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World's 'Smartest' House Created by CU-Boulder Team

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Environmentally Sustainable Design

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A former schoolhouse, more than 90 years old, is now what may be the world's 'smartest house', a dwelling whose environment is controlled by a computer system that learns the occupant's daily habits and preferences. The structure was purchased in 1991 by Associate Professor Michael Mozer of the University of Colorado at Boulder's Computer Science Department. It was then renovated and retrofitted with high-technology hardware. Using data gleaned by sensors installed by Mozer and his students, the computer system essentially 'programmes itself' by observing his lifestyle and habits over time, eventually learning to anticipate and accommodate their needs.

Mozer and more than a dozen graduate and undergraduate students have installed 75 sensors and nearly five miles of conductor in the home, as well as actuators to control lighting, ventilation and air and water heating. The sensors continually monitor temperature, ambient light, sound and motion in each room, the opening of doors and windows, outdoor environmental conditions, boiler temperature and hot water usage.

Many homes can be programmed to perform tasks like watering lawns or turning on televisions, but programming a home is a complex and difficult task that few homeowners are interested in doing. The twist is that this house programmes itself by observing inhabitants as they live. The system is based on neural networks, which are learning devices inspired by the working of the human brain. The human brain relies on billions of neurones constantly communicating with each other as they acquire knowledge and form memories. In Mozer's house, artificial neural networks consisting of hundreds of simple, neurone-like processing units interact to predict and control the environment.

The system predicts behaviour and movements, including which rooms will be occupied at what times, when people leave the house and return, and when hot water will be needed in the boiler. The system infers rules of operation and adapts to the lifestyle of the inhabitant, maximising comfort by setting appropriate temperatures and light levels while minimising energy consumption.

In Mozer's house, anticipating and carrying out the wishes of the inhabitant and conserving energy sometimes conflict. So Mozer and his colleagues at the Institute of Cognitive Science of the University of Colorado devised mathematical techniques for translating discomfort to a cost in dollars that can be weighed against energy costs. One technique, based on an economic analysis, depends on the loss in productivity that occurs when the system ignores the inhabitants' desires. Another technique adjusts the relative importance of the inhabitants' desires based on how much they are willing to pay for gas and electricity.

Even if the inhabitants do not have a particularly regular schedule, there are statistical regularities in their behaviour that the system can exploit. For example, if Mozer is not home by 3 am, he likely will not be home by 4 am and therefore the house does not need to be warmed up. Mozer demonstrated the bathroom light, which turned on to a low intensity as he entered. The system picks the lowest level of the light or heat it thinks it can get away with in order to conserve energy, and occupants need to complain if they are not satisfied with its decision. As an example to express discomfort, a wall switch when operated causes the system to brighten the light and to 'punish itself' so that the following time the room is entered, a higher intensity will be selected.

The house has been the source of a dozen student research projects and two masters theses, and is a good testing ground for undergraduates who have never built anything in the real world. Much of Mozer's neural network research has been funded by the National Science Foundation. For further information, contact:

Michael Mozer: (303) 492-4103 or Jim Scott: (303) 492-3114;
e-mail: mozer@cs.colorado.edu ;
http://www.colo.edu

Energy Consumption in Schools

In May 1997, the Ministry of Education of Quebec published the results of a survey on energy consumption in schools for the year 1996-97. Data concerning 94.8 per cent of the total surface of public schools real estate were provided, reflecting 91.3 per cent of the total number of schools.

Major conclusions of the study were:

- there has been an increase of energy consumption of 4.0 per cent in comparison with the previous year;
- the total cost of energy increased by 4.6 per cent over 1994-95, from Can$ 149.0 million to 155.9 million, in spite of a 3.5 per cent decrease of the cost per unit ($ per GJ);
- electricity in bi-energy mode is 15 to 20 per cent less expensive than other fuels;
- the number of buildings heated with electricity changed very little. On the other hand, about 150 buildings that used to be heated with oil are now gas-heated;
- electricity still represents the most commonly used form of energy (50.7 per cent), whereas gas represents 40.7 per cent. Oil consumption has been decreasing since 1992-93 and currently represents 8.6 per cent of the total. Other forms of energy (propane, etc.) represent only 0.02 per cent of the total;
- thanks to energy savings expenses have slightly decreased in 1995-96.

Detailed data are included in the report *Bilan 1995-96 concernant la consommation énergétique du réseau des commissions scolaires*, published by the Ministère de l'éducation, direction générale du financement et des équipements, Direction des équipements scolaires, 1035, rue de la Chevrotière, 14ème étage, Québec (Québec) G1R 5A5; fax: 418 643 9224.