

## Computer-based Assisting the Preliminary (Preparatory) Phase of the Architectural Process

Gregory B. Prokopski \*, Aleksandra Prokopska\*\*

The aim of the presented program for computer-based assisting the preliminary (preparatory) phase of the architectural process is to intensify and facilitate architectural design activity. This program is a specialized tool, which – in the preliminary phase of the architectural process – facilitates methodically creating variants of forms of the architectural project.

It is the first computer-based assisting program which intervenes in the creative preliminary (preparatory) phase of architectural design. As main information carrier in the program the definition of "Bézier" curves has been applied. In the program, a change of definition of shapes takes place into their mathematical description by Bézier curves [1,2]. In the described program the combinatorial method is used, facilitating the creation of forms of the architectural project. This is a well-known and generally applied method in technique, called method of morphological analysis [3-5]. This creative method was utilized, in an intuitive way, by Le Corbusier, architect. The presented program came into being, indeed, through imitating what was doing and achieving Le Corbusier. In the program the possibility is provided of a creative utilization of existing plastic artistic compositions preferred by the designer-architect. Design decisions in this program are made by the architect.

The designer draws on the display monitor, for example, horizontal projections of architectural forms of the being designed object, forming in this way new arrangements and modifications of forms that were earlier selected and recorded in the library of forms.

### Introduction

The proposed program is a specialized intellectual tool the architects-designers can use in their practice of professional activity during the preliminary (preparatory) phase of the design process. The main purpose of the being presented program of computer-based assisting the architectural process, created according to exemplary activities of Le Corbusier, is to intensify the potential possibilities and the creative activity of the architect, in the process of searching for a satisfying spatial solution, namely the architectural form. In design practice, the preliminary phase concerns, among others, executing sketches of the architectural solid

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(cubic) form of the project that meets earlier determined needs, assumptions and corresponds to sets of conditions in the domain of architecture, construction etc. On the basis of these sketches of the architectural spatial form the architect often draws horizontal projections, sections and façades of the architectural object.

The program renders more efficient the creative activity of the architect and proposes him/her to create, in a methodical combinatorial way, variants of the project and, next, to perform their successive selection leading to the choice of the best, satisfying solution. The program does not exclude, but contrariwise assumes the use by the designer-architect of computer-based assisting programs in the next, successive design phases.

### Project-oriented properties of the program

The program is partially automated [1,2], being inspired by methodical elements of Le Corbusier's creative activity as pattern. The starting point for elaborating the program was the set of conclusions from the earlier performed methodical investigations and analyses of the creative activity of Le Corbusier.

The design-oriented qualities of the program concern the architectural and methodological aspect. These qualities were obtained in the program through connecting elements of the method applied in technique, called morphological analysis<sup>1</sup> and Bézier's curves<sup>2</sup> [1, 2]. The program intensifies, in a methodical and methodological way, the creative capabilities of the designing architect in the preliminary phase of the design process.

In the creative design processes of Le Corbusier design operations can be discovered that are characterized by methodical features [4]. Such features are assigned, for example, to his methodically gathered, numerous freehand notebook drawings (they were utilized sometimes after many years) [3, 5] and his drawings concerning concrete architectural processes (e.g. freehand drawings from the architectural process concerning the Carpenter Center) [3, 5, 6]. Le Corbusier laid great stress upon his drawings from design processes<sup>3</sup> and stated that they would perhaps become useful for future generations of architects [3-5].

<sup>1</sup> One of the well-known forms of graphical record of that method (as mathematical method of morphological analysis) is the morphological matrix. The number of dimensions of that matrix is equal to the number of the main features of the solution, and each of its elements corresponds to a determined combination of features. The Mendeleev' table is an example of the record of a morphological interval [4,5].

<sup>2</sup> These curves have been invented by Bézier in the seventies of the 20th century for designing oval-form motor-car bodies of Renault make.

<sup>3</sup> Le Corbusier during a long period used to paint in the morning his puristic pictures, and to design, i.e. to draw his architectural projects in the afternoon. As a consequence of these creative, methodical actions and operations of Le Corbusier forms, "congealed" in his paintings were sometimes transferred into his projects [3]. The above-mentioned methodical actions were many times described by himself in different way and at different opportunities [7]. At present, according to contemporaneously existing knowledge on design methodology, such activity can be described in a partially objectified way, i.e. in a methodical and methodological way. Freehand drawings from design processes, elaborated by Le Corbusier, generally concern the preliminary phase of his complex architectural process [4,5] and constitute a transfer for future generations of architects, as he self used to call it.

The presented program proposes to the designer-architect a partially automated combinatorial approach to forms. Elements of that method are applied by each designer-architect in an intuitive way in his/her professional practice.

When building the program the combinatorial approach to forms was used as one of many possible kinds of the creative morphological analysis, according to the contemporaneous knowledge on design methodology [8-11]. The application of Bézier's curves [1, 2] permits to adapt, for example, the being designed architectural form to the user function it has to fulfill. In the discussed program shaping the architectural form in three geometrical projections is assured. It goes on analogically in a traditional design atelier of an architect.

The program assures the possibility of creating a set of forms inspiring the designer, or, in other words, a dictionary of forms. The creative design activity of Le Corbusier and the application by this architect of an open "set of forms" in designing and creating modern architecture became the pattern for such type of actions (operations).

According to the possibilities assured by the presented program based upon the dictionary of forms - forms being selected from among the ones the designer prefers - the designer further selects forms considered to be particularly inspiring in the accepted concrete design task. The designer-architect performs a regrouping of these forms as well their juxtaposition and arrangement; he/she modifies them so as to obtain a new proposition of the form of the spatial solid, with drawing horizontal, vertical projections and façades of the being designed object.

The program is characterized by technical possibilities of multiplication, combination and modification of determined sets of forms. These forms were previously recognized by the designer to be suitable and were collected in the dictionary of forms. Such forms, stored in this dictionary, are utilized through their creative arrangement and successive modifications in order to create variants of the architectural form, among them the searched for, final variant. Le Corbusier proceeded in an analogical way in his architectural design practice, in this case basing upon forms of his puristic painting [3-5].

The program assigns to combinatorial design operations their technical sense but does not replace the designer in his/her creative activity and design decision based upon his/her professional architectural knowledge. Forms foreseen for creating the library of forms can appear as forms in freehand drawings and can be transferred into the vocabulary (set, library) of forms.

In the program two phases of design operations can be distinguished, determining possibilities of creatively shaping the architectural form. For example, according to the proposed program and the creative imagination of the designer forms that fulfill different architectural requirements can be efficiently obtained in the first phase of architectural designing.

The program, as intellectual tool of the architect, does not limit the possibilities of creative artistic expression of the architectural achievement. Contrariwise, this tool renders more efficient and intensifies the creative and technical creation

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of variants of architectural solutions. The final selection of the architectural form during the design process is made by the designer-architect in the program.

Architectural sketches of projections of the spatial solid (cubic) form, designed in the preliminary phase according to the possibilities of that program show, in an illustrated way, the creative consequences of the just thought by the architect associations of forms being placed in space [13]. The dictionary of forms can serve the architect-designer for creating new attractive architectural objects through new arrangements e.g. of new forms and through their modification in the architectural creative process [12, 13].

The presented program permits an efficient transformation of creative visions of the designer into projects being in conformity with modern architectural knowledge and with concrete architectural conditions, among them with concrete technical and environmental possibilities.

### Technical description of the program

The employed combinatorial method facilitates the creation of architectural forms. The aim of the presented program is to support the early creative phases of an architectural process. Its use involves two phases. In the first phase model existing architectural forms are modeled to create a library or a dictionary of forms. In the second phase this library is used to create drafts of new architectural designs. The architectural forms in both: a project and in a dictionary are, from the low-level point of view, composed of curves (N.B. a line is a special case of a curve). The main operation that the program needs to perform internally is to create, store and manipulate descriptions of curves. To that it was decided to use the definitions of Bézier curves [1, 2], as they provide the needed ease of use, flexibility of manipulation, and are suited to model a wide spectrum of shapes.

The first phase concerns gathering of selected shapes to be put in a dictionary. This program can load any kind of graphics in a bitmap format: a sketch, a painting, a landscape. This graphics is treated as a kind of background. The designer then models the forms visible in the background into Bézier curves and adds the ones he finds interesting to the dictionary of forms. This way a dictionary can be created, changed or extended. Dictionaries can later be used and extended for multiple projects. The use of a library of forms allows for a closer imitation of the early phases of real-world architectural creation process. The library constitutes a record of this part of designer's inspiration that is related to the creative choice of forms considered as having potential for their use in a newly created architectural composition.

The second phase is the actual design phase. The background graphics is turned off and the designer is given an empty plane and a selected database of forms is loaded. Inspired by the work previously used to harvest the forms or just by the forms alone he creates in his mind and on the computer screen a new vision of a solution for the architectural problem he undertook. The spatial vision of a new

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architectural form is created by putting together selected forms from the dictionary of forms.

The forms are copied onto the plane, rotated, scaled, stretched and freely modified to create the draft of a new architectural project in accordance with the needs, assumptions and other earlier established guidelines. If so desired, new forms can be at any time added to the currently used dictionary of forms. The program allows for segregation of forms into virtual layers of the design project, similarly to layers of transparent sheets put together. A form placed on a plane is initially associated with the layer selected as "current". Visibility of in each layer can be turned on or off, has an assigned color and line thickness. All these mechanisms are included to facilitate designer's tasks of selection and manipulation of architectural forms.

As mentioned earlier to describe forms in our program we use Bézier curves because they provide the needed ease of use, flexibility of manipulation, and are suited to model a wide spectrum of shapes, see Figure 1 a,b. Mathematically speaking they are called Cubic Bézier curves. According to [1]: "Four points  $P_0$ ,  $P_1$ ,  $P_2$  and  $P_3$  in the plane or in three-dimensional space define a cubic Bézier curve. The curve starts at  $P_0$  going toward  $P_1$  and arrives at  $P_3$  coming from the direction of  $P_2$ . Usually, it will not pass through  $P_1$  or  $P_2$ ; these points are only there to provide directional information. The distance between  $P_0$  and  $P_1$  determines "how long" the curve moves into direction  $P_2$  before turning towards  $P_3$ .

The parametric form of the curve is:

Modern imaging systems like PostScript, Asymptote and Metafont use Bézier splines composed of cubic Bézier curves for drawing curved shapes."

In the presented program each form is composed of one, two or more connected Bézier curves. Every such connection between two Bézier curves can be done in one of three ways (see Figure 2). To allow a wide range of connection shapes we enforce different sets of requirements on the control points (e.g. points  $P_1$  and  $P_2$  in Figure 1) adjacent to a connection point. In the first, default case, the points are moved symmetrically around the connection point of the two curves. If one of the control points is moved, the control point of the other curve is moved to keep the symmetry, as shown in Figure 3. In the second case it is only required that both control points and the connection point are kept in one

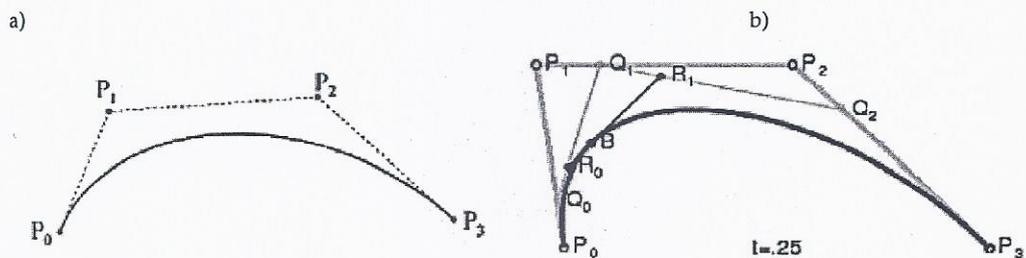


Fig. 1 a,b: Construction of a cubic Bézier curve [1]

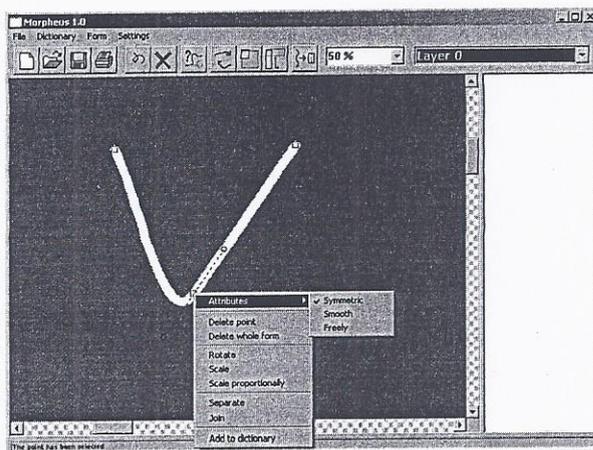


Fig. 2. Three methods curves can be joined

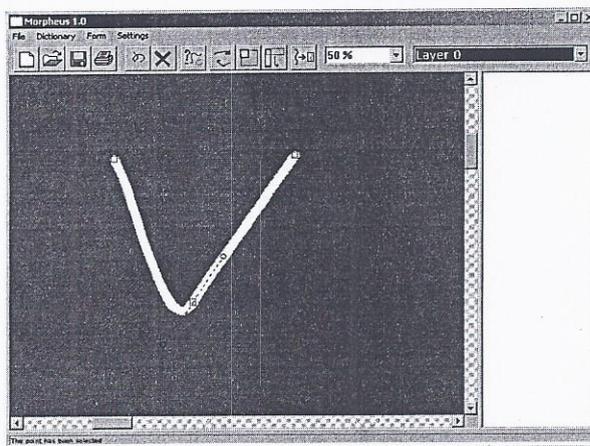


Fig. 3. Control points symmetrically

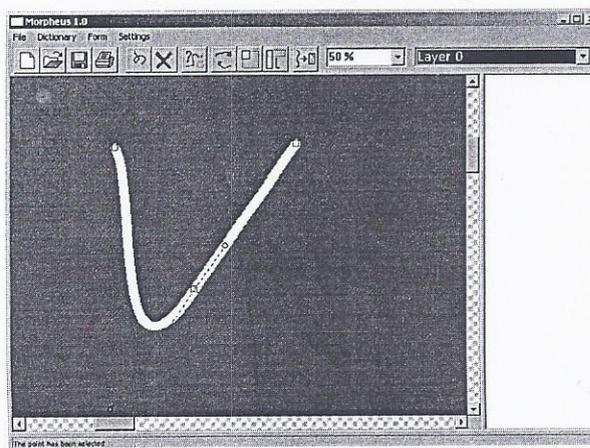


Fig. 4. Control points in line with curves join point

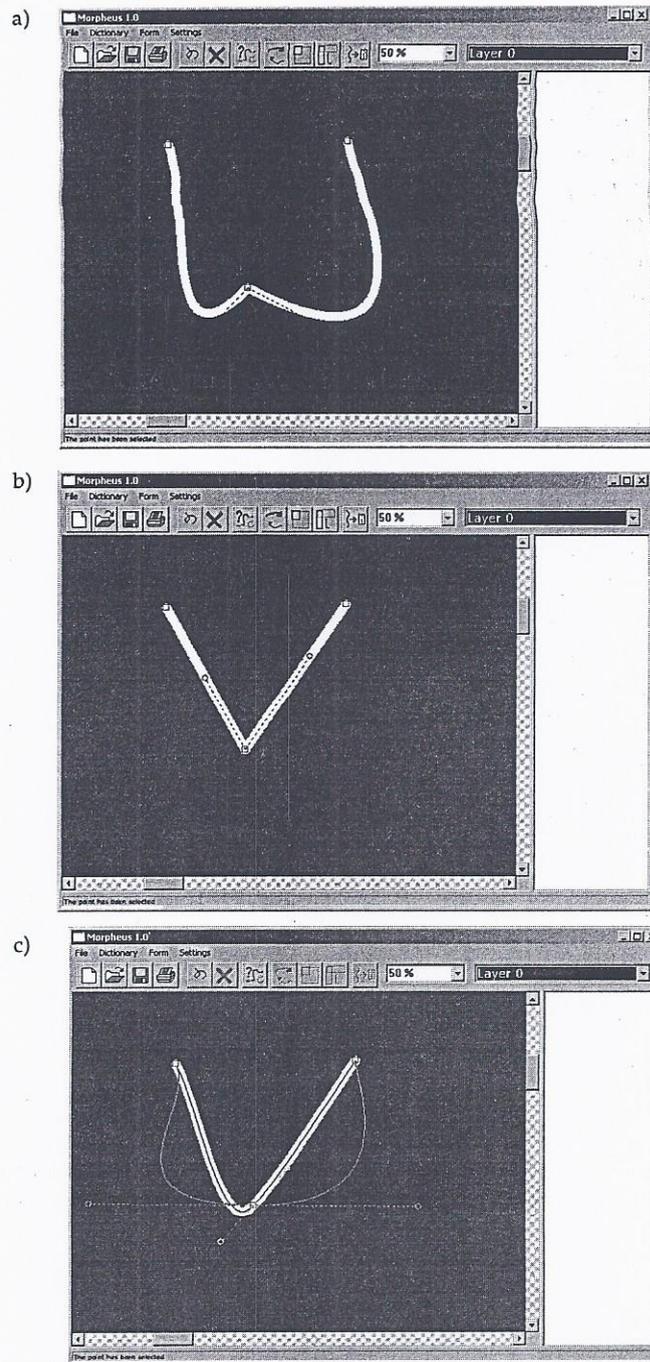


Fig. 5. a) Control points placed freely. Free form,  
b) Control points placed freely. Rectangular form,  
c) User view during modification of a curve

line, as shown in Figure 4. The third setting allows the control points to be placed freely and independently, which allows for creation of rectangular forms, as can be seen in Figure 5 a,b. As is shown in Figure 5c, we ensured that during curve modifications the designer is given all information about the future shape of the curve, before the decision to change a shape is made.

The presented tool gives the designer a number of powerful features to facilitate a creative architectural process. From the technical point of view the program allows for harvesting interesting and inspiring shapes (forms) from any kind of graphics, creating a library of forms that can be later used in and extended during the design process. Our tool allows a designer to freely reuse, modify, and join various forms during the creative architectural design work.

## Discussion and conclusions

The presented program is the first one that makes it possible to assist in a computer-based way the first phase of the creative architectural process; this phase was generally recorded by the designer, in the classic approach, in the form of freehand sketches. Design decisions in this program are made by the architect.

Design operations in the program are methodically and technically assisted, basing on imitation of the architectural design activity of Le Corbusier, what provides for their technical realization in the form of an architectural project.

The technical and methodical differentiated qualities of the program, adapted to the requirements of the architect-designer, are obtained by connecting elements of the method of morphological analysis and the technical possibilities assured and presented thanks to the use of Bézier curves.

The program improves capabilities of architectural creation in the phase of creating the vision of the spatial solution, by intensifying that vision and assisting it in intellectual and technical sense. Through imitating the artistic and architectural activity of Le Corbusier the creative opportunity of designing forms of the architectural spatial solid is assured to the designer, according to his/her free will. The example of not automated methodical operations in the creative activity of Le Corbusier is a factor convincing of such possibility and simultaneously is a proof thereof. By imitating the design activity of Le Corbusier the program assures collecting a dictionary (library) of forms and next its creative utilizing through recombination and modification of forms selected from the library. Such creative operations assist new projects to come into being. The program is characterized by technical qualities for multiplying, combining and modifying determined arrangements of forms earlier found to be interesting by the designer. Operations of such type are constant elements in the creative process of architectural designing.

The application of the program in the designing practice of the architect can lead to facilitate creative architectural processing and render it more efficient in the first phase of the composition of the architectural spatial solid form. The pre-

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sented program does not limit the creative capacities of the designer but assists and improve them by imitating the procedure of design activity of Le Corbusier.

Le Corbusier who was dealing in the morning with painting puristic pictures (or plastic art forms), and in the afternoon with designing new, from the point of view of the world in those times, spatial forms of modern architecture, basing on the painted in the morning artistic plastic forms [7], has twice changed in the 20<sup>th</sup> century the direction of development of architecture. This program, elaborated by imitating his real design activity allows the designer to create in a methodical, thus efficient way, on the basis of selected forms, new architectural forms and to modify them according to given architectural needs. In the program possibilities are assured for the designer to undertake design operations according to his/her creative will and his/her skills with maintaining in the being created project the original esthetic features of the earlier chosen set of forms.

As intellectual tool that intensifies the creative and technical operations of the designer, the program does not constrain the possibilities of expression of the architectural achievement but assists the designer in solving different, conditioned in a many-sided way, problems of composition of the architectural spatial solid.

This program improves, from the technical point of view, the architectural creative process in its preliminary (preparatory) phase and assures the opportunity of a richer realization of the creative capabilities of designers-architects.

Perhaps, with this program it will be possible to design more efficiently than hitherto a more and more beautiful modern architecture, e.g. pro-ecological architecture.

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