Adaptive Building Intelligence

This diploma thesis about *Adaptive Building Intelligence* was conducted during the period october 2003 till december 2003 (7.5 weeks). The project is a cooperation between the HSR and the INI (Institute of Neuroinformatics, ETH/University Zurich), and was supervised by Prof. J. Joller (HSR) and Prof. R. Douglas (INI).

Modern approaches to the architecture of living and working environments emphasize the dynamic reconfiguration of space to meet the needs, comfort and preferences of its inhabitants. The configuration can be explicitly specified by a human building manager, but there is now increasing interest in the development of intelligent buildings, which adapt to the needs of its inhabitants without human intervention.

Framework for a Dynamic Multi-Agent-System

We describe a novel multi-agent framework for intelligent building control that is deployed in a typical commercial building equipped with standard sensors (e.g. presence, temperature, illumination, humidity, wall-switches) and effectors (e.g. lights, window blinds). Agents communicate with each other by an asynchronous, interested based messaging mechanism. Within the multi-agent-system it is possible to run multiple different networks with sensors and effectors (e.g. LonWorks, EIB, IP network) because they are preprocessed in an abstraction layer.

We implemented multiple different agents where each is trying to reach its own goal whereby it has to collaborate with some others. There are for example a *StructureAgent*, *BusAgent* and a *ControlAgent* by mention only the most important ones.

Parallel Fuzzy Controller Architecture with a Temporary and Memory-Based Learning Unit

Usually learning occures on the basis of a pre-defined representation (e.g. number of variables, possible values of these variables) which implies that the underlying structure of the problem itself is static. That fact (or assumption) reduces the complexity of the learning. But in the case of an intelligence building, we can not assume such a stability. Structure must be able to detect and incorporate structural changes at any point of time. We think hereby by incorporating new devices or changing the physical structure (e.g. by installing new walls in a multi-office working environment).
Furthermore the behavior of the inhabitants is not deterministic. There are a lot of different situations with a different behavior which can not be measured by sensors. Therefore, we extended our framework with a novel online learning algorithm with two parallel units. One is learning a temporary set of rules where another takes also already learnt knowledge into account. Our learning algorithm is capable of learning a maximal structure fuzzy rulebase from very sparse user interaction in an unsupervised environment.
Many small agents control and learn about sub-parts of the whole environment whereas they use a hybrid controlling architecture. Imprecise knowledge is represented with human readable fuzzy rules and decisions are made with a fuzzy logic controller. A genetic learning algorithm adapts and incorporates new acquired knowledge into the current rulebase. Genetic search is guided with an adaptive boosting algorithm to find an optimal set of rules which covers only these states which are really reachable by the buildings sensors during normal operation.

In our new approach all decision making is now fuzzy. The architecture of our controller and the learning algorithm are specifically designed to continually adapt the decision making processes almost in realtime according to the sparse feedback it receives from the inhabitants. An virtual agent generates rewards if users are satisfied with the current state of effectors because they can only give negative feedback to the learning system by punishing the systems decision and changing the effectors state.

Further information are available on the project homepage: http://abi.ini.unizh.ch