

SC: Prototypes for Interactive Architecture

Henriette Bier¹, Kathleen de Bodt², and Jerry Galle³

¹ Delft University of Technology, Berlageweg 1, 2628 CR, Delft, The Netherlands

² Institute of Architectural Sciences, Mutsaardstraat 31, 2000, Antwerp, Belgium

³ Royal Academy of Fine Arts, Academiestraat 2, 9000 Ghent, Belgium

Abstract. This paper describes an ongoing research, SpaceCustomiser : InterActive, [SC : IA] which deals with development of digital design strategies based on non-Euclidean geometries, whereas the body in movement generates interactively architectural SPACE. The input – movement – is being electronically processed in such a way that the output represents a continuous, real-time modification of the space. For this purpose an on-site-built InterFace employing sensor/actuator technology enables translation of the recorded movement into spatial configurations. The InterAction between the body and the architectural space gives insight into, how the human body shapes space.

1 Background

At the time being large scale architectural projects incorporate interactive systems focusing on light. Kunsthaus in Graz, for instance, has a light installation incorporating a matrix of fluorescent lamps integrated into the acrylic glass faade enabling display of movies and animations.

However, small scale installations seem to target more complex configurations such as dynamic, interactive systems. R. Glynn's project Reciprocal Space, for instance, is a room where the walls change shape in response to inhabitant's movements.



Fig. 1. Reciprocal Space by R. Glynn

Similarly, J. Poenisch's Dynamic Terrain is an interactive surface, which changes shape in correspondence to spatial and/or bodily requirements in real time. Other projects such as Decoi's Aegis Hyposurface work with triangulated

surfaces in a similar way. However, Hyperbody Research Group's MuscleTower adds the third dimension to the movement allowing rotation and torsion of the structure.

All these projects work with input, processing and output tools, such as sensors, camera tracking systems, projectors, speakers, and software such as Macromedia Shockwave, Max/MSP, Virtools. SpaceCustomiser : InterActive uses Max/MSP, camera tracking, and projection to study and implement double-curved space generation by following the movement of the body in space.



Fig. 2. SC: Projection and interactive set-up

In opposition to the horizontal and vertical surfaces employed in the previously mentioned examples, SpaceCustomiser : InterActive employs a three dimensional double-curved cylindrical space surrounding the body in movement.

2 Implementation

The interactive processes in the SpaceCustomiser : InterActive project are controlled with software developed by K. de Bodt and J. Galle in Max/MSP, which is a graphical programming environment to create software using a visual toolkit of objects. The basic environment that includes MIDI, control, user interface, and timing objects is called Max. On top of Max are built object sets such as: MSP, which is a set of audio processing objects that enable interactive filter

design, hard disk recording, and Jitter, a set of matrix data processing objects optimised for video and 3D graphics.

The interactive environment has been developed for transcribing the movement of the body into 3D-space based on SpaceCustomiser [1], which has been developed by H. Bier in 2005: SpaceCustomiser and can be seen as the Modulator [2] of the Digital Age, since it establishes relationships between the human body and the architectural space. As a system of proportions Modulator uses measures of the human body in architecture by partitioning it in modules according to the golden section and two Fibonacci Series. It puts, basically, man as measure of architectural spaces, which SpaceCustomiser does as well in a more drastic manner, since it generates 3D space by following the movement of the body in space based on ergonomic principles.

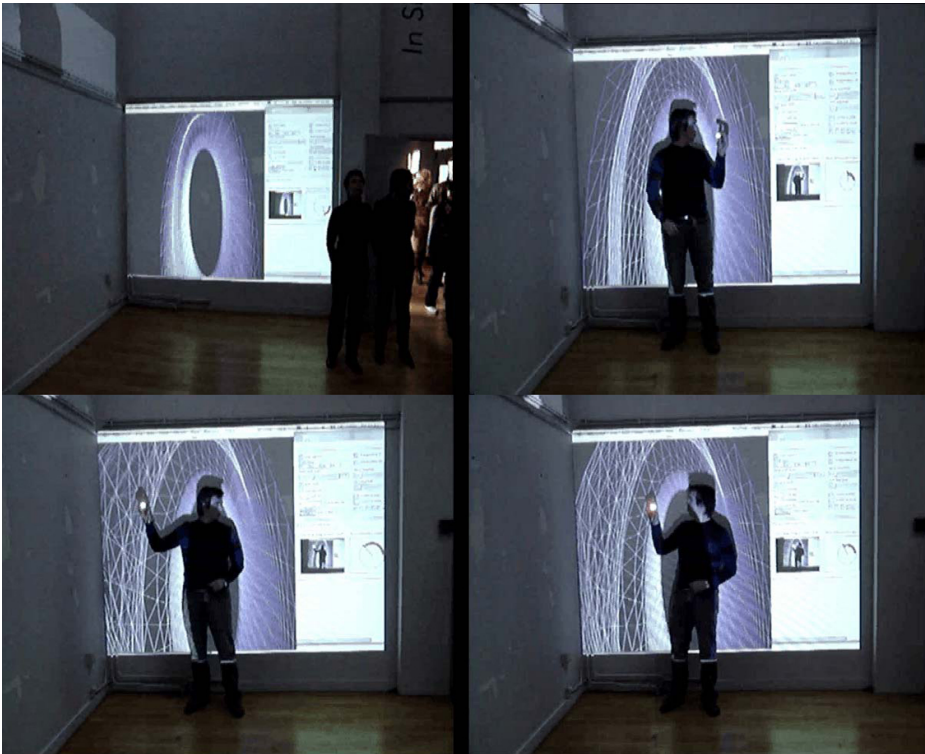


Fig. 3. Deformation of the ellipsoidal cylinder

While Modulator applies a 2D proportioning system, SpaceCustomiser employs a 3D, dynamic, space-generating system. If in this context can be talked about a paradigm shift based on the influence of digital technologies, than this shift can be described in the methodology: In opposition to modular, repetitive architecture developed by using grids and proportions based on functional and formal

rules, curvilinear architecture is being developed by generating space through following the movement of the body in space.

The initial space is an ellipsoidal cylinder, which represents the minimum space a standing person needs. This space has been divided in five segments, while the ellipse itself is divided in eight sectors. Each of the eight sectors is being activated, when movement in this area is detected. This means the movement of the arm to left/up triggers a deformation in the corresponding sector. The movement is being tracked by using a colour/movement tracking technique, which involves several steps: A camera captures the movements, while specific data is being extracted from the image sequence, for instance, an arm is tracked, while moving in space. This movement activates the spatial deformation in a direct way: A movement induces a proportional deformation of space. The space enlarges to accommodate the body in movement.

Geometrically speaking, the movement tracking is based on the conversion of the Cartesian coordinates of the tracked point into polar coordinates, while the deformation principle is based on NURBS, which is a mathematical model for generating and representing curves and surfaces. Editing NURBS-based curves

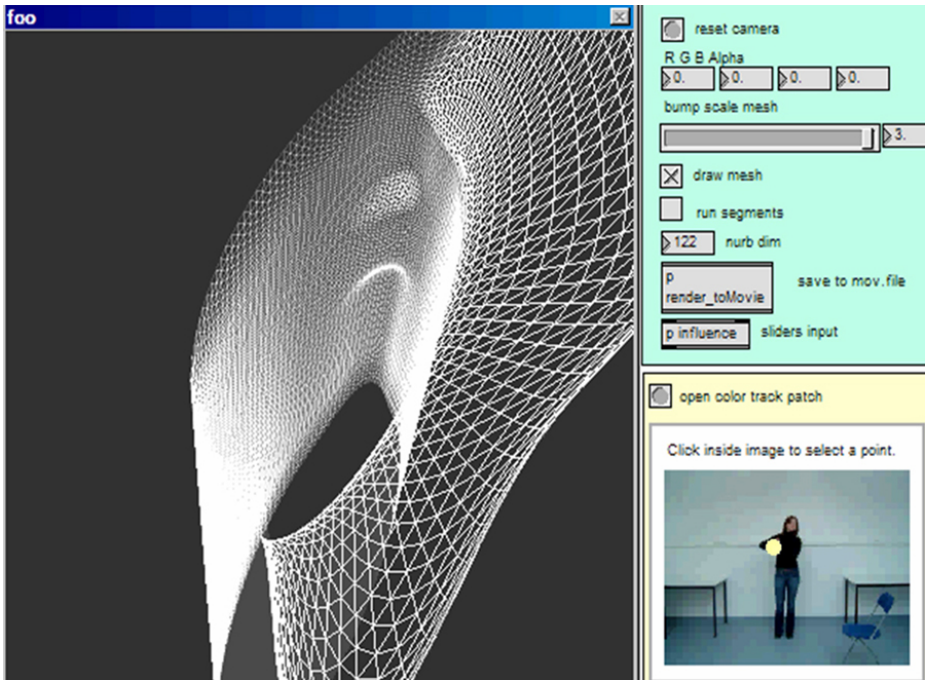


Fig. 4. SpaceCustomiser: InterFace

and surfaces is easy: Control points are connected to the curves and/or surfaces in a way that their pulling or pushing induces a proportional deformation. While it is easy to manipulate NURBS surfaces by pulling control points, the question

is how to control this manipulation, which rules and design methodologies can be developed to control designs based on NURBS geometries? SpaceCustomiser proposes a NURBS-manipulation based on the movement of the body through space.

The interactive manipulation of space is monitored on two interfaces: One of them is projected on a wall the other one is shown on the computer display. While the projected interface serves as a representation and monitoring device, the interface on the computer screen enables generation and control of spatial deformation. A series of parameters such as mesh resolution, colour, and NURBS dimension can be defined on the computer screen interface.

The computer screen interface has a display window for rendering, one main and several sub-patches, which contain programming packages. The user works mainly on the main patch. By starting the program, the processing of data, which is fed into the system, is initiated, while the NURBS surface is being rendered in the display window.

Interface elements on the main patch are: 1. On/off switch: This is a toggle that sends a trigger signal every 20 milliseconds; 2. RGB alpha: Controls the colour of the NURBS surface. 3. Bump scale mesh: Slider to control the relative amount of the deformation. The input can be chosen for a smaller or larger deformation effect. The default is 1, which represents no scaling, while scaling corresponds to input bigger or smaller than 1; 4. Draw mesh: Switches between shaded and wire mesh rendering; 5. NURB Dim: Slider to reset manually the NURBS mesh density from 0 to 100 or more. The default surface density is set to 48 and the surface order to 3; 6. Video window: 320 x 240 display for the camera image.

3 Programming

Max/MSP is a graphical programming environment for music, audio and multimedia, used to design cross-platform programs and user interfaces. Programming takes place in the Patcher window, where Max/MSP Objects, represented as boxes, are connected with patch cords. The program library includes several Objects to perform a wide range of tasks, from adding two numbers together to waveform editing, etc.

SpaceCustomiser : InterActive consists of three patches: 3.1 3D Shape, 3.2 Deformation, and 3.3 Movement Tracking.

3.1 3D Shape

This patch implements 3D modelling in OpenGL. It is, basically, a rendering patch, enabling NURBS representation in real-time.

The 3D shape itself has been developed by following a more steps procedure: The `jit.gl.nurbs` object has been used to generate the cylindrical shape, from which the ellipsoidal cylinder has been derived by scaling it down to 1/3 in the y-direction. An 8 x 5 `jit.matrix` has been mapped onto the control points of the

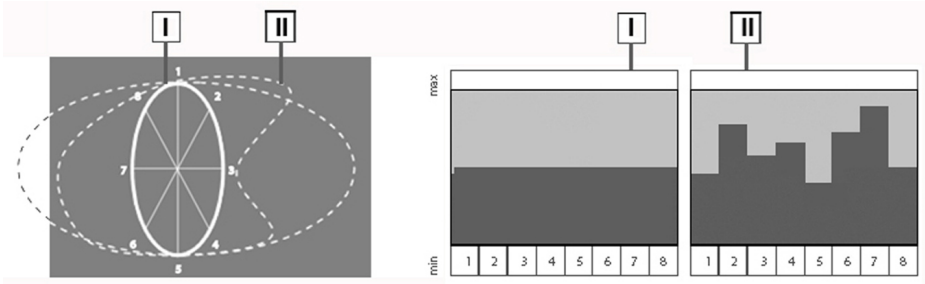


Fig. 6. Diagram of the displacement matrix

The colour to be tracked is being selected by clicking with the mouse in the video frame window, which shows the real-time movements captured with the camera connected to it. The Cartesian coordinates of the tracked colour/point are then converted into polar coordinates, which find their correspondence in the eight ellipsoidal sections.

4 Conclusions

This exercise in interactivity shows that the concept of responsive environments applied to architecture can be implemented in spaces, which dynamically react to the movement of the human body in space.

In this context, emergence and self-organization can be seen as principles on which interactive architectures can be based on, since building components dynamically adjust to their users needs. Space-customisation, as described in this paper, is one of the modes of emergence and self-organisation interactive buildings can be based on.

5 Perspectives

The next step in the development of this interactive prototype is the implementation of movement transcription not only on one segment of the ellipsoidal cylinder but on all five segments. For that, each segment of the ellipsoidal cylinder needs to be connected to push sensors on the floor, so that a forward movement of the body can be applied to the corresponding segment allowing transformation and deformation of space in three dimensions.

Furthermore, the proactive potential of the space has been not yet explored: Following the example of interactive floors, which configure themselves as surfaces to lie and sit on, the interactive building components might follow principles such as *store agenda and move accordingly* and/or might use sensor/actuator technology interacting with the environment according to the principle *sense your proximity and react on it*.

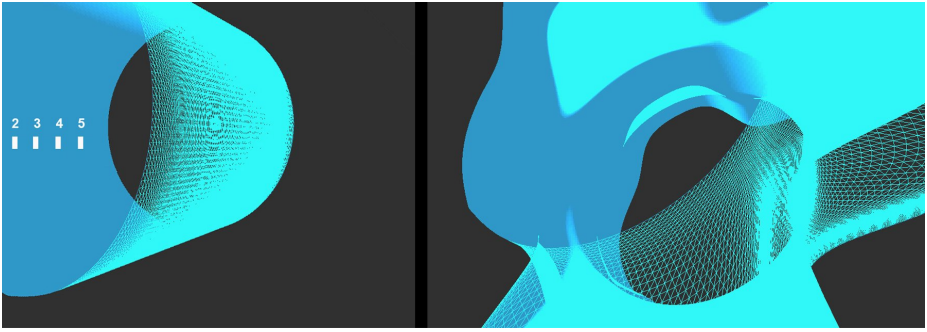


Fig. 7. Five-part segmentation of cylindrical space

In this context, architectural space based on NURBS can be understood as a space, which reconfigures itself according to the principle of swarms: Control points of NURBS can be seen as birds/boids [3] in a swarm, which configure themselves spatially according to preset rules, which accommodate the users' needs.

References

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