Thinking Skins – Swarm-Bot Building Envelopes

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Summary: In light of the ever increasing complexity of the demands on building facades, this paper investigates the potential of intelligent building envelopes comprised of swarms of nano robots. These systems could help immensely improve the performance of facades in respect to building efficiency and uncover new realms of spacial/architectural qualities.

Keywords: building envelope, swarm robotics, self-organization

ABSTRACT

The demand on a building's facade are high. As the interface between the outside world and the building's insides, the facade takes on a multitude of (often contradictory) tasks. In the light of increasing climate protective stipulations, as well as heightened expectations of the buildings inhabitants in respect to comfort, it seems that the demands on building facades only ever intensify.

Adaptive facades, which react to a diversity of environmental factors, can be described as a new stage of development in building facades. Adaptive facades generally possess a network of sensor/actuator networks which can be regulated globally or locally. This allows for a high degree of reactivity and adaptivity, although this flexibility is limited to the programmatic specifications of the control system. This paper proposes a new typology of facade: facades which through the application of groundbreaking technology exhibit a functionality and intelligence which reaches far beyond the current concept of an "adaptive" facade.

A conceptional work by the author (Philipp Hoppe) which won, among other things, the first prize for the "Mind21 factory" competition in Graz Austria, (2006) and special recognition for the "Future Cities" competition in Hamburg, Germany (2008), serves as inspiration for the subject. In this work, a building system is controlled by means of an innumerable count of nano robots ("utility fog"). These nano robots can unite in continuously new configurations to react on environmental influences as well user interests.

Such an organizational system, a collective intelligence known as "swarm intelligence", can be observed in nature. For example, in a flock of birds or an ant colony. Swarm intelligence is characterized by the ability of part of a swarm to autonomously make decisions on unpredictable situations for the benefit of the system as a whole. The total system is, as a distributed network, capable of self-organization. Because of a high cost-to-gain ratio, swarm intelligence is particularly economical with resources.

Based on this organizational system, we can envision a new type of facade; facades which are not only reactionary but can exhibit emergent qualities, i.e. are capable of conditionally solving a problem statement and undoing optimization processes. The unique uses and gains which such a system yields are unfathomable. Such facades would not only capable of managing an efficient energy gain-loss system. They would be able to keenly calibrate area specific environments within a building in respect to light screening, heat protection, noise control and ventilation.

The emergent qualities of a swarm system are interesting from an aesthetic point of view. They create out of their own initiative new perplexing structures and could help provide coherence in the confusion that often accompanies a highly complex system. As a subdomain of bionics, which learns in a technical as well as aesthetic sense from nature, the collective intelligence of the swarm offers a high aesthetic potential.

In regards to material composition, "thinking skins" consist of a swarm of nano robots in an endless network. Robots which continuously change position in the network. Robots which continuously negotiate with environmental factors and in turn manipulate internal programming. And therefore, these robots live in an interactive matter.

In an advanced development phase, nanobots can even change their individual size by means of material transformation and can even reproduce. The programming of the system knows no bounds. The nanobots have the continuous ability to learn. They will continually reprogramm themselves and consequently continually optimize the overall system.

References