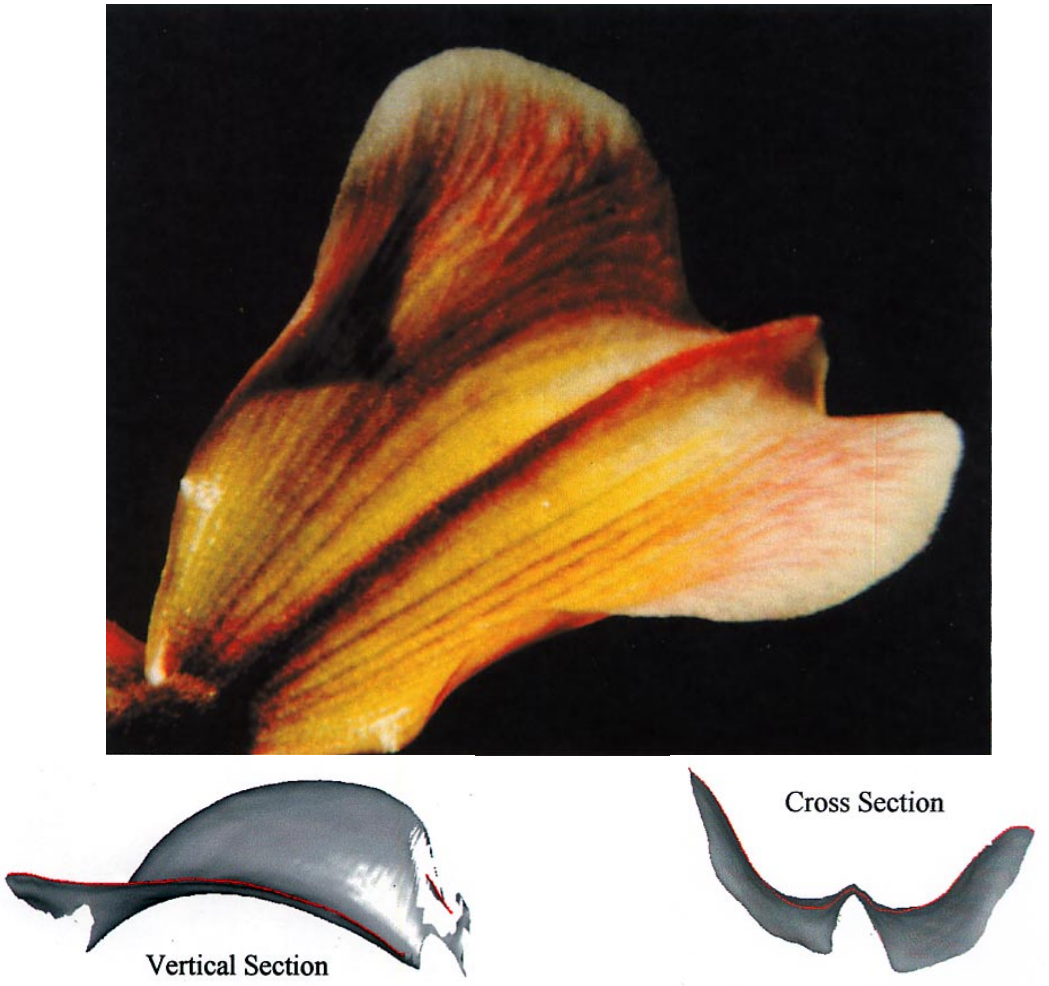
Looking around with the eyes of an architect and designer one is fascinated by the blossoms of orchids; of their beautiful elegant shapes and various colors. My first intention was to compare the synclastic shell shapes of the flowers with the forms of shells 1 built in quite another size and System together with Prof Heinz Isler. After further consideration of the facts it became clear that there is a remarkable difference between the big concrete shells and the light and translucent little petals of blossoms. Blossoms are short-living hydraulic erected structures. Their task and function is to care for their propagation by pollination with the help of insects which must be enticed by colors, by a fragrant and by the shape of the blossoms.

The approach to the flowers leads directly to the world of botanic life with the fantastic and fascinating systems where nature builds by growing. For further optimization of our building methods it is very important to consider and to understand the methods in which nature

develops and improves - not only focusing on static structures hut also to see the whole process of botanic life with the deep sense of morphology. The outer appearance of each plant is determined by many different requirements of its environment.

2. **MEASURING PROCESS**

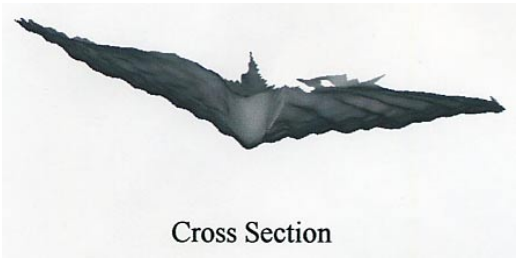
Coordinate measuring machines are the standard tool for making three-dimensional shape measurements in industry. However, due to the deformable nature of the petals, touch probes cannot be used to digitize their surface. Researchers at the Institute for Photogrammetry of the University of Stuttgart have developed an optical 3D sensor based on the principle of triangulation. Optical 3D sensors measure the shape of objects, without the need to physically probe surfaces. The system provides dense point measurements (sampling distance < 0.5 mm) at a high precision (σ < 0.1 mm). A LCD device projects a sequence of specific light patterns onto the object. The light patterns are distorted by the objects surface.

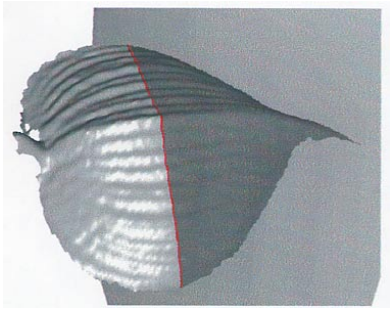


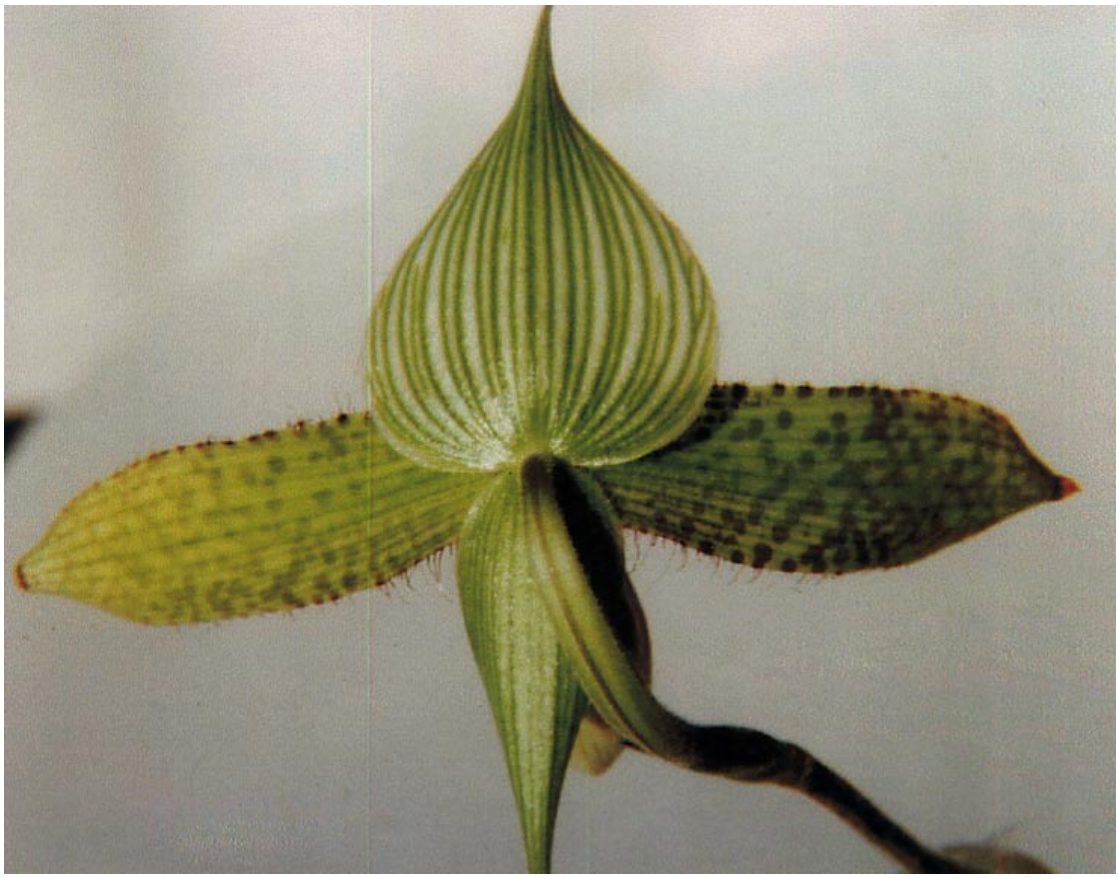
These distorted patterns are observed by at least one camera and then used to reconstruct the three-dimensional shape of the object. The measurements can be converted into a triangular mesh representation containing up to a few hundred thousand vertices. Triangular meshes can be used as input data for a finite element (FEM) analysis of the physical structure of the petals. Despite their large size modern Computers allow to visualize and explore these datasets interactively lt is also possible to generate cross-sections at arbitrary orientations.

3. GROWTH OF PLANTS

The complete morphological and functional genetic plan of plants is deposed in their seeds. Right from the beginning of life the evolution of plants developed shell structures as leaves and blossoms in countless variations. These are just parts of the biological structure and their shape is a functional result of the process of surviving for the whole plant. This aim includes constructive optimization as well as aesthetic signals to for the environment. For stability in space a double curved surface is required, which also provides the elasticity as a principle of surviving importance.





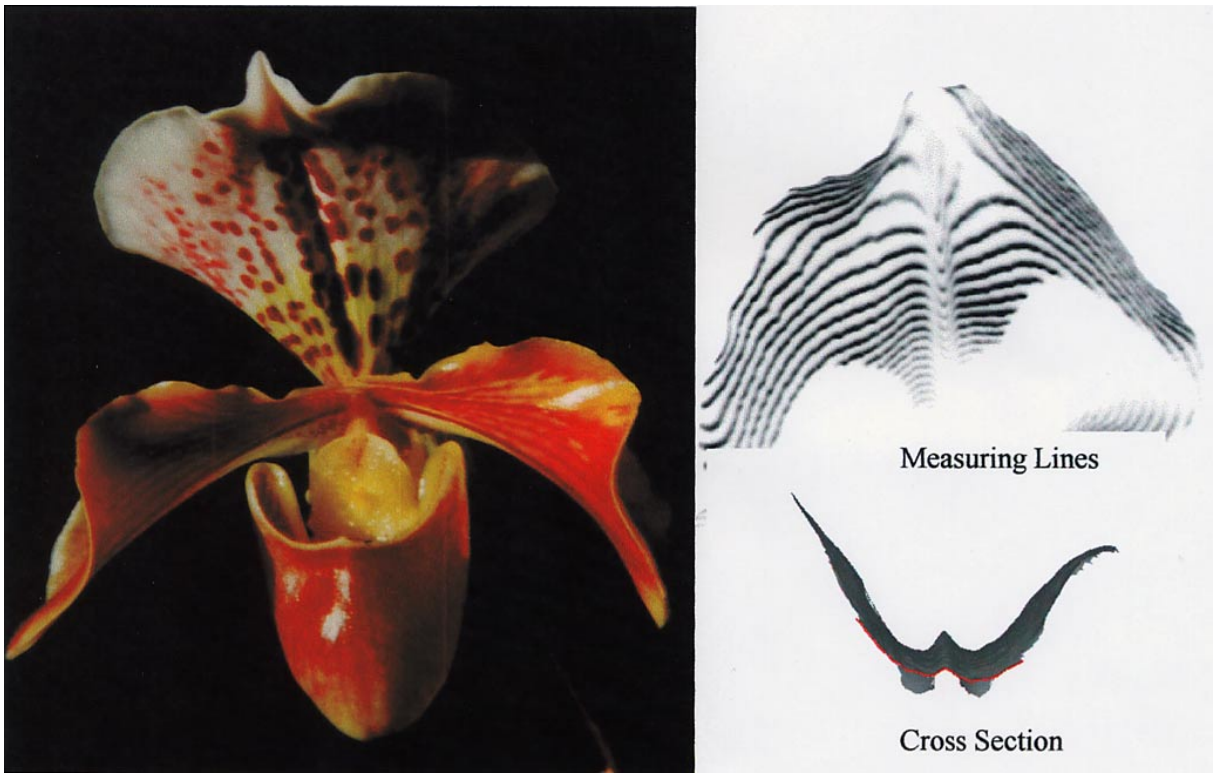


The growing process of plants always has to do with hydraulic pressure within the single cells. Membranes of cellulose regulate the stream of fluid in the plant and develop the morphologic

shape following the genetic plan. By photosynthesis CO^2 is produced within the cells. The cells are able to detect the blue light rays of sunlight. Plants tend to grow always in direction towards light. Consequently there is a permanent fight between all plants for sunlight. Movement and erection of plants to light results from the inside pressure and from the stretching of the cell walls. The whole elasticity of plants comes from the relation between insides pressure and stability of cell walls. When deep-freezing a plant, the natural elasticity is lost; in this state it can be compared with stiff conventional buildings.

4. ORCHID BLOSSOMS

Orchid blossoms exist in vast variety but all of them are built up following the same basic system, which contains as a main part a symmetric axis in the blossoms. To study the static structures of the blossom it is interesting to consider the upper middle petal.



Its stiffness is the result of inner pressure and the double bent shell structure. For of the unfolding and the growing process from the bud to the blossom the grooves and gutters along the main axis provide stiffness.

A pollination leaf to be touched by insects for insemination is centered in the orchid blossom. There exists a special insect for each kind of orchid; this is the reason why the flowers often cannot be pollinated.

Blossoms are minimal constructions with a very short living phase. They consist of 98% water and 2% cellulose fibers. Maybe this kind of structure once is usable for deployable or temporary buildings made of membranes and erected by air or water pressure.

5. MORPHOLOGIC SYSTEMS

A conclusion of this study is that human beings themselves grow following laws of nature. It should be possible to find forms and shapes for human living which are as functional and as beautiful as a blossom which nature builds for bees an d butterflies.

Through modern measuring and planning methods it is possible to develop organic building forms with shape similar to naturals structures. In that way human needs of living can be taken into account more adequate than with pure orthogonal planning patterns.

Another aspect is that plants are very complex and intelligent systems; they use light energy, water and minerals to build up their structures. After their life time plants disappear completely, the building materials dissolve and are to be used again for another natural system. Looking at these principles we should discuss if our building methods with stone and metal which develop products with life times of centuries are the only possible solution for our building.

REFERENCES

Balz, Michael: Fantasy in Space. IASS Proceedings 4. International colloquium on Structural Morphology. University of Technology, Delft, Netherlands. Delft, 2000.

Gühring, J., Brenner, C., Böhm, J., Fritsch, D.: Data Processing and Calibration of a Cross-Pattern Stripe Projector, International Archives of Photogrammetry and Remote Sensing 33, Part B5/l, pp 327-338, Amsterdam, 2000

Nachtigall, Werner: Vorbild Natur. Bionik Design für funktionelles Gestalten. Berlin, 1997.