TWO APPROACHES TO TEACHING COMPUTERS IN ARCHITECTURE: THE EXPERIENCE IN THE FACULTY OF ENGINEERING IN PALERMO, ITALY

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1. The philosophy of CAAD instruction in the DPCE

Teaching the use of computers in architecture poses the same kind of problems as teaching mathematics. To both there are two possible approaches. The first presents the discipline as a tool of which the merely instrumental aspect is emphasized. Teaching is limited to show the results obtainable by existing programs and how to get them. The second approach, on the contrary, emphasizes the autonomous nature of the discipline, mathematics as much as computing, on the basis of the convincement that the maximum of instrumental usefulness can be obtained through the knowledge at the highest degree of generality and, then, of abstraction.
The first approach changes little in the mind of the student. He simply learns that is possible, and then worthy doing, a certain amount of operations, mainly checks of performances (and not only the control of the aspect, now easy with one of the many existing CAD) or searches of technical informations in some database. The second approach gives the student the consciousness of the manageability of abstract structures of relationships. He acquires then the idea of creating by himself particular structures of relationships and managing them. This can modify the very idea of the design procedure giving the student the consciousness that he can intervene directly in every segment of the design procedure, reshaping it to some extent in a way better suited to the particular problem he is dealing with.
Of course this second approach implies learning not only a language but also the capability of coming to terms with languages. And again it is a cultural acquisition that can be very useful when referred to the languages of architecture. Furthermore the capability of simulating on the computer also a small segment of the design process gives the student a better understanding both of the particular problem he is dealing with and of the very nature of design.
As for the first effect, it happens whenever a translation is done from a language to another one. One is obliged to get to the core of the matter in order to overcome the difficulties rising from the different bias of the two languages. The second effect comes from the necessity of placing the studied segment in the general flow of the design process. The organisation in a linear sequence of action to be accomplished recursively in an order always varying in any design occasion is an extremely useful exercise to understand the signification and the thecnics of formalisation of design problems.

2. The teaching curriculum

In the curriculum of building engineering (lasting five years) in the University of Palermo, two courses deal with computers. The first, *Fundamentals of Informatics* is common to all engineering students. The second is specific for building engineering students and is placed in the fifth year. It is called *Progettazione Edile Assistita ([Computer] Aided Building Design);* it is optional but almost all students follow it. Besides learning the most common types of programs (databases, spreadsheets, word processors, CAD) the students learn a language (generally AutoLisp, since the most frequent work is carried on in AutoCad) and are requested to write a program solving a problem of design. As the course is kept in the same year as the course of *Architettursa Tecnica II)* (a course in which a project is developed down to the executive details) many students use what they learnt in the CAD course in designing and drawing the project.

Some students discuss their degree theses dealing with problems that can be solved with the use of computers.

Hereunder some examples of the students's work follow. The arguments are: modeling pavilion vaults; an assistant to check the placing of sanitary fittings and fixtures in a toilet room; data base for thermo-hygrometric control of a room, control of the thermal comfort in a room through computation of PMV, constrained placing of areal objects within a given perimeter, automatic method for spatial units organization. The first four have been developed during the course of Progettazione assistita, the last two have been discussed as degree theses.

3. Examples of the student's work

3.1 Modelling pavilion vaults

The program generates and draws pavilion vaults on quadrangular plan.

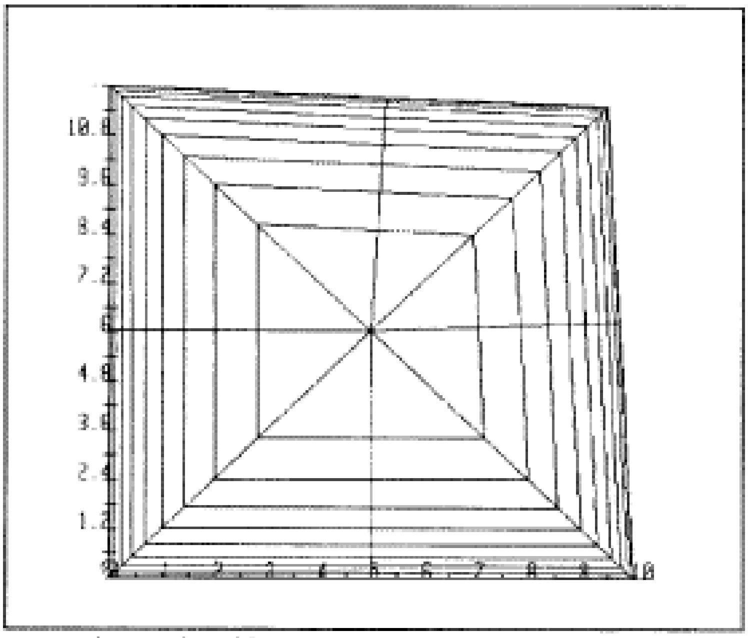

Fig. 1 - Graphic output of the program: plan view

The algorithm is based on Donghi's [1] construction.
The vault is built up in four parts. Each of these is a cylindrical vault having as its generatrix one fourth of an ellipse. The procedure to build up the four vaults is the following:
- perpendiculars to the sides are drawn from the crossing of the two diagonals; each of them is the major semi-axis, the horizontal one, of the generatrix of one vault;
- the vertical semiaxis is common to the four vaults and is the rise of the vault, in the crossing of the diagonals;
- the directrices of the four vault crossing along the diagonals are the horizontal lines parallel to the sides.

The algorithm provides for the representation in plan, section and perspective (rotating according to the point of view).
The program could well become a "primitive" in a 3D modeling CAAD.

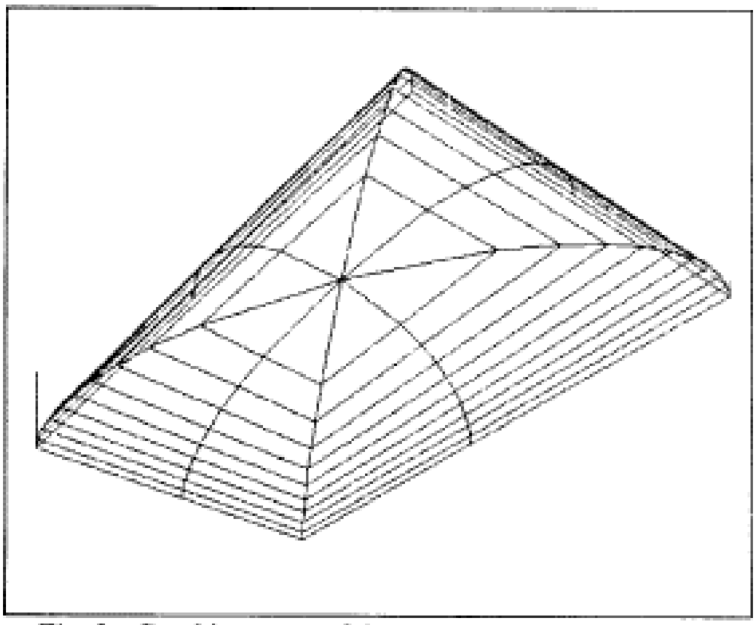

Fig. 2 - Graphic output of the program: perspective view

3.2 An assistant for positioning sanitary fittings and fixtures in a toilet room

The standards of Regione Emilia Romagna (NTR ER) for public residential building, represent a first attempt of a set of instructions and standards of relationships activity requirement-performances.
Starting from the analysis of the requirements deriving form the activities carried in a toilet room, the NTR ER provide for a set of fit spatial configurations of the room.
The progamm Veringo helps the designer in checking the consistency both of the position of the sanitary fittings and of fixtures with the geometry of the room.
Veringo was written in AutoLisp in order to run in AutoCad environment.

[I] ref. Donghi D., Manuale dell'architetto, UTET, Torino, 1935.

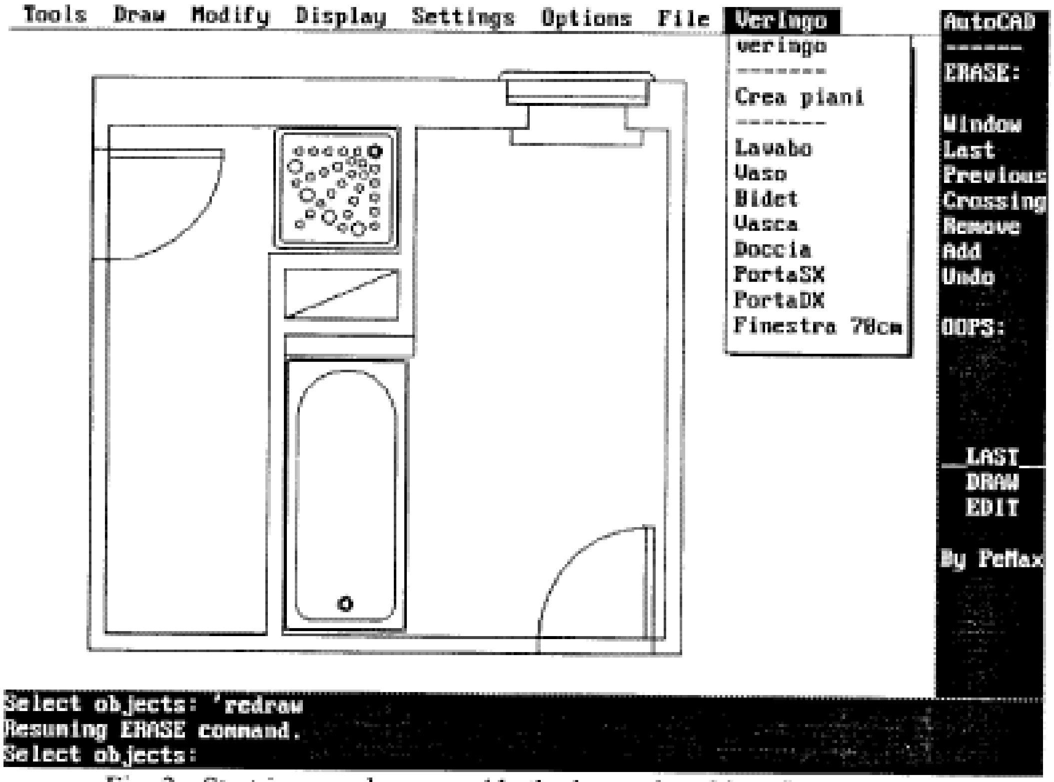

Fig. 3 - Start image: shower and bathtub are placed in a fixed position

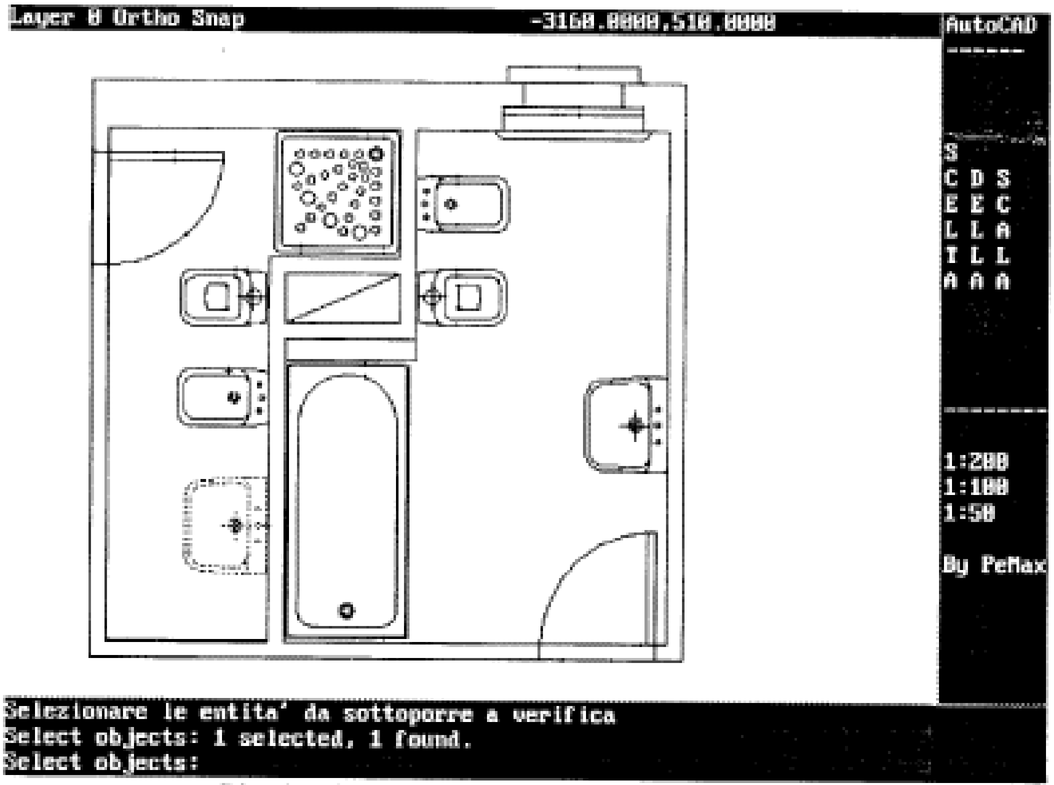

Fig. 4 - Final situation: no inconsistencies detected

3.3 A data base for thermo-hygrometric control of walls

The knowledge and the utilization of relational database programs is of primary importance in a course of CAAD.

A designer can avail himself of such tools in order to build up databases concerning particular problems in the design process.

A program has been set up as an assistant to design multi-layer walls considering their thermo-hygrometric performances.

Verter runs under DBXL, a relational database program DBase compatible that also supports graphic functions. In the Verter's database is possible to store both technical characteristics of wall materials (type, density, conductivity, permeability, thermal capacity) and boundary conditions.

The management of the data-base allows, besides the access to the informations, also to build up the multi-layer wall, later to be verified according to the Glaser method.

By the Verify menu it is possible to review both the wall characteristics and boundary conditions; the results are shown as a table or as a graphic.

In fact a drawing can be generated showing the course of pressures and, when existing, the presence of condensation.

The data of the problem can be interactively modified, thus restarting the verification procedure.

DATI STRATI

CODICE	Spess	Lambda	R	Rv	tf	Ps	Pv	d	ds	cts
Aria A	—	—	–	—	20.0	2338	1169	—	—	—
St.Lim	—	—	0.12	—	18.6	2143	1169	—	—	—
6	20.0	0.350	0.06	1.1	17.9	2051	1148	1200	24.0	18.75
174	20.0	0.039	0.51	6.4	11.9	1393	1021	30	0.6	0.60
86	250.0	0.190	1.32	9.3	−3.6	452	836	500	125.0	38.43
12	30.0	0.400	0.08	24.0	−4.5	419	361	1400	42.0	1.34
St.Lim	—	—	0.04	—	−5.0	402	361	—	—	—
Aria E	—	—	–	—	−5.0	402	361	—	—	—

Spess= 320.0   Rt = 2.13   Rvt = 40.80 E+9   DS = 191.6   C = 59.10

SPESS	=	Spessore	mm
Lambda	=	Conduttività Termica di Calcolo	W/m-K
R	=	Resistenza Termica dello Strato	m^2 K/W
Rv	=	Resistenza al flusso di vapore dello strato	s·m^2·Pa/kg
tf	=	Temperatura Superficiale a valle dello strato	°C
Ps	=	Pressione di Saturazione del Vapore d'acqua	Pa
Pv	=	Pressione del Vapore d'acqua	Pa
d	=	Massa Volumica del materiale dello Strato	kg/m^3
ds	=	Massa Areica dello Strato	kg/m^2
cts	=	Capacità Termica Areica dello Strato	kJ/m^2-K
Rt	=	Resistenza Termica della Parete	m^2 K/W
Rvt	=	Resistenza al flusso di vapore della Parete	s·m^2·Pa/kg
DS	=	Massa Areica della Parete (DS = Σ ds)	kg/m^2
C	=	Capacità Termica Areica Parete (C = Σ cts)	kJ/m^2·K

Fig.5 - Table output

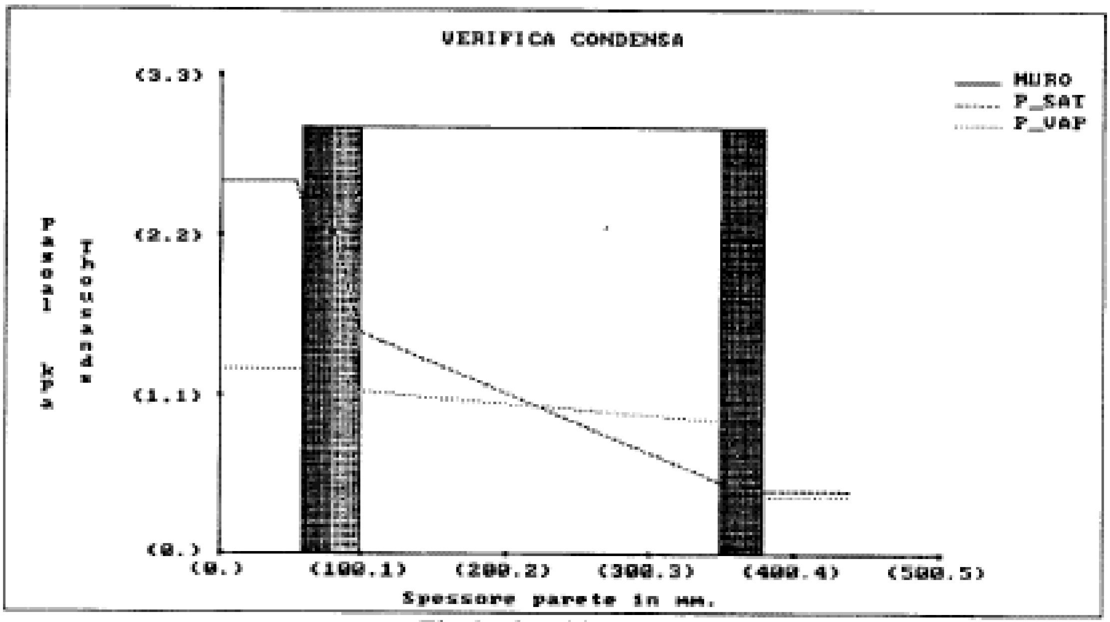

Fig.6 - Graphic output

3.4 Thermal comfort control of a room

In the course of Architettura Tecnica II each student makes a project of a building. He is required to control some environmental performances at least of some rooms.

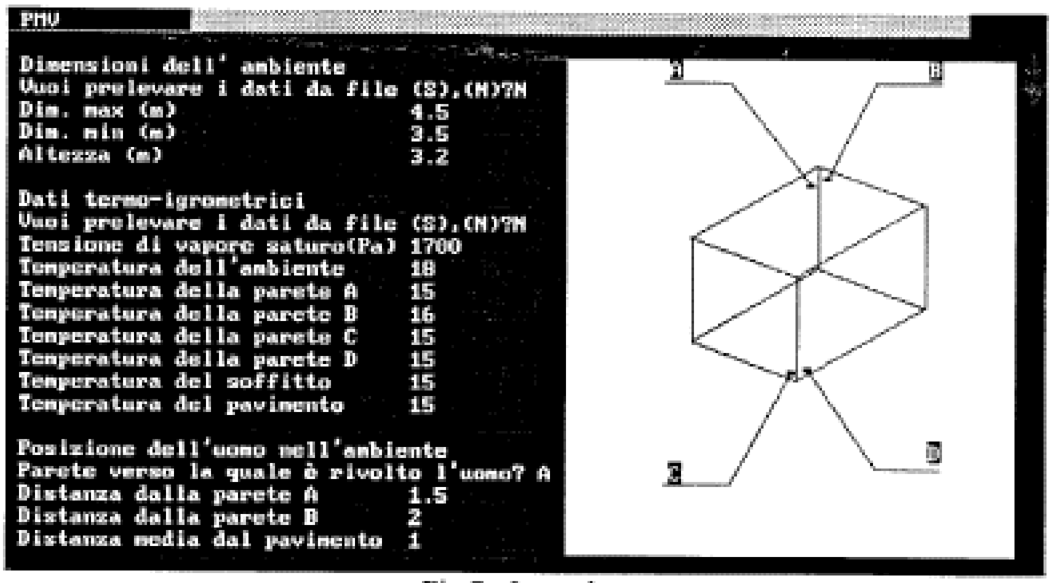

Fig 7 - Input data

The obvious purpose is to get the student used to give to the attainment of the imposed levels of some performances the same importance given to the geometrical definition of the building. The design task is to check the performance value as early as possible during the design process.

One of the employed tools is a program which allows calculating PMV (Predicted Mean Vote) in a room once the necessary inputs are given, while some derived performances are calculated.
It is well known that PMV reflects the subjective synthetical appraisal of the comfort in certain environmental situation characterized by thermo-hygrometric parameters and other parameters depending on the type of activity and of clothing of the subject. The comfort sensation depends on the energetic balance of the human body.
The program can be run interactively and recursively varying only the parameters reflecting the choices done while developing the design process.

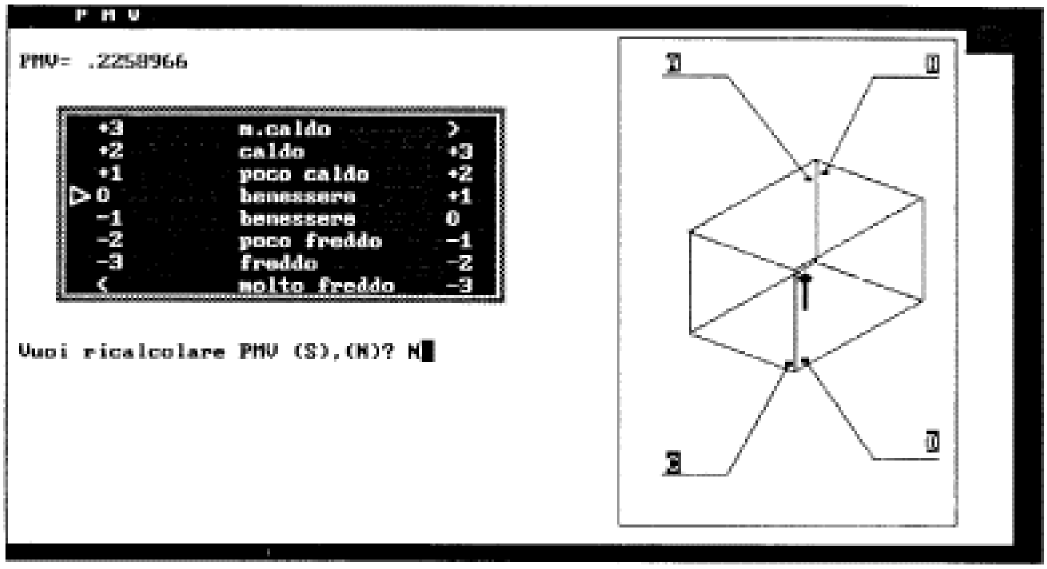

Fig 8 - Output data

3.5 Constrained placing of areal objects within a given perimeter

The program provides for constrained placing of areal objects in a predefined perimeter. Areal objects are mixtilinear polygons whose sides are curves of known equation. Constraints regard two types of spatial relationship: between ordered couples of areal objects and between objects and perimeter. As the relationship to handle cannot be exactly quantified, beeing of the type: near to, far from, approximately perpendicular, the mathematical tool best fits is the fuzzy set.
Couples are ordered because of non symmetry of the relationship.
For each couple of objects three functions are given, corresponding to the fuzzy field: each one measures the degree of membership in the relative fuzzy set.
The three membership functions are of proximity, of distance and of direction. Besides these functions the inputs are the geometrical characteristics of the perimeter and of areal objects and the values of the alfa-cuts, that is the threshold of satisfaction of each constraint.
The program is comprised of three sub-procedures:
the first one fulfills only the checking of the degree of satisfaction of the constraints for a set of objects in a perimeter given, returning the single values of satisfaction and the mean value.

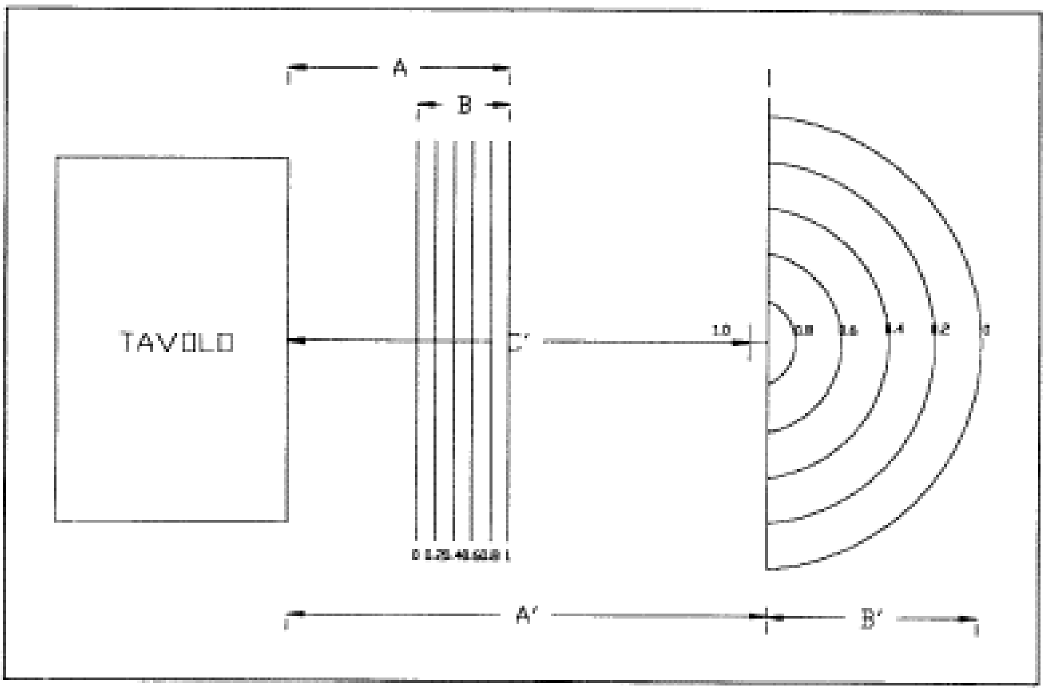

Fig.9 - Types of fuzzy functions

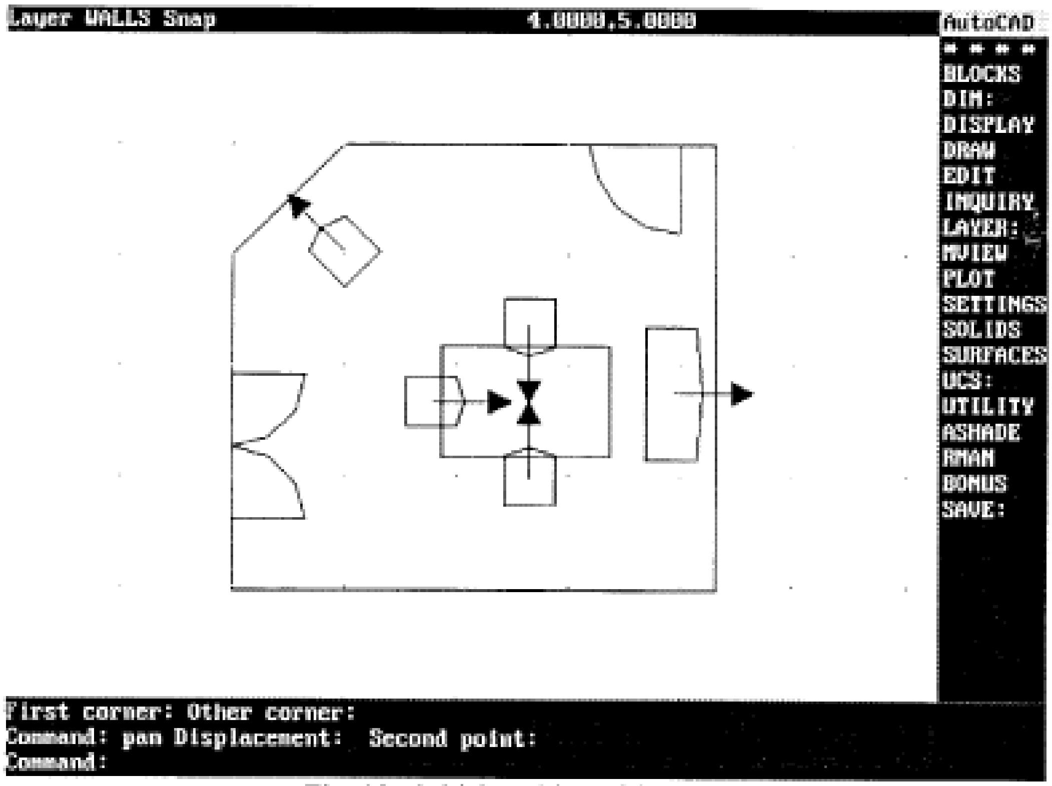

Fig. 10 - Initial position of furnitures

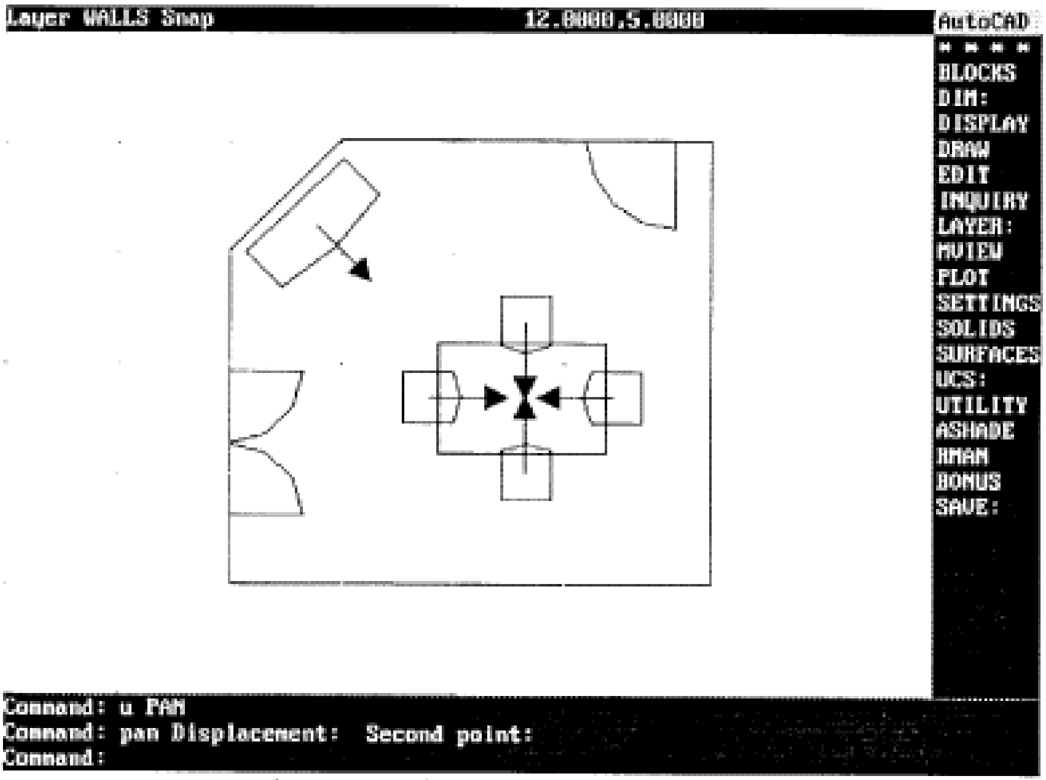

Fig. 11 - Furnitures arranged by the program

3.6 Automatic method for spatial units organization

The program proposes a new solution of the well known problem of automatic generation of composition of rectangles. It is based on a method of operational research, the Gradient Projection Method (GMP) that searches a minimum of constrained function.

The constraints are algebraic expressions of the relationship of adjacency, dimensional consistency, and communication between rectangles i.e. rooms. They must be linear and, preferably, inequalities. If *n* are the constrained variables and p the number of constraints (greater or equal to n+1) the admissibility region, i.e. the set of n-tuples of values of the variables satisfying the constraints is a region in the n-dimensions space bounded by *p* hyperplans.

The constraints satisfaction does not comprise the absence of superpositions among rectangles. The target function, always positive to minimize , is just the super-positions area.

The method consists in starting from a point lying on an edge of the surface bounding the admissibility of the region (rather easy to generate) and moving along the net of edges in the direction shown by the negative gradient projection of the target function on the edge. Under certain conditions, the absolute minimum, i.e. a "realistic" plan can be achieved.

Obviously the method has no practical value. It is only an advanced exercise aiming to getting the student accustomed to give the design problems a formal representation allowing the search of the solution through the use of computers.

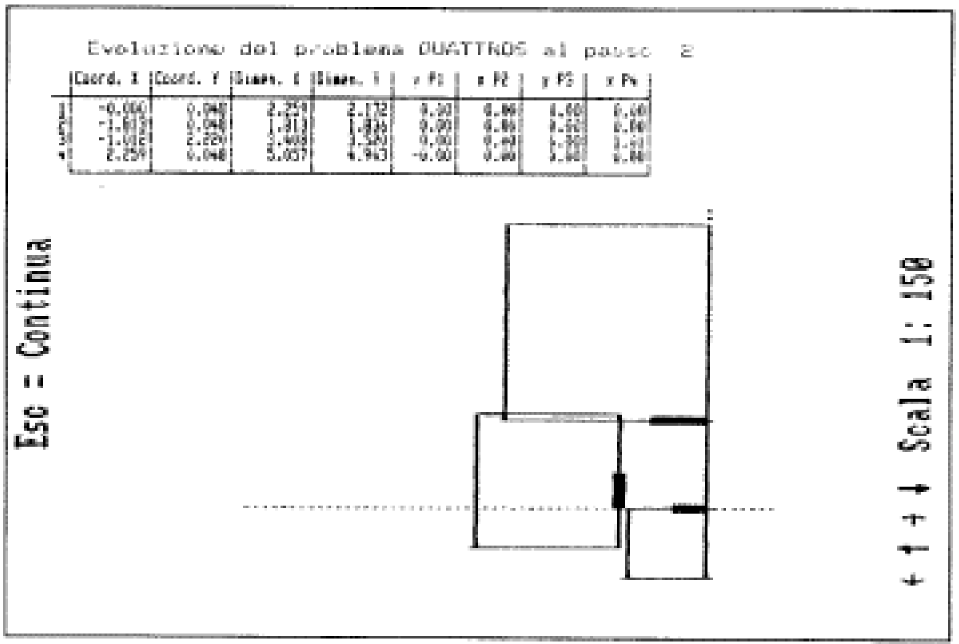

Fig. 12 - An intermediate situation: the rooms are not even correctly positioned

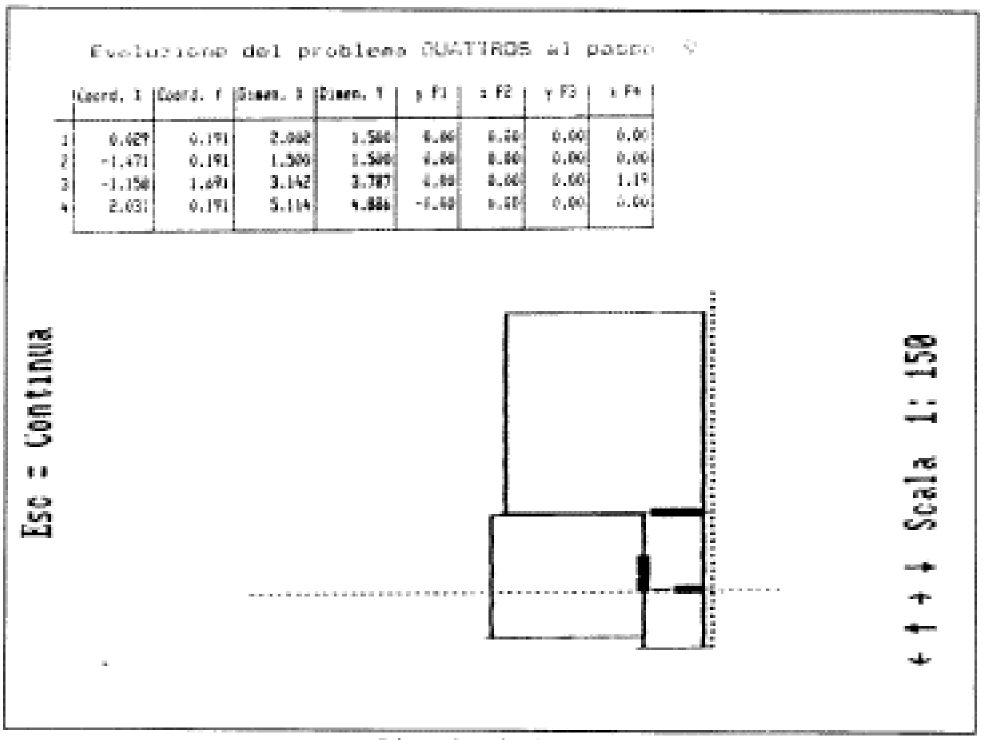

Fig. 13- Final plan

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