Interpretation Method for Software Support of the Conceptual Redesign Process

Emergence of new concepts in the interpretation process

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Abstract. *This paper deals with the process of synthesizing the innovative concepts, and especially with software and methodological support of this process. Our approach emphasizes the importance of the interpretation of the suggestions, which are generated by the system of software and methodological support of conceptual design. Just an interpretation is in this systems usually missing. Herein described method is based on the interconnection of the contexts in which the solution lies. For this context's interconnection a psychological approaches are used (especially the mind mapping). The core of this interpretation method is creating of the interpretation map.*
Keywords. *Conceptual design; redesign; interpretation; interpretation map; Human-Computer Interaction.*

CONCEPTUAL DESIGN AND REDESIGN

Design can be conceived of as a purposeful, constrained, decision making, exploration and learning activity (Gero 1996). The design process is possible to divide into three phases (Bila and Jura, 2007):

1. **Early** design phase - the aims of design and properties of the designed object are defined in this phase.
2. **Conceptual** design phase - the basic principles of the function are draw up in this phase.
3. **Detailed** design phase - the implementation is perform in this phase. The shapes, dimensions, materials and the like are projected here.

Conceptual phase is very important, because the consequences of the decisions made here are difficult to correct in the following phase. Conceptual phase of the design takes the statement of the problem and generates broad solutions to it in the form of schemes (French 1999). This broad solution incorporates the basic principles of function. The terms schema and principles of function are for the conceptual design fundamental. The schema expresses the essence of the designed object and simultaneously considers apart from its particular realization.

Redesign

In a redesign process some old solutions or designs (which we call vetera) are usually known and we are looking for an innovation (which is called novum). The aims and properties of designed object (from early design phase) are encompassed in the old solutions. And from this reason the early design phase is substituted by the vetera's analysis.

COMPUTER AND METHODICAL SUPPORT OF CONCEPTUAL DESIGN

There are many algorithms, methods and procedures (like a TRIZ/ARIZ or Morphological analysis) for the facilitating of the synthesis of the innovative concepts. Some of these methods work on computer platform and use means of artificial intelligence (e.g. AIDA, GALILEO, ARCHIE or CEADRE). This software is usually called CACD (Computer Aided Conceptual Design) or CAI (Computer Aided Innovation). One of them is CRDP (Computer ReDesign Process), which was developed on Faculty of Mechanical Engineering of the CTU in Prague (Bila and Tlapak, 2006).

CRDP - Computer ReDesign Process

Inputs to the CRDP software system (algorithm CRDP on the Figure 1) are 1) three old solutions (vetera), 2) criterions for a new solution and 3) formation parameters (fields of activities and principles which form a new solution). The output is a set of suggestions to an innovation (novum). The old and new solutions are described in a specification language GLB (Bila and Tlapak, 2004; Bila, Jura and Tlapak, 2006).

Specification language GLB

GLB is a language, which conceptualizes the domain of the conceptual design and represents semantic properties of knowledge elements by means of preformed semantic structures like fields of activities (FAct) and principles (Princ1 and Princ2). Basic grammatical form is: FAct <Princ1 <Prin2>> and its combination formed by AND connector. (see the dashed rectangle on Figure 1). Mentioned fields of activities are fields on which the design is realized – e.g. ME … Mechanics, PNU … Pneumatics, TCS … Technological Constructions, ELS ... Electromagnetic and Electronics, Materials, Structures, Environment etc. The GLB Principles 1 are the principles of function – e.g. Trns … Transformation, Contr … Control, Cnstr … Constructions, R-Eff … Relative Effects, Aggregation, Embedding, Production etc. And these Principles 1 are specified by the Principles 2 (described in the Table 1).

Software CRDP and others systems of the software support of Conceptual Design is short of the interpretation of their outputs. The proposed method is concentrated to the process of the interpretation of symbolical formations to the conceptual designs, which are generated by the CRDP system. The main thing here is the process, in which the new conceptual solution **emerges**.

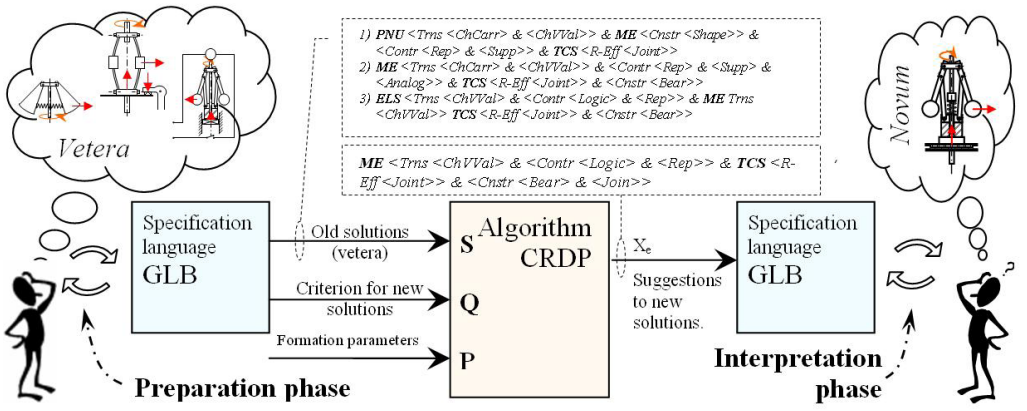


Figure 1
Description of designing process with CRDP software and methodical support.

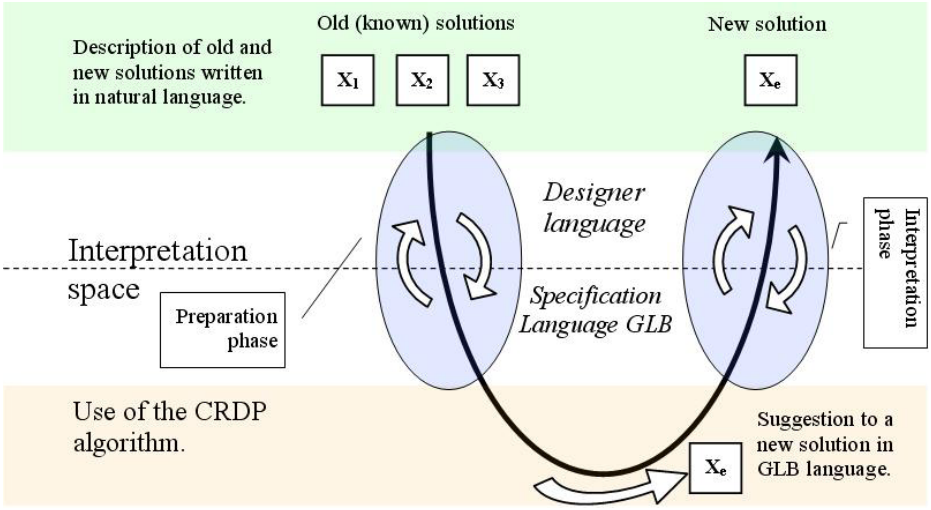
Table 1
Description of selected elements of GLB language.

Princ 1	Princ 2	Name of Princ 2
Trns (Transformation)	ChVVal	Change of Carrier Variables
Trns (Transformation)	ChCarr	Change of Energy Carriers
R-Eff (Relative Effects)	Joint	Joint
R-Eff (Relative Effects)	Bearing	Generalized Bearing
Contr (Control)	Supp	Support of an effect
Contr (Control)	Rep	Repression of an effect
Contr (Control)	Logic	Logic control of an effect
Cnstr (Constructions)	Fix	to Fix
Cnstr (Constructions)	Bear	to Bear
Cnstr (Constructions)	Shape	to Shape
Cnstr (Constructions)	Join	to join

INTERPRETATION

The term interpretation means an explanation or understanding in general. This article creates a context, which is possible to call the context of conceptual design. And in this context the word **interpretation** means a **process of connecting contexts** and this process leads to the emergence of new solutions on the field of conceptual redesign (Jura 2012). The contexts – which are interconnected here – are 1) the context of innovation thinking of the user and 2) the context of the description of the conceptual design, which is expressed in the specification language GLB.

Figure 2
Schema of the interpretation method.



INTERPRETATION METHOD AND INTERPRETATION MAP

The core of the proposed interpretation method is the interpretation map (Jura 2012) and its production. The interpretation method is constructed on the base of psychological items of knowledge e.g. Buzan's (2005) Mind Mapping method, Kelly's Personal Construct Theory, Tolman's Cognitive Maps, psychology of creativity or the Deep neurobiology of E. Rossi.

Note: The mind map is Tony Buzan's mean of visualization of mental contents of a given (usually in the center of the map placed) theme (Jura 2012).

The interpretation method is also based on the principles of emergence and emergent synthesis, computer ontology and the theory of interpretation. These principles and pieces of knowledge are incorporated into the structure of an **interpretation method, which facilitates synthesis of the new concept** by the user of the computer support.

The whole interpretation method consists of two phases (see Figure 2), which are divided into a partial interpretation steps:

A. Preparation phase (first fusing of the contexts).

B. Interpretation phase (makes more explicit the interconnection of the contexts).

Preparation phase – the first fusing of the contexts

Preparation phase (A) includes learning the GLB language and incorporating the GLB principles to the user's semantic network. This phase is divided into the two steps:

A1 – first **interconnecting** of the **contexts** – learning of the meanings of the elements of GLB from the list (something like a Table 1 extended to a meaning of the GLB's elements and examples).

A2 – finding out **old solutions** (Figure 3), their specification in a natural language, their **translation into GLB language** and backward translation (from GLB to the nature language). The context of the user is connected to the context of GLB in this step. The innovation of the speed regulator from the branch of fine mechanics is used as an illustration of the redesign process with proposed software and methodological support.

Three vetera (Figure 3) are x1) Foucault's regulator, x2) regulator of phonograph machine and x3) regulator based on the power supply switching off principle. The Foucault's regulator works on the mechanics, pneumatics and technological constructions fields of activity. Regulator of phonograph machine works on the mechanics field of activity and at the field of technological constructions. And the

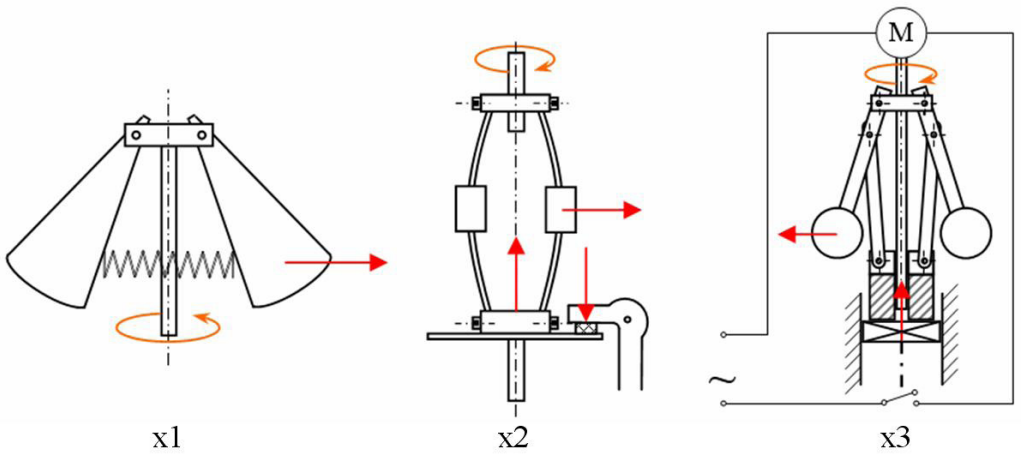


Figure 3
Illustration of redesign process – input to the CRDP system – three old solutions.

third device works moreover on the electromagnetic and electronics field of activity.

The Foucault's regulator (x1) uses the construction (Cnstr) principle of the shape (Shape) and control (Contr) principle of the support of the effect (Supp) by the centrifugal force and repression of the effect (Rep) by the spring on the mechanics (ME) filed of activities. And next there are the two types of transformation at the pneumatics (PNU) filed of activities. First is called the change of energy carrier (ChCarr) and second is called change of the carrier variable (ChVVal). And final there is used the knuckle joint principle (Joint) on the field of the technological constructions (TCS). The complete description of all devices in GLB language is:

x1 = PNU <Trns <ChCarr> AND <ChVVal>> AND
ME <Cnstr <Shape>> AND
<Contr <Rep> AND <Supp>> AND
TCS <R-Eff <Joint>>

x2 = ME <Trns <ChCarr> AND <ChVVal>> AND
<Contr <Rep> AND <Supp> AND <Analog>> AND
TCS <R-Eff <Joint>> AND
<Cnstr <Bear>>

x3 = ELS <Trns <ChVVal> AND
<Contr <Logic> AND <Rep>> AND
ME Trns <ChVVal>>
TCS <R-Eff <Joint>> AND
<Cnstr <Bear>>

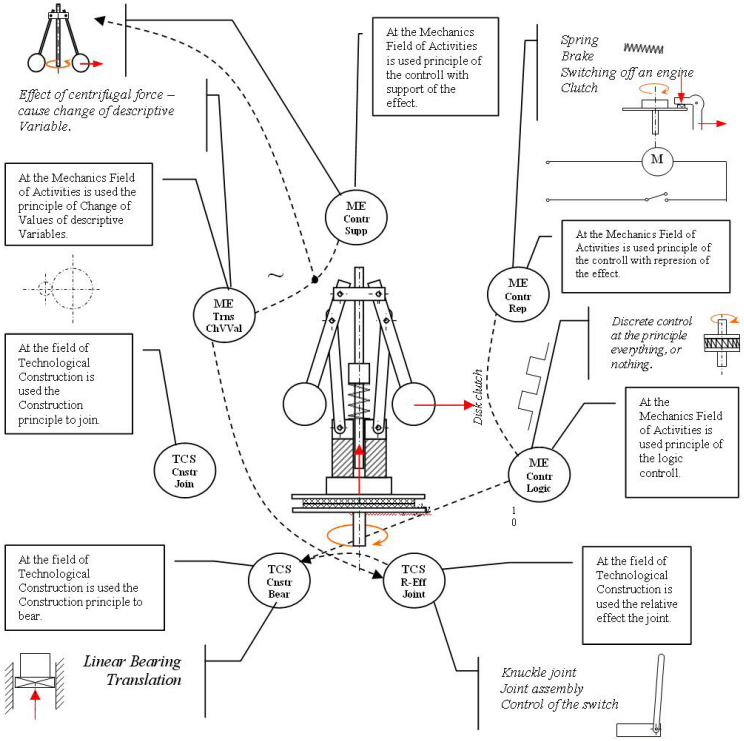


Figure 4
Example of complete interpretation map.

The design process continues by the input of these descriptions (x1, x2, x3) into the CRDP software and generation of suggestions of a new conceptual solution. The suggestions have a form of sign chains.

Interpretation phase – creating the interpretation map

Next phase is called the interpretation phase. This is the phase in which the interpretation map is build and a new solution arises. This phase consists of eight steps:

B1 – **selection** of the suggestion for interpretation (from the set of suggestions which is generated by the CRDP software). For example:
ME <Trns <ChVVal> & <Contr <Logic> & <Rep>> &
TCS <R-Eff <Joint>> & <Cnstr <Bear> & <Join>>

B2 – **decomposition** of the selected suggestion to the basic form, which is called **triplet** (<**FAct** <**Princ1** <**Princ2**>>>). Previous sign chain after the decomposition has a form:
<ME<Trns<ChVVal>>>,
<ME<Cnstr<Logic>>>,
<ME<Cnstr<Rep>>>,
<TCS<R-Eff<Joint>>>,
<TCS<R-Cnstr<Bear>>>,
<TCS<R-Cnstr<Join>>>.

B3 – the **plotting** of these **triplets** into the map (this is the first step of drawing interpretation map – Figure 4). The triplets are draw into the circles.

B4 – an addition of **first associations** to the triplets into interpretation map. Any first ideas, images, brainwaves etc. are draw in the map and are linked with their source triplets.

B5 – **connecting** the **GLB meanings** (as it is represented in user's mind) to the GLB elements (as it is represented in the interpretation map). User writes/draws his own meanings of the used GLB triplets in the form of verbal and graphical description. This description is also linked to the draw GLB triplet.

B6 – an addition of **free associations** to the meanings of the GLB elements. Any ideas, images to the GLB are written or draw.

B7 – an addition of **interassociations** (associations between the map's elements). These interassociations should be plotted by dashed line and entitled.

B8 – the **final reorientation** to the solution, for which the space in the middle of the map is designated. If the new solution does not arise it is possible to continue with adding associations and thicken the interpretation map or select another suggestion (step B1). Since this process is creative and emergent, the reach out of the new solution is impossible to guarantee, but this method creates a suitable background for the emergence of the conceptual innovation.

This interpretation method makes explicit the interconnection of contexts and also facilitates the process of emergence of a new conceptual solution on the intersection of these contexts.

CONCLUSION

The functionalities and specifics of the proposed methodology have been tested. On the basis of these tests has been formulated a qualitative model of performance of the solution. The CRDP system is an adviser system, which renders the emergence at the level of sign chains. The proposed interpretation method supports the emergence of a new solution in the user's mind (at the level of images).

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