An ecological approach to E-motive Architecture

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ABSTRACT: The research work presented here deals with the relation between building shape and energy state. We examine future possibilities to control the indoor climate by means of changing the transparency of the skin as well as the building’s shape and thereby its volume in a smart way. Neither changing transparency nor changing shape is to be understood as an energy-consuming process with contemporary kinetic structures. Instead the research bases on future smart nanotechnology materials that will be capable of changing their shapes by applying ultra low control voltage. In the ongoing research project two small case study applications have been developed. Using a free plug-in internet browsers they can be ‘played’ by anybody interested in exploring possible future non-static architecture in four dimensions. One application adjusts the transparency of a building’s skin to control the indoor temperature and the amount of penetrating sunlight. The other application contains a building that changes the shape of its solar energy capturing skin according to the sun. Over the course of the day a hump ‘migrates’ from the East side to South to West.

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INTRODUCTION

The term ‘E-motive Architecture’ refers to buildings that in a first place react according to stimuli from both the users and the environment [1]. Sliding doors triggered by motion-detection sensors can be seen as already common examples of motive architectural parts in a smaller scale.

But our work bases on the notion of an E-motive building as a whole instead of the notion of a building as an accumulation of interactive parts. Such a motive building establishing interactivity between building and user has to consume energy, of course. So the question arises how comfort and other promising properties of future ‘E-motive architecture’ can be achieved in an ecological way.

The ‘E’ in the term ‘E-motive’ is supposed to become also an abbreviation for ecology.

2. RELATION BUILDING AND ENERGY

Starting point for our work is a vision to establish a visible relation between a building’s shape and its energy state (see Fig. 1).

Based on the notion of E-motive architecture our idea is to adjust a building’s skin in real time to match the requirements needed in the very situation in a smart way. So the volume of the building envelope should in general be minimised.

The benefit of this approach is that e.g. during a heating period in wintertime the amount of air that needs to be mechanically heated is reduced. So less energy will be consumed. To establish such an adaptable motive skin it is helpful not to distinguish between wall and roof. In a first place the whole skin has the same tasks: to form an interior space that protects physically against water and snow and provides a comfortable indoor climate in terms of temperature, light, oxygen offer etc.

Furthermore the shape of the skin is supposed to immediately lead rainwater away without obstacles in order to prevent evaporation or possible leakiness.

Figure 1: Vision interactive building
This way a maximum amount of water can be collected for further usage.

Having these goals in mind non-rectangular shapes in the section seem to fit best (see shapes in Fig. 1). Such shapes can especially help to minimise the volume.

3. CASE STUDY APPLICATIONS

3.1 Changing transparency

The first computer-based case study application deals with illuminance and energy. Given a fixed building shape the interactive simulation tool in a first place calculates both illuminance and energy inside the building at a given time.

A menu offers to do the calculations either in summer, winter or spring/autumn. Illuminance and energy are being calculated based on a tiled skin whose tiles are capable of taking in one of three possible stati: transparent, translucent, opaque.

3.2 Changing shape

The other case study application developed so far deals with another approach to improve overall energy balances with the help of future smart technology. Based on the notion of E-motive architecture the idea is to adjust the shape of the pv-cell covered skin orientating to the sun. With a shape changeable in realtime we can achieve that sunrays hit a lot of pv-cells in an efficient angle of almost 90 degrees.

We can imagine that at sunrise some skin tiles looking to the east side should take an almost vertical position. By doing so a hump will be formed. This hump ‘migrates’ in the course of the day – roughly from the East side to the South side to the West side.

The main parameters used for the forming process are horizontal and vertical angle of the sun. These values are integrated by virtue of a formula. That means that the application is capable of calculating the angles at each desired time – not only in the course of a day, but also in the course of a year.

4. FROM THEORY TO PRACTICE

4.1 Conditions

Today’s technology does not offer possibilities to turn the work of our case study application into practise at reasonable conditions. Kinetic structures e.g. capable of changing a building’s shape would consume more energy than optimised pv-cell positions could ever win back.

Instead the desired building skin is supposed to be flexible but still strong enough to support itself without depending on a load-bearing primary structure. The vision is to have a smart material with properties of both rubber and steel. Smart in this case means programmable or even self-adjusting in terms of shape and transparency level.

4.2 Promising nanotechnology

Research done raises hope that we could have such materials at our disposal in the future. Nanotechnology promises to be the main driving force towards materials with phantasmagoric properties [2]. This is particularly interesting as our hopes concern a building’s skin - hence an object in the macroscale.

The term nanotechnology however - the prefix ‘nano’ deriving from the Greek word for dwarf - describes in general the manipulation of molecules or even individual atoms. Hence it is technique acting upon the nanoscale with high precision. The difficulty of constructing structures in the scale of a nanometer (1 thousandth of a thousandth of a thousandth of a
meter) is that the task does not include merely the actual difficult configuration of molecules. Instead a lot of the fundamental research work being done right now is engaged in constructing the nanotools which do not exist yet either.

But still there are already products being launched that feature improved properties by virtue of applied nanotechnology. Examples include such items as stain-resistant fabric, ski wax, brighter flat-panel displays and tennis balls that keep their bounce longer.

5. FROM NANOTECHNOLOGY TO NANOARCHITECTURE

Architects also dream of materials nanotechnology might offer in days to come. One realistic example is material whose macroscale will be adjusted and controlled by means of ultra-low-voltage electrical circuits in the nanoscale. In short: in reality the skin of our case study buildings would be realised in material consuming little energy to realise drastic deformation.

John M Johansen already drew a sketch showing this approach being used for architectural purposes a while ago [3].

Knowledge gathered in research projects affirm that such processes by virtue of nanotechnology can be performed in efficient parallel operations. Structures created this way are also capable of storing information. The capability of performing operations in parallel even qualifies such nanomaterials to replace today's mechanically driven computer harddisks.

But the vision of nanotechnology's impact on architecture goes far beyond just dreaming of improved material's properties. Again visionary architect Johansen developed the idea of architecture that can be bred just as flowers. Also Johansen expects nanotechnology to help turning his vision into reality within the next 200 years.

Concerning sustainability this notion of future architecture comprises another interesting aspect: Johansen wants his Nanoarchitecture buildings not only to grow from a seed placed in a vessel but also he imagines them fading away after finishing their lifecycles. They are supposed to end up as seeds again. Recycling problems are not an issue anymore.

Hence we can notice a paradigm shift in the notion of architecture. According to Johansen buildings can be as alive as creatures. They might be(come) what Kevin Kelly calls 'vivisystems' – hybrids being both made and born, being both natural products and engineered by humans [4].

Our work presented here however is pointing at a less far future. Applying sophisticated technology is our approach to achieve e.g. satisfying energy balances.

CONCLUSION

We hope to have pointed out two promising examples introducing energetically autonomous self-adjustable smart buildings. But furthermore our proposals are also aiming at establishing a new relation between human being and environment. In both examples the turning of the sun can be experienced from inside the building. This way the viewers senses will probably even be stimulated – emotive architecture hence.

Another aspect: the migrating hump points towards the sun. Thus it displays the energy source and thereby reminds us where most of our energy derives from. (Even wind energy and energy generated by water flows in the sea can be traced back to sun energy.) E-motive architecture becomes narrative and explaining.

In the course of digitalisation ever more electronic items seem to inexorably find their ways into today's homes. Electronic roller shutters, surveillance cameras and door openers connected to personal computers become more and more popular. This questionable tendency towards electrificated and computer-controlled flats denotes a call for action. So it requires also and especially the architect's responsibility to guide the development and try to finally find a twist. With our work we accept the challenge being aware that we cannot stop the ongoing electrification process. But with our work we hope to prove that electrified, even moving building parts and sustainability do not necessarily have to be a contradiction.

We rather believe that E-motive architecture has huge potential. This potential mainly bases on the still almost unexplored promises of nanotechnology. So with our work we would also like to stimulate architects to look into the future and to probably join research groups as well.

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REFERENCES