DEPARTMENT OF COMPUTER SCIENCE

A Hierarchical Fuzzy Genetic Multi-Agent Architecture for Intelligent Buildings Sensing and Control

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Problem Definition

- According to building managers and architects “An Intelligent-Building is one that provides a productive cost-effective environment through the optimisation of four basic elements; systems, structures, services, management and the inter-relationship between them.
- Computer scientists, however, have a very different view of intelligence. In the context of a building, a system works by taking inputs from building sensors (light, temperature, passive infra-red, etc), and using this and other information to control effectors (heaters, lights, electronically-operated windows, etc). If this system is to be intelligent, an essential feature must be its ability to learn and adapt appropriately. Thus the notion of “autonomous governing” is important, as it implies a system which can adapt and generate its own rules

Intelligent systems

•an intelligent system should be able to learn quickly from large amounts of data therefore using fast learning.

• An intelligent system should also adapt in a real time and in an on-line mode where new data are accommodated as they come.

•Also the system should be able to accommodate in an incremental way any rules that will become known about the problem. It should be memory-based, plus possess data and exemplar storage and retrieval capacities.

•It also should be able to learn and improve through active interaction with the user and the environment.

•It should have parameters to represent short and long term memory, age, forgetting, etc. It should also analyse itself in terms of behaviour, error and success. To the my knowledge no system in the field of machine learning satisfied these conditions and applied to difficult problems such as online learning and adaptation of outdoor robots.

Our definition of IB

•We propose an IB definition “An Intelligent-Building is one that utilises computer technology to autonomously govern and adapt the building environment so as to optimise user comfort, energy-consumption, safety and monitoring-functions”.

•We view an IB as computer-based systems, akin to robots, gathering information from a variety of sensors, and using embedded intelligent agent techniques to determine appropriate control actions. In controlling such systems one is faced with the imprecision of sensors, lack of adequate models of many of the processes and of course the non-deterministic and sometime idiosyncratic aspects of human behaviour.

Why using Fuzzy Logic and Genetic Algorithms for control and learning

•Fuzzy logic offers a framework for representing imprecise, uncertain knowledge.

• It uses a mode of approximate reasoning, which allows it to deal with vague and incomplete information.

•It exhibit robustness with regard to noise and variations of system parameters.

•However it have the problem of determination of its parameters. In most fuzzy systems, the fuzzy rules were determined and tuned through trial and error by human operators.

• Also it suffers from the curse of dimensionality problem.

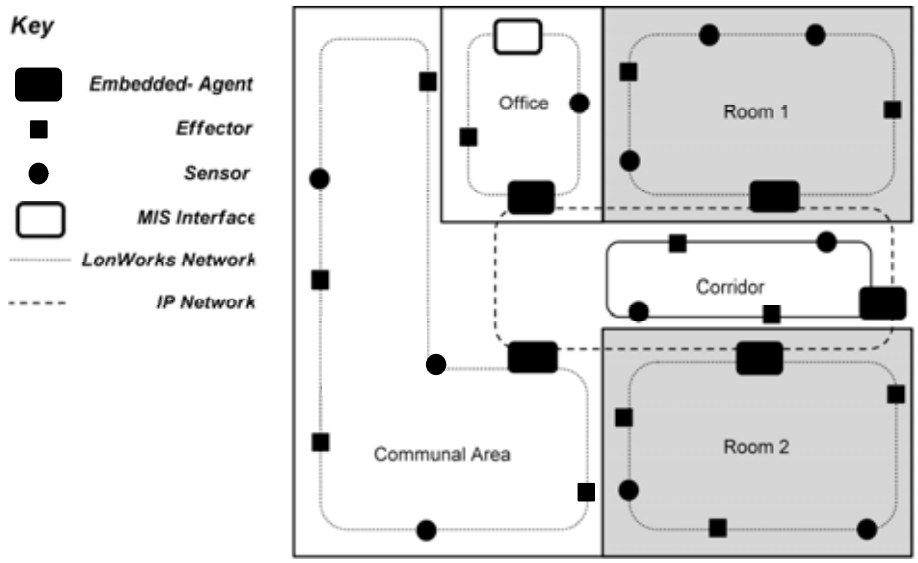
•Evolutionary algorithms constitute a class of search and optimisation methods guided by the principles of natural evolution.

•But usually it takes a large number of iterations for the GA to develop a good controller thus it is not feasible for a simple GA to online learn and adapt a robotic controller.

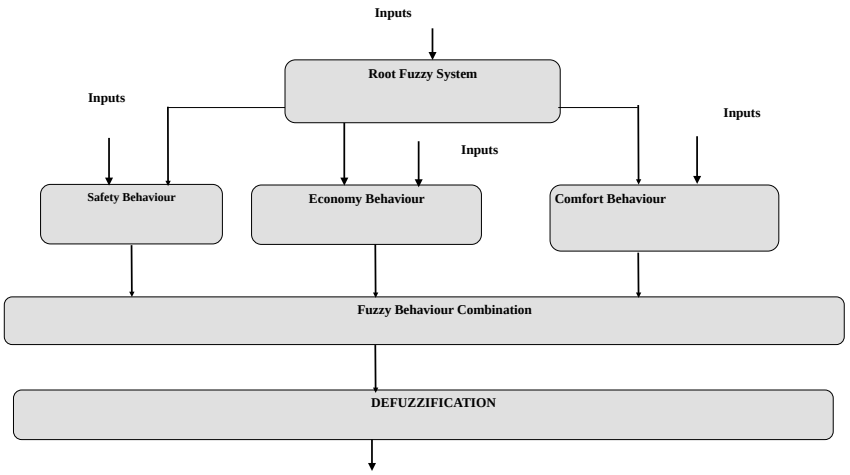
•Unfortunately, most of the evolutionary computation methods developed so far assume that the solution space is fixed, i.e. the evolution takes place within a pre-defined problem space and not in a dynamically changing and open one, thus not allowing for real on-line adaptation.

•The implementation so far has been also very time-consuming, and this also prevents them from being used in real-time applications.

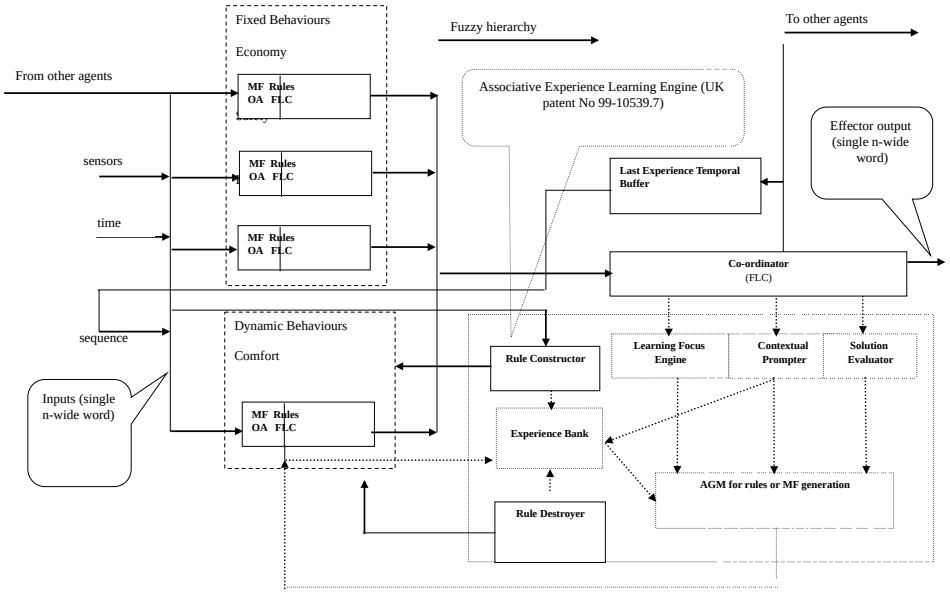
Distributed Architecture



Fuzzy Hierarchical Controllers



Patented Hierarchical Fuzzy-Genetic Techniques for online learning



Experiments and Results

•The agent was tried under different conditions such as hot sunny days and cold and dark days, also the system was tested with different artificial situations such opening the window or closing the curtain.

•The agent using our patented techniques was able to find a satisfactory rule base for different users in an average of 22 trials which is a small number of iterations that take only 3 minutes of learning and this time is mostly consumed in interacting with the human.

•Our method had also optimised the number of rules by using only the rules that are important to the room occupier, also the system has the ability to adapt to add or delete rules and modify the actions of the existing rules to adapt to the room occupier desires.

•our method had optimised the number of rules from an expected $3^4 = 81$ rule base to only 49 rules.

Conclusions and Future work

- The system had learnt an optimised rule base for the comfort behaviour in a short time interval of 3 minutes.
- Our system according to [Kasabov 98] and [Steels 95] are satisfying the definition of a real intelligent autonomous system.
- For our future work, we will construct intelligent rooms equipped with these agents and we will try to deal with more inputs and deal with different human desires in different rooms in a house.