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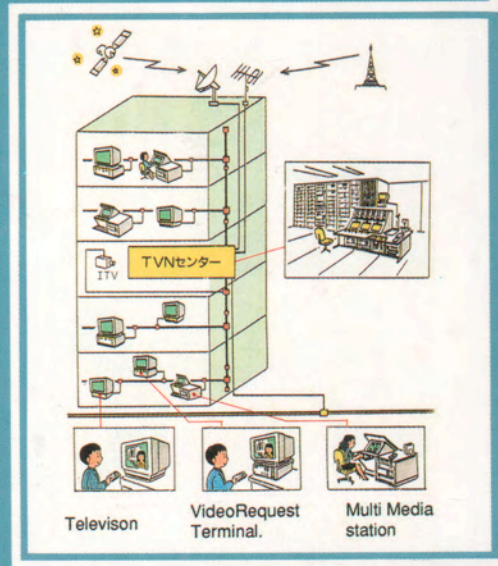
CNR  
Italian National Research Council



ICITE  
Central Institute for Building Technology



Edited by  
Annalisa Morini



# Information technologies for buildings in a changing society

Proceedings  
Capri, October 1992

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**i**nformation technologies for buildings  
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# **INFORMATION TECHNOLOGIES FOR MAINTENANCE AND MANAGEMENT OF THE URBAN BUILDING STOCK**

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## *Abstract*

*Information technologies and advanced software can be crucial for an appropriate maintenance and management of urban building stocks. The paper focuses on a building expert maintenance system, based on a Neural Network Pattern Associator Technique (NNPA), which associates the information on the building to be 'identified' with the information and data stored into a statistical building database module.*

## 1. INTRODUCTION

Maintain comes from *manutenere* or *manu tenere*, lit. to hold in the hand, fr. manu (abl. of manus, hand) + tenere, to hold. It means to keep in a state of repair, efficiency or validity; preserve from failure or decline. Now, the maintenance activity is becoming more and more a softainance activity, from soft (contraction of software) + tenere, to hold, due to the large use of computerized system for assessing, forecasting and programming the building maintenance. We can identify three kinds of software based tools for building maintenance (softainance):

b. self evaluation tools for building degradation auditing

The purpose of self-evaluation tools and software is to assist the auditor in dealing with 'how' to initiate a building maintenance program. Checklists and rating scores assist in determining the type of corrective action required. Recommendations to improve any faulty conditions and cost analysis are generally included in this type of tools (Figure 1).

c. decision support systems for building maintenance through expert systems

In this area, the research activity has just started, and there are few examples of operational applications.

Most of the effort has been devoted to the development of 'expert' software on specific topics: i.e., selection of facade paintings, energy efficient building design, technical performances of roofs, etc. However, the area of expert systems for building maintenance is of strong interest for institutional building owners, private real estate corporations, insurance companies, public housing authorities, etc.; and major efforts in the future can be easily expected, as the one here presented.

## 2. BUILDING EXPERT MAINTENANCE SYSTEM

SEMPER is a demonstration program oriented towards the development of knowledge based software for maintenance audit of buildings.

SOFTECH is developing SEMPER under a three years contract with the Italian National Research Council Building Program.

The method of SEMPER consists of the full expression of a knowledge based recognition system of maintenance needs of buildings.

The current field of application of the demonstration software is the maintenance planning on residential housing stocks, but future developments of the database modules would permit different application fields to the software.

The tool operates to select Building Maintenance Opportunities (BMO) and to predict the effects due to candidate BMOs, in account of the 'experience' coming from the results of a high number of building audits stored in the system, which constitute the knowledge reference. The model can be considered a decision support system based on the 'experience'. Software implementation on DOS platforms, C language, Microsoft Access Windows as interface, can provide for the system the necessary evolution and future expansion.

### MODEL STRUCTURE

The "expert management system" framework can be summarized in few basic steps, corresponding to different functional modules or 'objects':

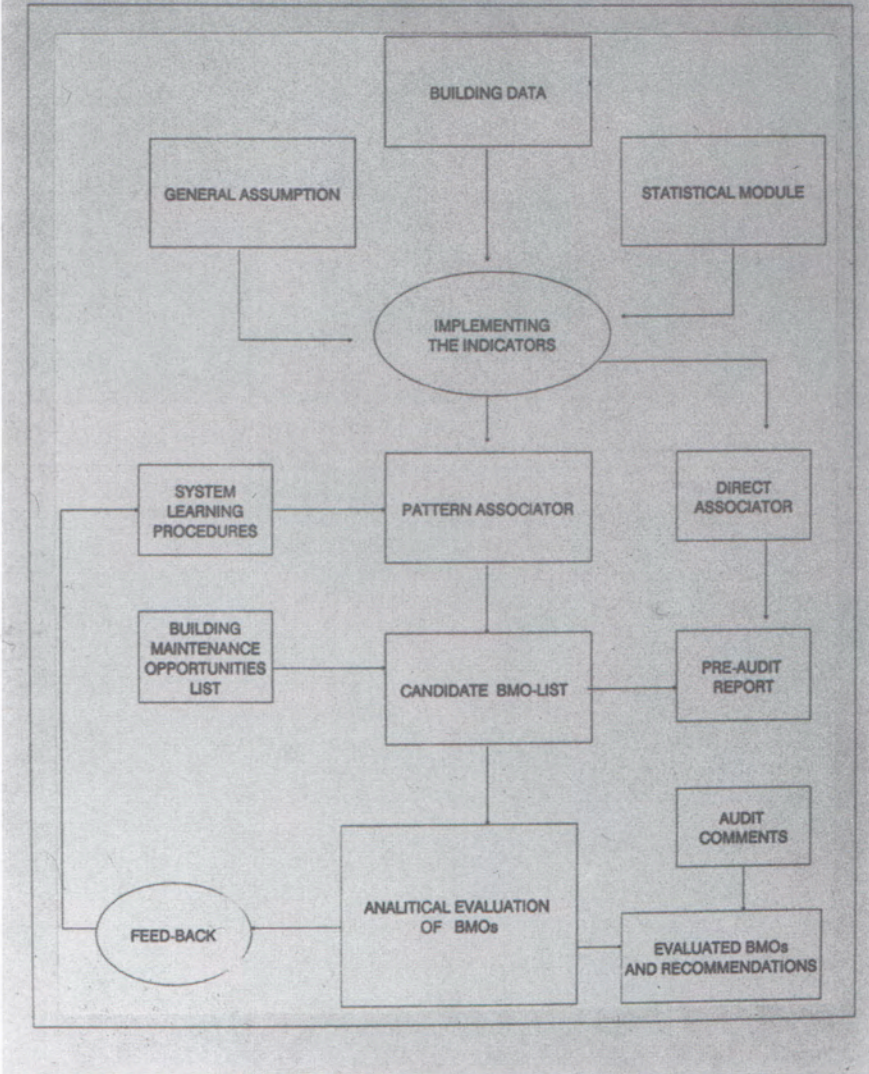


Figure 2. Structure of SEMPER model



maintenance opportunities forecasting (i.e. unitary consumptions, surface/volume ratios, etc.).

- Pattern associator

It is the 'core' of the model. It relies on a Neural Network Pattern Associator Technique (NNPA) which associates the information on the building to be 'identified' with the set of data stored into the building database (statistical module) (Figure 4).

SEMPER system uses a NNPA to guess plausible recommendations and an appropriate subset of Building Maintenance Opportunities that are very likely to be suitable for the case under investigation.

This guessing is drawn from the previous experience of similar audits.

- Direct associator

The model allows to enable the pattern associator, by inserting the type of association of the examined building with the set of buildings included in the statistical module.

- System learning procedures

It consists of an algorithm that re-calibrates the network of the association mechanism, between the examined building and the set of building data stored into the statistical module.

The screenshot displays the SEMPER software interface. At the top, it reads 'SISTEMA ESPERTO PER LA ORGANIZZAZIONE E LA MANUTENZIONE DI GRANDI PATRIMONI IMMOBILIARI PUBBLICI'. The main area is divided into several sections for data entry and selection:

Provincia	MILANO	Comune	Abbadia Cerreto
Quartiere	abbadia cerreto	Fabbricato	0
Indirizzo	roma	n.	3
Anno costr.	1957	N.piani	2
		N.scale	1
Volume lordo risc.	522	SV	0.5
		N.alloggi	4
		Sup. vetrata/Sup. opaca	14

Below this table, there are several input fields and a list of construction technologies:

- Tipologia edilizia:
- Tecnologia costruttiva:
- Spessore parete verticale opaca prevalente:
- Tipologia impianto di riscaldamento:
- Potenza installata (kW):
- Situazione manutentiva:
  - chiusure opache:
  - chiusure trasp.:

The list of technologies includes:

- 11 tradizionale muratura portante
- 12 tradizionale struttura in C.A.
- 13 tradizionale mista
- 21 tradizionale evoluta struttura vert.
- 22 tradizionale evoluta struttura orizzontale
- 23 tradizionale evoluta mista
- 31 prefabbricata monodimensionale
- 32 prefabbricata bidimensionale
- 33 prefabbricata tridimensionale

At the bottom, there is a button labeled 'Campione 60' and a status bar showing 'Record 1'.

Figure 4. Building data: input data and information to be processed by the 'pattern associator'.



- System consult

A routine allows the auditor to access to an HELP module (Figure 6), which can be consulted at any step of the procedure. Once fully developed, the 'consult' module will contain the basic items of a source book for building maintenance, with the following framework:

- List of Retrofit technologies
- Audit Procedures
- Measurement Techniques

- Analytical evaluation of BMOs

This module provides basic assumptions, data sheets, and analytical procedures for the evaluation of Building Maintenance Opportunities. As a result, the procedures intend to give useful information for the design phase.

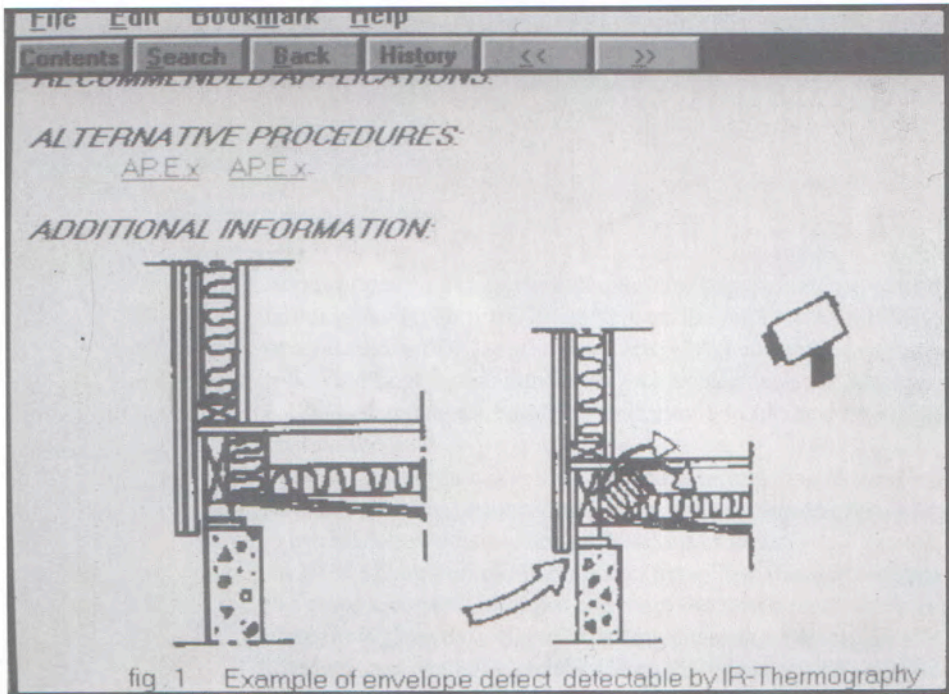


Figure 6. Example of help information in the 'consult' module

a. tools for managing the maintenance activities on large building stocks

They belong to the category of decisional support systems, which allow the management of building stocks, through effective and comprehensive databases. We are talking of conventional information systems devoted to management of maintenance activities and administrative data implemented with some interesting results by many public and private housing authorities.

**SELF - EVALUATING CHECK LIST FOR : \_\_\_\_\_ WINDOW \_\_\_\_\_**

EVALUATOR \_\_\_\_\_

DATE \_\_\_\_\_

UNIT NAME \_\_\_\_\_

SHEET No. \_\_\_\_\_

			WINDOW CONDITION										TOTAL POINTS		
No.	Location	Dating Value Max = 10	Storms	Solar Protection	Tight Fit	Minor Infiltration	Major Infiltration	Cannot Be Opened	Can Be Opened	Weather Stripped					
1	Bldg. 4, Room 401	2	2	2	2	1	0	3	0	1					4
2	Bldg. 4, Room 402		2	2				3		1					8
3	Bldg. 4, Room 609					1			0	1					2
4	Bldg. 4, Room 102		2	2	2			3		1					10
5	Bldg. 4, Room 104,W1		2			1			0	1					4
6	Bldg. 4, Room 104, W2		2				0		0	1					3
7	Bldg. 4, Room 104, W3		2	2					0	1					5
25	GRAN TOTAL														36

$$\text{RATING SCORE} = 100 \times \frac{36}{(7) (10)} = 51\%$$

Figure 1. Example of self-evaluating method.

The model, once fully implemented, will operate in a quite innovative way. Instead of a conventional building auditing software, where data and information have to be fully gathered in order to predict maintenance opportunities, the expert management system acts with the same knowledge mechanism of a human expert, collecting only the information strictly needed to develop preliminary ideas, sort elementary conclusions and provide the subsequent request for information.

This is to reach, as soon as possible, the candidate list of Maintenance Opportunities, by minimizing the cost for getting the information.

The model is driven by a 'pattern associator', for examining the characters of the building and comparing this information with the set of data stored into the 'statistical module'.

### 3. MODEL STRUCTURE

The 'expert management system' framework can be summarized in a few basic steps, corresponding to different functional modules or 'objects' (Figure 2).

- Statistical module

It maintains the essential information on a sample building stock, (currently more than 100 buildings, in perspective 2000 bldgs of the Milan Low Cost Housing Authority), giving the basic knowledge to the pattern associator.

- Building data

Consists of input data and information on the new building (Figure 3a and 3b) which shall be evaluated by the 'pattern associator'.

The input information is classified in the following data sheets:

- general information
- geometry & typology
- degradation
- heating plant
- hot water
- energy bills
- main building characteristics
- technology
- occupancy
- air conditioning
- other plants

- Implementing the indicators

Using the preliminary information gathered in the building data module, the model develops some significant indicators, which allow the building classification and the



File Edit view Records window help

SISTEMA ESPERTO PER LA ORGANIZZAZIONE E LA MANUTENZIONE DI GRANDI PATRIMONI IMMOBILIARI PUBBLICI

**SCHEDA ANAGRAFICA**

Provincia  Comune

Quartiere  Fabbricato

Indirizzo  n.  Codice

Anno costr.  N. piani  N. scale  N. alloggi

Volume  S/N  Sup. vetrata/Sup. opaca

Tipologia edilizia  Tecnologia costruttiva

Spessore pvo  pvo(kcal/m<sup>2</sup>\*C)

Tipologia imp. di risc.  Combustibile

Potenza installata (kW)

Situazione manutentiva:

chiusure opache  chiusure trasp.  coperture

URBANISTICA  
ANAGRAFICA  
TIPOLOGICA  
FUNZIONALE  
TECNOLOGICA  
IMPIANTISTICA  
MANUTENTIVA

Record: 1

Figure 3a. Example of building information sheet included in the 'restricted' statistical module.

File Edit view Records window help

SISTEMA ESPERTO PER LA ORGANIZZAZIONE E LA MANUTENZIONE DI GRANDI PATRIMONI IMMOBILIARI PUBBLICI

**SCHEDA URBANISTICA (1)**

Quartiere  Comune

Anno  Progettisti

Impresa costruttrice

Tipo di finanziamento

Proprietà:

IACPM

Comune

Condominio

Tipologia dell'insediamento:

Quartiere autosufficiente

Quartiere giardino

Isolati a cortina su strade

Isolati con edificazione aperta:

Insediamenti indipendente dalla maglia viaria

Insediamenti sparsi

URBANISTICA  
ANAGRAFICA  
TIPOLOGICA  
FUNZIONALE  
TECNOLOGICA  
IMPIANTISTICA  
MANUTENTIVA

Record: 1

Figure 3b.

The use of a NNPA technique adjusts the quality of the guessing by a sort of statistically settled knowledge on what predicted previously on similar cases. This mechanism needs a 'Supervising Authority' to confirm that the association between the PreAudit information and the whole set of results for the examined building is a good and meaningful association.

A System Learning Procedures module will be provided for such adjustment. For now, this module is under study and not yet available on line: the learning procedures are carried out by the research team outside the SEMPER System, by means of a back-propagation algorithm on some test cases.

- List of Maintenance Opportunities

The pattern associator and the learning algorithm produce, as output, a list of candidate measures, that is the BMO list showing the best fit with the test case (Figure 5). The model allows the user to introduce the measures not included in the list of candidate BMO, when one knows the positive result of them, in order to let the model processing the new information within the learning algorithm.

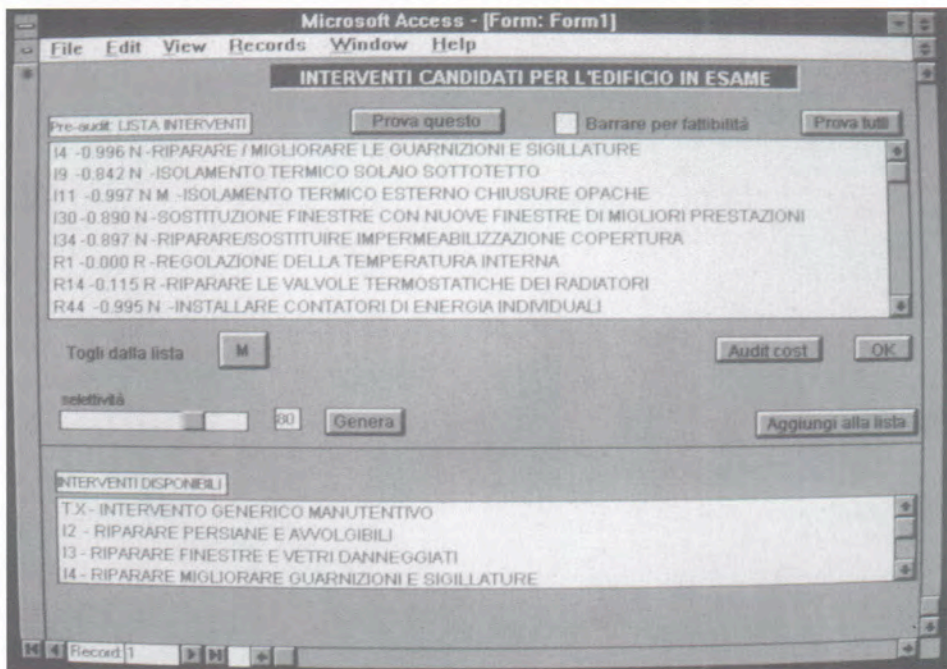


Figure 5. Candidate list of maintenance opportunities for a sample building.

- Preaudit report

Final output of SEMPER, consisting of the presentation of the list of candidate BMOs and related building quality improvements. Referring to planned maintenance operations, the key results listed in the preaudit report will be stored in order to select the maintenance actions to be implemented. A free digitable space for comments of the auditor is also available.

#### 4. OUTCOMES

The procedures here presented are under development and the first release of SEMPER software will be available within the end of 1993. Some preliminary runs of the program and the learning mechanism allow the research team to be optimistic on the quality of processed information and results. Before the research and software completion, a major effort will be devoted to verify the possible application of the tool to interested building stock owners, as well as the future implementation of new modules concerning tertiary and commercial buildings.