# Discovery of logical structures in a multisensor environment based on sparse events

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Modern approaches to the architecture of living and working environments emphasize the simple reconfiguration of space to meet the needs, comfort and preferences of its inhabitants and to minimize the consumption of resources such as power. The configuration can be explicitly specified by a human building manager, but there is now increasing interest in the development of intelligent buildings equipped with standard sensors (e.g. presence, temperature, illumination, humidity) and effectors (e.g. lights, window blinds, wall-switches) that adapt to the needs of it's inhabitants without human intervention.

We describe and demonstrate an algorithm that dynamically discovers and hierarchically clusters related sensors and effectors. Based on the temporal occurrence of events, generated by sensors and effectors, we build up a weighted directed graph. These weights are event-dependent and are constantly adapted based on a Hebbian style learning algorithm. In a second step the graph is partitioned using a normalized cut [1] algorithm. The partitions of the graph are small clusters of logically related devices.

The problem itself can be shown to be NP-complete. For the particular application in our intelligent building environment, several assumptions regarding causal event sequences had to be made; but the concepts and algorithms are fairly general.

The algorithms were implemented and tested using real data from a mixed intelligent / standard business environment. It can be shown that the discovered clusters directly correspond to the office and suboffice structure of the building.

This dynamic structure discovery system is part of a multi-agent-based intelligent building system project[2].

## References

[1] Jianbo Shi and Jitendra Malik. Normalized Cuts and Image Segmentation. *IEEE Transactions on Pattern Analysis and Machine Intelligence, 22: 888-905, 2000*

[2] Ueli Rutishauser et al. Online learning from sparse data by an intelligent building controller. *Abstract for IEEE Transaction on Systems, Man and Cybernetics Part A: Systems and Humans, Special Issue on Ambient Intelligence, 2004. In Submission.*