FORMOTIONS*

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Introduction

This paper reports on three recent projects carried out in the no_LAb, the laboratory for augmented architecture at the institute of architecture and media of TU Graz, where in 2006 an optical 3D motion tracking system was installed in order to support various types of motion-based investigations.
Optical 3D motion capture systems have become standard in the special effects industry and are increasingly common in medical applications, as well as in Virtual Reality (VR) and Augmented Reality (AR) set-ups.
While applications in the mentioned industries (medicine, special effects, virtual and augmented reality) have driven the development of optical 3D tracking systems, their application is not limited to these. We see a number of areas, where such systems can enable new types of investigations that are relevant for architectural design. There was a shift in research on computer interaction towards a growing interest in physicality that recognized human beings as having a body, rather than just being "brains" and there are many investigations about what such gestural interfaces could potentially do (Camurri, 2004). Moreover, it has been shown in the work of artists and researchers, that by means of tracking, space itself can become the interface: an invisible architecture (Novak, 2001). This was the main reason for our decision to install an optical system at the no_Lab, the laboratory for augmented architecture of the institute of architecture and media (IAM) of TU Graz.
Tracking in space is an important bridge between physical and virtual realms. With optical 3D motion capture systems, the user can be completely untethered from the computer, moving and behaving naturally. The possibility to track complex movements in space in real time and at high precision can open up new modes of interacting with spaces, and of generating or analyzing movement as form as part of an architectural design process. The three workshops described in this paper explore the potential of these upcoming fields of research. They were carried out in a "hands-on" fashion with groups of students, typically lasting one intense week.

Workshop 1: "sculpting motion"

The focus of the first workshop was the generation of form through movement. The workshop was held under the title 'Sculpting motion', referring to earlier work of two of the authors (Hirschberg, 2003) and a class with this title, taught at IAM and the Harvard GSD. Rather than exploring synthetic motion, as in those earlier projects, the goal of the workshop was to create suspended wooden motion sculptures. As is usually helpful in workshop situations with limited amounts of time, the goals and the technical means to reach them were clearly stated up front. The larger context of the task also involved reflecting about motion in art and architecture, where it has long been a central topic. Particularly in the modern movement, inspired by contemporary discoveries in mathematics and physics, theories about its importance and its expression were developed.

The futurist movement in Italy, with artists such as Boccioni or Balla, was among the first trying to find an artistic expression of this new condition. But their work was not only a reaction to scientific theories. Just as Marcel Duchamps' famous nude descending a stair, their work clearly was inspired by the photographic motion studies of Eadwaerd Muybridge and others. (Figure 1)

Figure 1: Technology influencing artistic expression: Marcel Duchamps' famous nude descending a stair was inspired by Eadweard Muybridge's photographs of bodies in motion.

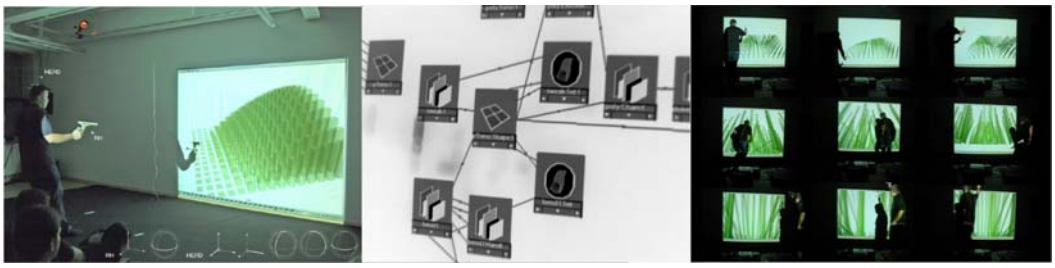
Thus a technological development – high speed photography – triggered these influential artistic experiments. The photographic experiments of Muybridge, which were later perfected by Harold Edgerton at MIT, opened up a new way to perceive and analyse motion (Solnit, 2003). In many ways, this can equally be said about today's 3D motion capture systems. We again find ourselves at a time when technology opens up an avenue of creative investigations unavailable up until now.
Among the first artistic fields to capitalize on this new technology was dance. There are practical reasons for this. Before motion capture systems came along, dance had neither a notational convention nor a recording technology general enough to record dances fully – a consequence of the complex movements in space dances consist of. The interest of dancers in the virtualization and thus preservation of their art is therefore not surprising. Artistic applications of motion tracking systems in dance, like in the work Paul Kaiser did with Merce Cunningham and others have already quite a tradition (Kaiser, 2002).
While artistic projects that have used motion capture technology typically deal with unusual types of motion, such as dance, one of the guidelines we gave the students at the outset was that they should develop scenarios with everyday types of motion – not only because we didn't have any dancers, but mainly because we felt that seeing motion as form was spectacular enough as such. Another rule for everyone was that the tracking setup wasn't an individual movement, but some social interaction between two or more persons. The step from having the tracking data to actually developing a sculptural form wasn't automatic, but one where students had to make design decisions about the type of object they would derive from their dataset. Once the movement had been tracked by our VICON Tracking System, the tracking data was worked on in the program MAYA. Most students applied their knowledge of MEL, the MAYA embedded scripting language to turn the data into a form according to some formal logic that would work well with the tracking paths. In most cases the data had to be simplified or trimmed. Many also went back to recording their action again with different marker positions.
For the massaging of the digital model, different strategies were explored: some turned the tracking points into individual objects, varying their size and/or rotation based on the speed of the movement (eg. the distance to the next object) thus creating a jagged, expressive look. Others lofted a surface along the tracking paths. They started developing a design-identity. Every change of media developed its own formal potential. The step to turn the projects into physical sculptures was a great challenge. The students had to invent a construction logic that could be implemented for building their models using the laser cutter. A lot of hands on work was necessary despite the help of the machine.

Massaging the motion capture data: students followed different procedures in turning the motion capture paths into digital models. Most made use of generative scripts to interpret the tracking data in an interesting way. The coming together of the 'Clap your hands' wooden sculpture: "It's impossible to think up forms like that" (pictures in the second row);

The results of the workshop presented to illustrate this approach show that bringing our own bodies' movements into a form-making process can lead to rich and inspiring results. One thing that many expressed is that *"it's impossible to think up forms like that"*. Turning movement into form can give unexpected insights into the intricate relationship between time and space – the very essence of what architects need to deal with.

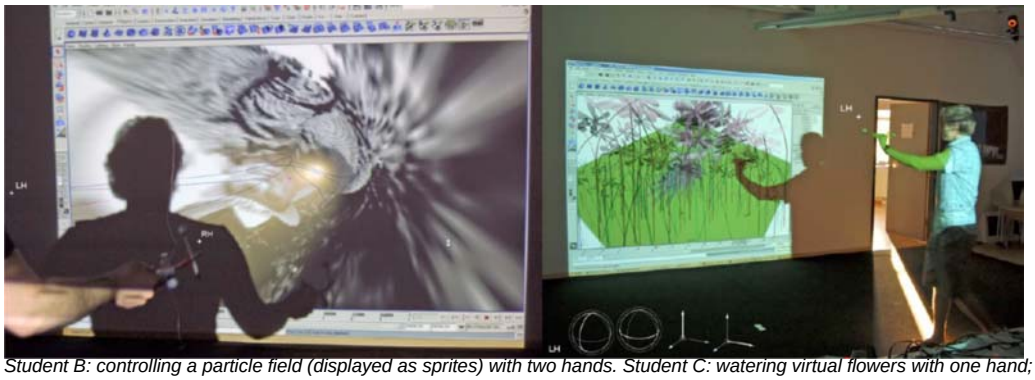
Workshop 2: “puppeteering architecture”

Shortly after the first workshop we initiated the second of this kind, focusing not directly on the creation of objects but on the human-computer interaction possibilities the tracking system opens up.
The larger issue the second and third workshops address is how we can create tools that allow us to bring our intuition into the design process and in how far tapping into the expressive powers of our body movements might provide new possibilities in this respect. It has often been pointed out that current CAAD systems are particularly weak in supporting the early stages of design. Among the most important (and perhaps most obvious) conclusions most researchers in this field came to is the need to make the interface as intuitive as possible, ideally to make it “disappear” altogether. The goal put forward in many such projects was to come to a mode of interaction similar in ease as the traditional sketching. We may infer that an underlying premise of choosing sketching with its fluid type of movements as an inspiration for an ideal interface is that such movements allow us to interact with the computer in a more direct or more intuitive way. This notion can be taken further by exploring gestural interaction.
In order to stay away from the common notions of computer tools, the analogy to puppetry was chosen as a playful approach that put more emphasis on narrative than on the creation of form. This proved to be successful as many of the applications the students produced contain rather novel interactive features. The students developed gestural interfaces by means of a real-time interface of a high end optical 3D motion tracking system with the modeling and animation software Maya, making use of the MEL scripting language. The analogy was also appropriate as most students used just one object with markers to control their model, tying the X, Y, Z coordinates and the three angles by which the object’s position is defined in space to various functions or properties in the modeling system.

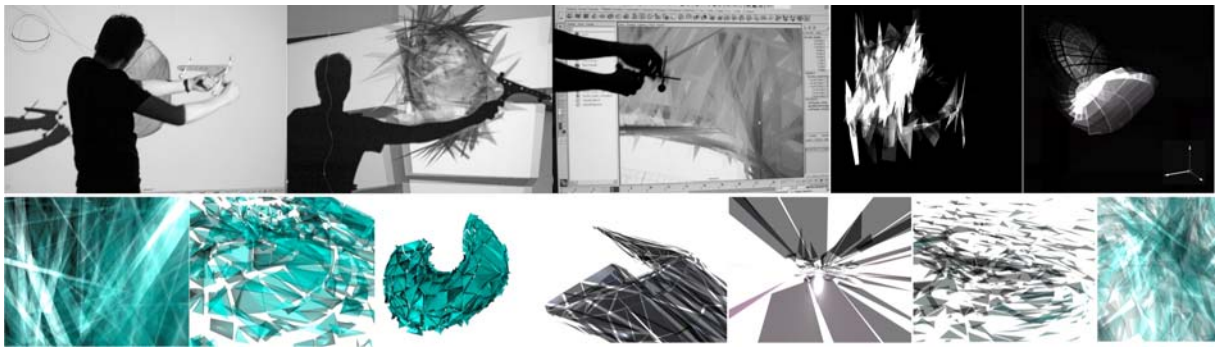


Project Student A: Interacting with a field of green cubes in different modes. Main control with object in right hand, switching of modes and adjusting parameters with head gestures (nodding, shaking); midle: Linking of parameters and objects in the Maya hypergraph interface. The right picture shows a sequence of interactions in different modes, switching of modes is controlled by nodding or shaking head;

While puppetry per se has very little in common with the way architects tend to design (or for that matter sketch) spaces, what interested us was its narrative dimension. To control their puppets a puppeteer makes highly artificial and awkward movements, yet they are held together by the narrative of the play the puppets enact. The students’ final presentation was labeled as a performance rather than a presentation of their project. In fact it was only then that we brought the question into the discussion whether they thought that their puppeteering interface could also be used as a way to construct form. Many of the inventions they had made out of necessity for their performances (switching modes through certain extreme movements, using a second marker object to control the environment rather than the model, animating the environment for continuous modeswitching) represent rather unusual, but interesting ideas when applied to a modeling paradigm. The results and the experiences gained in the second workshop laid the foundations for the third workshop, in which the idea of modeling by movement was explored further.



Student B: controlling a particle field (displayed as sprites) with two hands. Student C: watering virtual flowers with one hand;



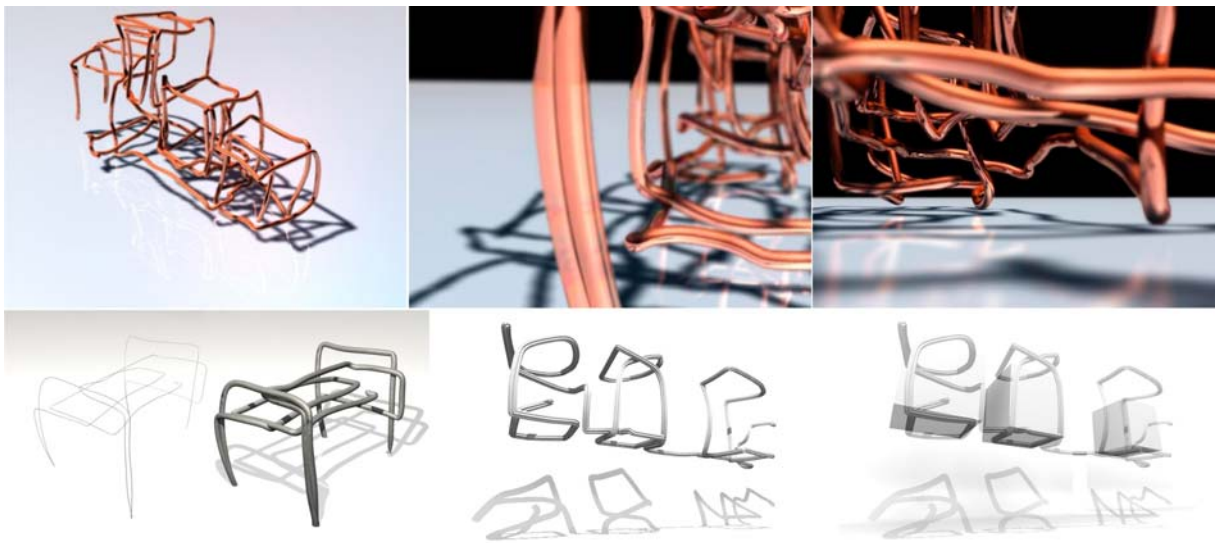
Student D: controlling a deformation node connected to an object with two hands and his head marker;

Workshop 3: “formotions”

The title of the third workshop (which is also the title of this paper) describes rather well what it was about: formotion can be read as the short version of form through motion, or formation by motion. The main difference to the second workshop was that students could use a head mounted display during their interaction with the virtual model. Our initial enquiry was stated as: *“Is it possible to let a first sketch become an object, to design directly onto space?”*

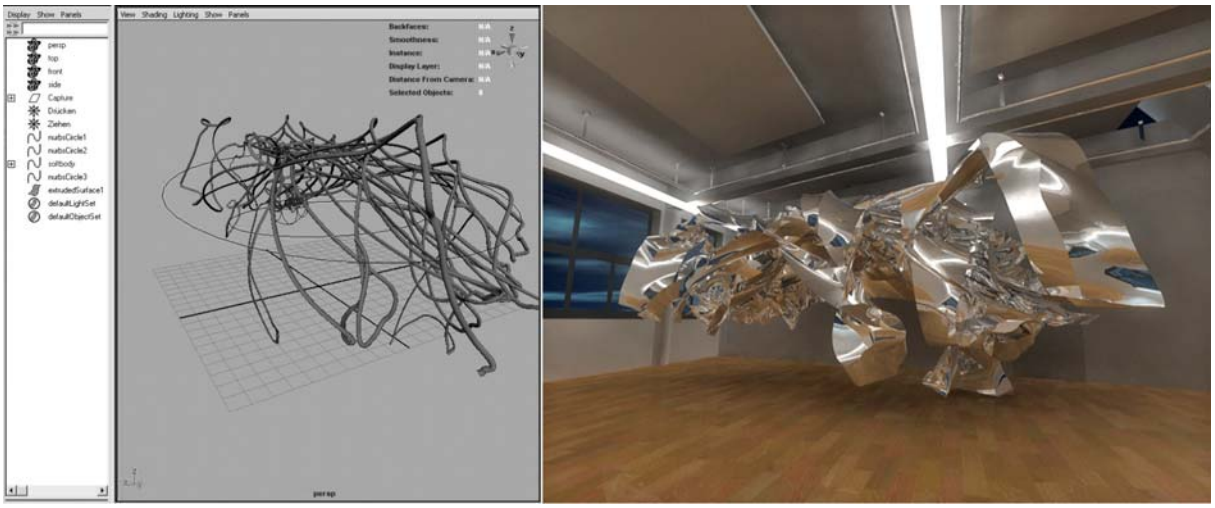
In using the Animation software Maya in a somewhat unusual manner, the students had to create, modify and visualize formations of different objects and the relationships between them as design proposals in real-time. In connection with the 3D-Motion-Capture System from VICON we invented a new method to digitize natural body movements and project them immediately onto virtual realms. Therefore we are able to extend the linear design process – from our intellect through our hand to a novel medium of abstraction – with the simultaneity of those mentioned steps.

Thereby, the tracking space itself became our interface. As a warm-up assignment – called “blind reviving”-, the students were asked to redraw a piece of furniture into space (without wearing the head mounted displays, thus not seeing what they were drawing).



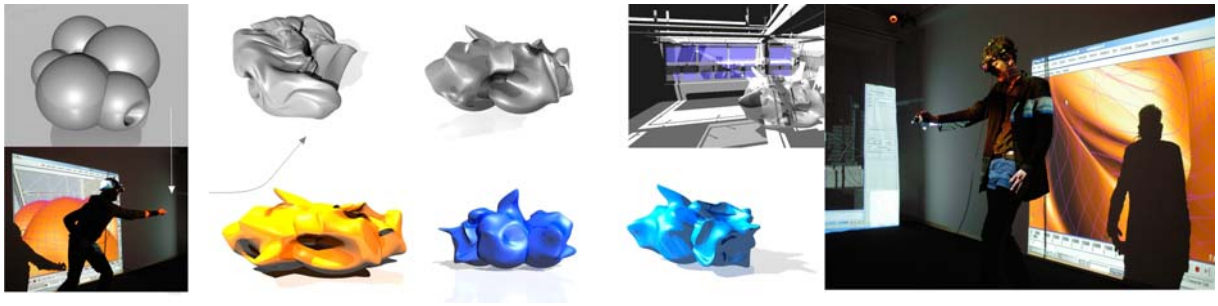
“Blind Reviving”: pieces of furniture redrawn in real-time into space like a freehand sketching in 3D;

While the resulting spatial sketches seemed somewhat clumsy, they turned out to be good starting points for further investigations. Some sort of sketching in space is probably the most obvious initial idea one might have about a 3d interface for a design tool. But despite their quirky aesthetic qualities, the furniture sketches suggest that, when operating in space, sketching might actually not be the most successful metaphor.

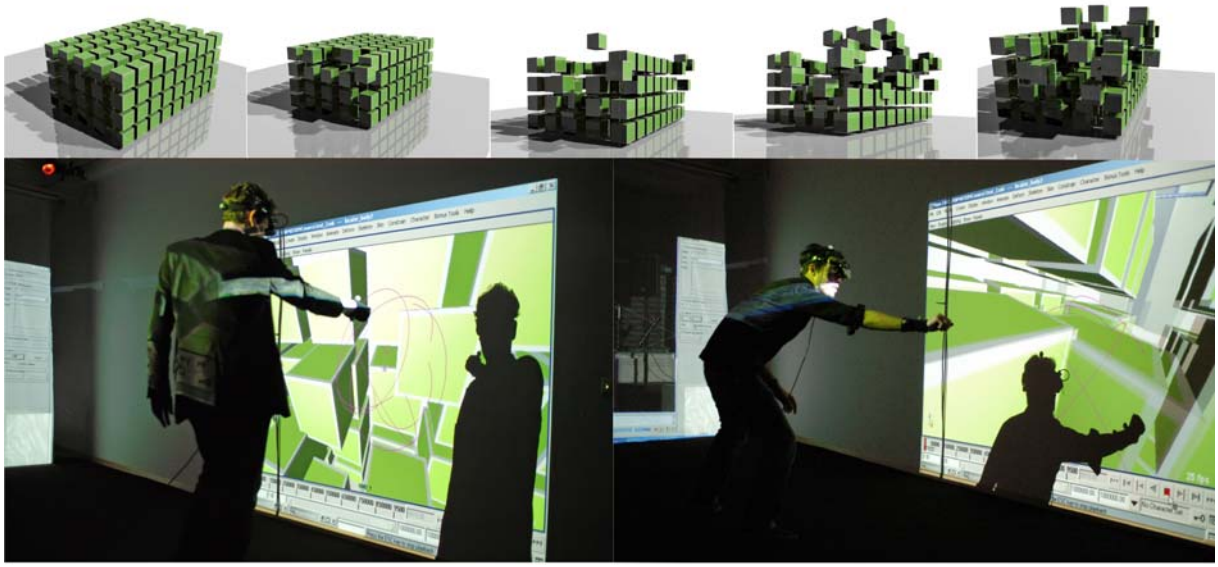


The space drawings (3D Taping) of the redrawd objects were then developed further in Maya and placed into the virtual model of the no_Lab; The right picture shows an exploration of the "borders" of the tracked space, border hulls, border-"lines";

The ideas the students came up with in the phases after this first test were often inspired by less refined movements: pushing and pulling, blowing… It turned out that the dynamics engine of Maya provides some very effective modes of interaction, that the students experimented with in their Formotion projects.
One idea put forward by the teachers was to conceive of the role of the computer in these projects as enabling 'Augmented Daydreaming'. The immersive feeling of being able to physically walk around a virtual model and the possibility to interact with it in the soft and indirect ways the dynamics engine allows really brought out this feeling in the students.



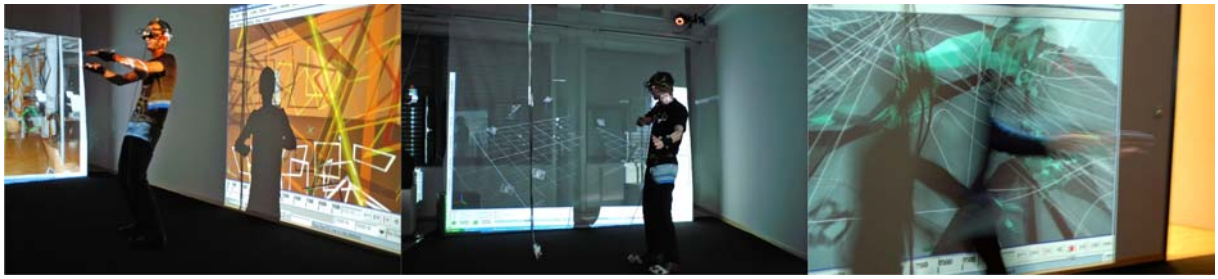
Using the virtual model of our lab as the setting, students had to come up with a scenario of how they could interact constructively with a virtual model. Student E shaping a soft, ephemeral object with a virtual blowdrver;



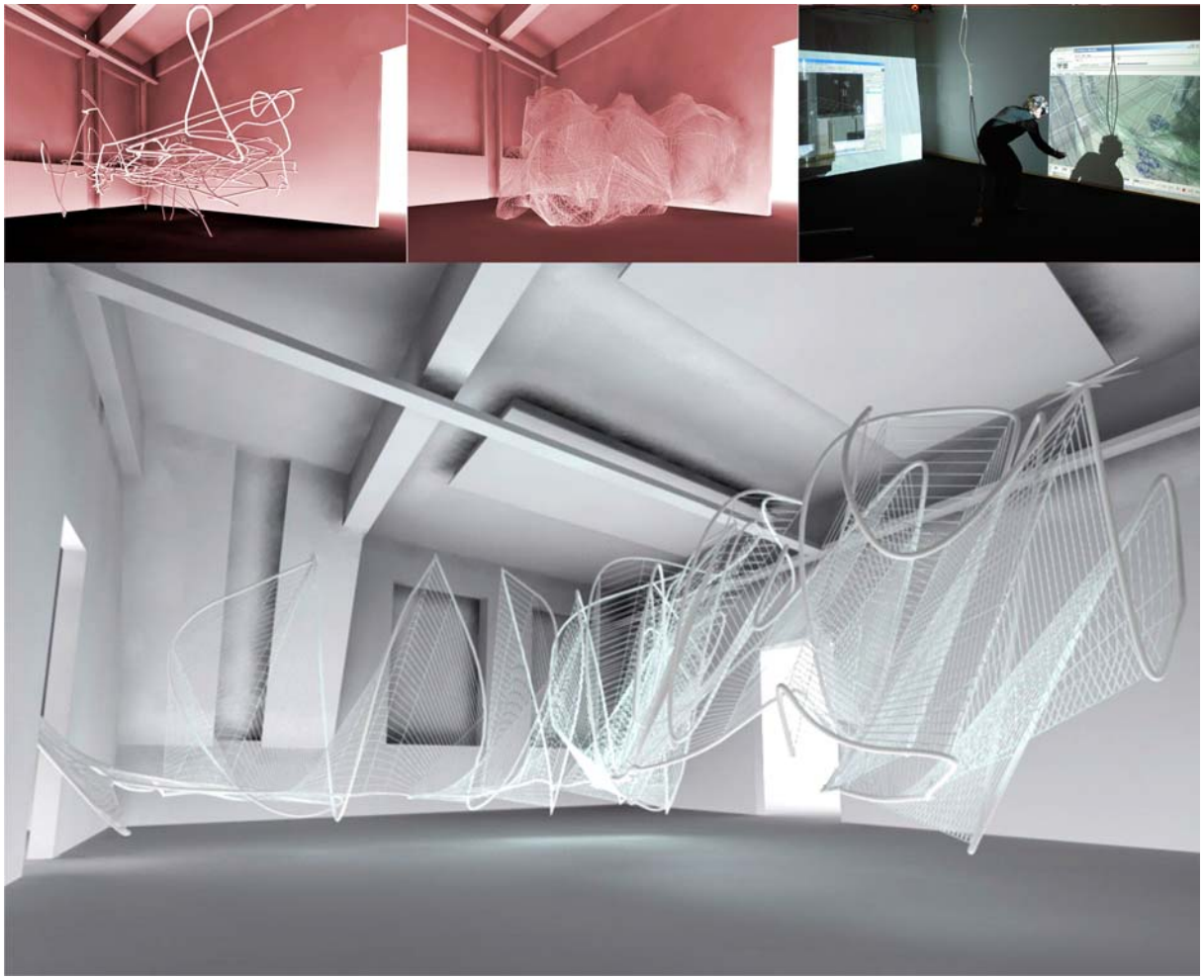
Student F differentiated between pushing and pulling by turning his hands around, which proved to be a very successful gestural metaphor that people picked up easily;

Beside the dreaminess, some projects also featured real inventions. One student differentiated between pushing and pulling by turning his hands around, thereby triggering the force field attached to his hand's position to change direction. This turned out to be very effective and was also immediately understandable for other users who picked up on it almost instantly.

One student worked on spheres with a wind field, effectively shaping a soft, ephemeral object with a virtual blow-dryer. There is something idiosyncratic about operating a virtual blow-dryer, but as a way to define large, curvy shapes it seemed to be very practical. It reminded one of the experiments in wind channels that are done in car design; with much less overhead, of course. To subsume, all the investigations during this workshop do concern an individual research, which can somehow be located between 3D-Drafting, 3D-Taping and 3D-Painting in connection with personal feeling.
"…feeling and thinking while acting" (Protzon, 1993).



Midweek Impressions: testing the interface in different manner using and acting with a HMD; The immersive feeling of being able to physically walk around a virtual model with the HMD and the possibility to interact with it in the soft and indirect ways the dynamics engine allows, really brought out this augmented feeling in the students.



Student G: investigations and transformations on the imaginary spatiality between the stones inside the Zen garden (Ryoanji Tempel Kyoto)

Conclusion

In this paper we described three different workshops that explored motion tracking and gestural interaction with virtual models as ways of designing, making use of an advanced optical tracking system. Given the 'indirect' approach and the limited time of the workshops, the projects presented in this paper are obviously not meant to be understood as fully fledged gestural design tools. Nevertheless as experiments they are indicative of the potential of gestural interaction in design and provide ample reasons why this area should be explored further.

The results of the workshops suggest the following future tendencies:

- **"Craft is back"**: the computer is more and more turning into a tool for both the mind and the hand.
- **"Build the tools you build with"** (Kapoor). Our having the students use their (limited) MEL scripting skills as part of their design projects was successful. We are particularly happy about this, as we believe that the richer the technological possibilities are getting, the more urgent is the need for designers to also control the design of their tools. In order to get the full potential of the technology we have to start designing the way we design.

Furthermore, the workshops are examples of how we can explore digital (realtime-) environments as places where the creation and reinterpretation of abstract architectural design processes using a variety of digital and physical media can unfold. The use of rapid prototyping systems (such as 3D Printer, Laser cutter, CNC Milling Machine) was not focused on much in this paper, but they were available and must be seen as part of the general context within which this work was done. We conceive of the design process as augmented by things – a hybrid meta-model of things and machines which help us think. The investigations made during these workshops used the no_LAb as a facility for **"augmented daydreaming"**, involving not only student's creative thinking, but their whole bodies in their individual design processes in correlation with their own personal feeling and thinking.

In this environment, the non-orthodox goals and content of the workshops in combination with the intense collaboration with the students proved to be a successful strategy for design research. Using deliberately induced errors, the forced changing of media and wilful "misinterpretation" of design artefacts, digital media and its immersive applications did not create limitations, but rather evoked new insights and encouraged creative contemplation about design. Thus, based on our experience, it seems possible that the entire architectural design process can be redefined from the inside out. Going back to the need to build our own tools, mentioned above: Maybe the tools we need to build are environments!

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