Study of different principles for automatic identification of Generalized System of Contradictions out of Design Of Experiments

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STUDY OF DIFFERENT PRINCIPLES FOR AUTOMATIC IDENTIFICATION OF GENERALIZED SYSTEM OF CONTRADICTIONS OUT OF DESIGN OF EXPERIMENTS

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ABSTRACT: *Problems in design of technical systems can be solved by optimization or inventive solving principles. Two representation models are studied: Generalized System of Contradictions (GSC) as inventive principle and Design of Experience (DoE) as optimisation principle. Our purpose is to improve the capacity of design problems resolution by using the both solving principles articulated to one representation model. We will show how it is possible to shift from DoE representation model to GSC representation model by using different methods. On the one side this transition can be done by the identification of Generalized System of Contradictions out of Design of Experiments based on a set of equations to resolve. On the other side methods of data analysis can be used to visualise and reorganise the DoE matrix in the form of "contradiction blocks" reflecting the set of equations. This reorganisation of representation model will be illustrated on a simple technical system.*

KEYWORDS: *Design of Experiments, Generalized System of Contradictions, methods of data analysis.*

1 INTRODUCTION

Problem solving in design of technical systems implies the evolution of these systems. Two types of the evolution are possible: one can improve the system efficiency by system parameters optimisation or redesign the technical system as an answer to some changes. The first type of technical evolution uses mainly the optimisation solving principles whereas the redesigning uses mostly the inventive solving principles. At the beginning of the design process one cannot predict which kind of solving principle will be required. Hence the common representation model is necessary to enable shifting from optimisation representation models to the inventive ones and the simultaneous use of both solving strategies.

The Generalized System of Contradiction was proposed as a generic model for inventive problem statement satisfying the condition "a contradiction exists if and only if no solution can be found by optimisation of a known model" (Eltzer and De Guio, 2007). It is based on logical assertions about values of parameters which mean that two concepts based on sets of action parameters satisfy simultaneously two sets of evaluation parameters.

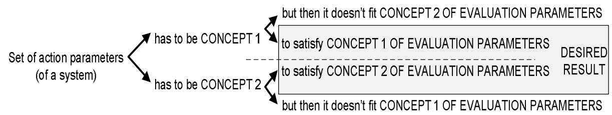

Figure 1: Generalized System of Contradictions

As shown later in this article the representation in the form of GSC can be obtained from the optimisation model of representation issued from Design of Experiments (DoE). The DoE (Montgomery, 2004) is a strategy to gather empirical knowledge on the studied technical system. It is based on the analysis of experimental data expressed in the rectangular table. The rows of table represent the experiments and each column corresponds to different process variable expressing one system parameter. One can distinguish two kinds of parameters: the controlled ones usually noted X and the measured ones usually noted Y.

	x_1	…	X_l	y_1	...	y_i	...	y_r
e_1	v_{11}		v_{1l}	z_{11}		z_{1i}		z_{1r}
e_2	v_{21}		v_{2l}	z_{21}		z_{2i}		z_{2r}
…								
e_{k-1}	v_{k-11}		v_{k-1l}	z_{k-11}		z_{k-1i}		z_{k-1r}
e_k	v_{k1}		v_{kl}	z_{k1}		z_{ki}		z_{kr}

Table 1: A Design of Experiments table

The identification of GSC in the DoE representation model permits to solve the problem by inventive solving principles in the case that the optimisation ones do not work. The goal of this article is to study different principles of reorganisation and visual representation of matrix in order to obtain the GSC representation from DoE matrix and so to identify the sets of evaluation parameters in contradiction.

An example will be presented in the last section to illustrate the identification of GSC in the DoE representation matrix.

2 GENERALIZED SYSTEM OF CONTRADICTIONS IN DESIGN OF EXPERIENCE

The Generalized System of Contradictions is an extension of the models of contradiction defined in TRIZ (Altshuller, 1988). The models of contradictions in TRIZ are based on a dialectical representation of the problems. This kind of problem formulation frames has proved its benefits for problem resolution in many domains. In (Dubois *et al.*, 2009) the limit of this model has been defined as not satisfying the equivalence between the two propositions: "the problem has no solution" and "a contradiction exists". To overcome this limitation the GSC has been defined. In this part the properties of this model will be presented.

The properties of the Generalized System of Contradictions can be characterized by the set of definitions that enables the extraction of the GSC out of a DoE. Let one considers a DoE characterized by:

- a set of action parameters $X=(x_0, x_1, \ldots, x_n)$
- a set of domains $D=(D_0, D_1, \ldots, D_n)$ where D_i defines the possible range of values for x_i
- a set of evaluation parameters $Y=(y_0, y_1, \ldots, y_p)$ characterized by binary values, either 1 if y_i is satisfied, 0 otherwise
- a set of experiments $E=(e_0, e_1, \ldots, e_m)$. An experiment e_i is a particular instantiation of the action parameters: $(a_{i1}, a_{i2}, \ldots, a_{in})$, so that $a_{ij}\alpha D_j$ and the induced values of evaluation parameters $(z_{i1}, z_{i2}, \ldots, z_{ip})$, so that $z_{ij}=1$ if y_j is satisfied in experiment e_i, 0 otherwise.

The goal is to satisfy all the evaluation parameters – let consider that such a solution does not exist in the considered DoE, i.e. that no experiment enable the satisfaction of all the evaluation parameters.

Identifying a Generalized System of Contradictions in such a DoE is looking for:

- Three sets of evaluation parameters Y_0, Y_1 and Y_2, such as $Y_0 \cap Y_1=\varnothing$, $Y_1 \cap Y_2=\varnothing$, $Y_0 \cap Y_2=\varnothing$, $Y_0 \cup Y_1 \cup Y_2=Y$, $Y_1 \neq \varnothing$ and $Y_2 \neq \varnothing$.
- Three sets of experiments E_0, E_1 and E_2: $E_0 \cap E_1=\varnothing$, $E_1 \cap E_2=\varnothing$, $E_0 \cap E_2=\varnothing$, $E_0 \cup E_1 \cup E_2=E$, $E_1 \neq \varnothing$ and $E_2 \neq \varnothing$.

Moreover

- E_1 is a set of experiments for which all the evaluation parameters of Y_1 are satisfied.
- E_2 is a set of experiments for which all the evaluation parameters of Y_2 are satisfied.

Such a definition gives the way to reorganize the DoE table by permutations of the rows and of the columns in order to group the previously defined Ei and Yi (cf. table 2).

<table>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td colspan="3">Y1</td><td colspan="3">Y2</td><td colspan="3">Y0</td></tr>
<tr><td></td><td></td><td>x1</td><td>x2</td><td>…</td><td>xn</td><td>ys</td><td>…</td><td>yt</td><td>yu</td><td>…</td><td>yv</td><td>yw</td><td>…</td><td>yh</td></tr>
<tr><td rowspan="3">E1</td><td>ei</td><td>ai1</td><td>ai2</td><td></td><td>ain</td><td colspan="3" rowspan="3">E1 x Y1: zij = 1</td><td colspan="3" rowspan="3">∀ ei ∈ E1 ei x Y2: ∃ j / zij = 0</td><td></td><td></td><td></td></tr>
<tr><td>…</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>ej</td><td>aj1</td><td>aj2</td><td></td><td>ajn</td><td></td><td></td><td></td></tr>
<tr><td rowspan="3">E2</td><td>ek</td><td>ak1</td><td>ak2</td><td></td><td>akn</td><td colspan="3" rowspan="3">∀ ei ∈ E2 ei x Y1: ∃ j / zij = 0</td><td colspan="3" rowspan="3">E2 x Y2: zij = 1</td><td></td><td></td><td></td></tr>
<tr><td>…</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>el</td><td>al1</td><td>al2</td><td></td><td>aln</td><td></td><td></td><td></td></tr>
<tr><td rowspan="3">E0</td><td>eq</td><td>aq1</td><td>aq2</td><td></td><td>aqn</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
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<tr><td>er</td><td>ar1</td><td>ar2</td><td></td><td>arn</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table>

Table 2: GSC representation in a DoE

2.1 Extraction of the GSC in a DoE

The analysis and definition of the equations to solve in order to extract the three sets of evaluation parameters Y_i and the three sets of experiments E_i out of the DoE will be presented in this part. Our purpose is to obtain two sets of evaluation parameters that are "in contradiction". This contradiction is translated as two orthogonal blocks of ones obtained by permutations of the rows and columns of rectangular DoE matrix. Different methods of data analysis can be used to identify the blocks in the matrix as we will show in the next section. First a set of equations characterizing these blocks will be described as the extraction of a GSC in the DoE matrix involves resolution of these equations:

$$z_{ij} = 1 \text{ or } 0$$

$$\sum_{i/e_i \in E_k;\, j/y_j \notin Y_k} \overline{z_{ij}} \geq 1$$

$$\forall (e_i, y_j) \in E_{k \neq 0} \times Y_{k \neq 0}; z_{ij} = 1$$

$$\forall (e_i, y_j) \in E_0 \times Y_{k \neq 0} : \sum_{j/y_j \in Y_k} \overline{z_{ij}} \geq 1$$

$$\forall (e_i, y_j) \in E_{k \neq 0} \times Y_0 : \sum_{i/e_i \in E_k} \overline{z_{ij}} \geq 1$$

Concerning the algorithm to solve the set of equations defining a GSC; several questions have to be explored and answered.

In fact there are several ways to build a GSC and moreover to choose the GSC that has to be solved firstly. Two criterions could be defined:

- Solving a problem means understanding the limits of the model used to represent the problem, and so being able to change this model (Rasovska et al., 2009). Thus, to propose an efficient model change, it is meaningful to build a model based on the biggest amount of knowledge about the problematic situation. Such a strategy leads to the building of a GSC **minimizing the cardinality of E_0**. Such a GSC is based on more experiments of the problem model; this GSC could be referred as exhaustive GSC.

- To solve a contradiction also means to satisfy all evaluation parameters implied in the contradiction, whereas solving the problem means satisfying all evaluation parameters. If one aims at solving the problem in a "one-shot" contradiction resolution, the contradiction model has to be based on all the evaluation parameters. This strategy has as the objective to **minimize the cardinality of Y_0**. Such a GSC will be built by defining a GSC so that Y=Y1≥Y2 and could be called an efficient GSC.

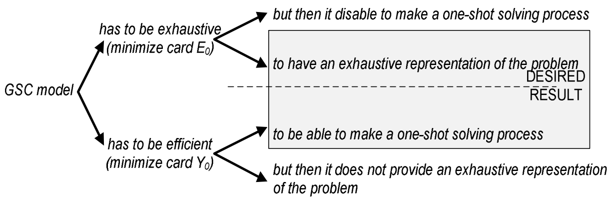

Figure 2: Contradiction of the strategy to build the GSC

These objectives should be used in different principles of automatic identification of the GSC in the DoE table in order to minimize the computational costs. The structure of DoE in the form of matrix and the set of equations describing the GSC reveal two possible solving strategies:

- the resolution of equations by optimization methods which is quite hard to solve because of its complexity and/or
- the reorganization of DoE matrix by data analysis methods which is simplified by the binary character of the matrix.

In this article the second approach is adopted in order to avoid the time-consuming calculation of set of equations. Different possible reorganisation methods are presented in the next section.

3 DIFFERENT REORGANISATION METHODS

The reorganisation of matrix and its visualisation is usually used in order to clarify its structure before the statistical analysis, particularly in domains such as sociology, ecology, archaeology, geography etc. The goal is to study the data in more details and express the existing relations between groups, categories or parameters of different systems or communities. This remains the central problem in GSC – the relation of contradiction between different evaluation parameters. Different methods of reorganisation exist with regard to the required objectives.

3.1 Principal component analysis

One of the widely known methods of statistical analysis is the **principal component analysis** PCA (Shlens, 2009). The PCA is a variable reduction procedure expressing the data in such a way as that highlights their similarities and differences. The goal is to reduce a number of observed correlated variables into a smaller number of artificial variables called principal components which are uncorrelated. It is closely related to the singular value decomposition and usually used for the image compression. The PCA belongs to linear transformation methods; as other methods such as the factor analysis, the projection pursuit or the independent component analysis. The goal of all these methods is to search special components of the representation that are linear combinations of the original variables. The PCA involves the calculation of the eigenvalue decomposition of a data covariance matrix or singular value decomposition of a data matrix, usually after mean centering the data for each attribute. The results of the PCA are usually discussed in terms of component scores and loadings. For our purpose this method is interesting if two independent orthogonal principal components are identified representing two sets of parameters in contradiction.

3.2 Seriation methods

Another method aiming at visual reordering of the two dimensional binary table is a **seriation** (Björke and Smith, 1997). The seriation methods offer a visual means of examining the structure of data by reorganizing the data to present as homogeneous a picture of the data structure as possible and hereby assisting in the problem interpretation. The idea of seriation is to bring similar rows and similar columns as close to each other as possible by their permutations, then the seriated table (image) reveals a structure demonstrating the relationship between the variables. The concept of seriation is quite simple but in general form it is difficult to implement it on a computer. In our case we can use the quasi-seriation method of two classes where the residuals define Y_0 and the two classes define Y_1 and Y_2. This remains the block seriation methods (Kusiak, 1983) which search the simultaneous partition of objects (experiments) and attributes (variables). The principle is based on the permutation of the rows and the columns of binary table in order to identify on the diagonal disjoint blocks of maximal density.

3.3 Clustering

The seriation methods are related to **cluster analysis** (Jain *et al.*, 1999). Cluster analysis is the organization of a collection of patterns – observations (usually represented as a vector of measurements, or a point in a multidimensional space) into clusters (groups) based on similarity. Typical clustering involves the pattern representation (feature extraction), definition of pattern proximity measure, the proper clustering (grouping) and eventually data abstraction and assessment of output. Clustering is a subjective process; the same set of data items often needs to be partitioned differently for different applications. This subjectivity makes the process of clustering delicate. Different types of clustering methods are known such as hierarchical clustering, K means clustering or two way clustering. The k-means algorithm assigns each point to the cluster whose center is the nearest. For our purpose the two-way clustering could be used where not only the objects are clustered but also the features of the objects, i.e., if the data is represented in a data matrix, the rows and columns are clustered simultaneously.

3.4 Blockmodeling

The **blockmodeling** (Doreian, 1999) deals with the clustering of a network. The goal is to reduce a large, potentially incoherent network to a smaller comprehensible structure that can be interpreted more readily. Blockmodeling is based on the idea that units in a network can be grouped according to the extent to which they are equivalent, according to some meaningful definition of equivalence. One of the main procedural goals of blockmodeling is to identify, in a given network, clusters (classes) of units that share structural characteristics in terms of equivalence relation. This method is based on the graph theory and particularly on relations of dominance between different units. Two types of such relations are distinguished: a structural equivalence and a regular equivalence. In the first case the equivalent units have the same connection pattern to the same neighbours; meanwhile in the regular equivalence the equivalent units have the same or similar connection pattern to (possibly) different neighbours. For our case the structural equivalence with complete blocks – block of ones should be searched.

3.5 Quadratic assignement problem

Quadratic assignment problem QAP is one of the most known combinatorial optimization problem (Commander, 2005). It can be used for data analysis tasks characterized by the use of proximity matrices. The QAP is an extremely hard problem from both theoretical and practical points of view. In order to find a global optimal solution for a given QAP one can use methods of dynamic programming or branch and bound procedures. The problem is NP-hard, so there is no known algorithm for solving this problem in polynomial time. However quite a lot of algorithms was proposed to deal with the complexity of the QAP. The very popular procedure used I QAP is the branch and bound algorithm based on lower bounds which are also used to evaluate the goodness of solutions produced by different heuristics. This principle will be used to illustrate the automatic identification of General System of Contradictions in the Design of Experiments.

4 BINARY ORDERING ALGORITHM

To illustrate the automatic identification of GSC out of DoE we propose to use a Rank Order Clustering algorithm from (King, 1980). It is quite simple to use and not really time consuming. This algorithm is based on bloc diagonal structure; the diagonal blocks represent the natural groups. This reminds a principle of group technology using in the manufacturing. The binary ordering algorithm is based on several assumptions. It considers the rows and columns as binary strings. To get block diagonal form, the similar rows should be brought together and similarly similar columns. A row is a binary number, then similar rows have similar values; similarly we can envision columns. That is, we can reorder rows or columns in the descending order of their binary value.

Algorithm

Step 1:
For row $\mathrm{m}=1,2\ldots\mathrm{M}$ compute the decimal equivalent of binary string $\mathrm{c_m}$:

$$c_m = \sum_{p=1}^{P} 2^{P-p} a_{pm} \ ; \ a_{pm} = 0 \vee 1 \ ;$$

where P is a number of parts (columns) and p index of column.

Reorder the rows in decreasing order of $\mathrm{c_m}$. In case of tie, keep the original order.

Step 2:
Compute the decimal equivalent of binary string $\mathrm{r_p}$ corresponding to column p:

$$r_p = \sum_{m=1}^{M} 2^{M-m} a_{pm} \ ; \ a_{pm} = 0 \vee 1 \, .$$

Reorder the columns in decreasing order rp . In case of tie, keep the original order

Step 3:
If the new matrix is unchanged, then stop, else go to step 1. The process should be reiterated till the stabilisation of rows and columns.

Ending orderings are not unique for a given data set. Different starting orderings may yield different ending orderings. It provides starting point for most of the grouping procedure.
This algorithm should be applied just on the evaluation parameters where one searches the set of parameters in contradiction. After the reorganisation of the DoE matrix the visual analysis of blocks is necessary to identified different possible GSC.

5 ILLUSTRATION ON ELECTRICAL CIRCUIT BREAKER

Let consider a simple technical system such as an electrical circuit breaker. When an overload occurs, the overload creates a force (due to magnets and electrical field) which operates a piece called firing pin. The firing pin opens the circuit by pressing the switch, located in the circuit breaker. In case of high overload, the firing pin, this is a plastic stem, breaks without opening the switch. Components are presented on figure 3.

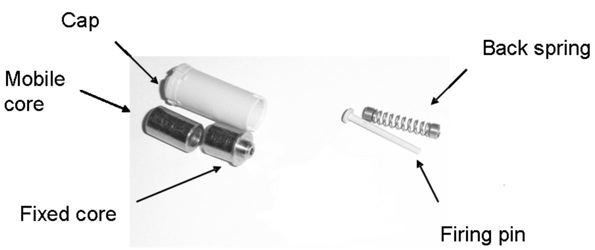

Figure 3: Components of electrical circuit breaker.

5.1 Problem statement

The problem has been studied and the main system parameters and their domains have been defined as: x_1: firing pin material (plastic – 1, metal – 0) ; x_2: core internal diameter (high – 1, low – 0) ; x_3: core external diameter (high – 1, low – 0) ; x_4: firing pin diameter (high – 1, low – 0) ; x_5: spring straightness (high – 2, medium – 1, low – 0) ; y_1: circuit breaker disrepair (satisfied – 1, unsatisfied – 0) ; y_2: circuit breaker reusability (satisfied – 1, unsatisfied – 0) ; y_3: spring core mounting (satisfied – 1, unsatisfied – 0) ; y_4: firing pin bobbin mounting (satisfied – 1, unsatisfied – 0) ; y_5: normal mode release (satisfied – 1, unsatisfied – 0) ; y_6: firing pin initial position return (satisfied – 1, unsatisfied – 0). In this definition of the problem the x_i are the action parameters whereas the y_i are the evaluation ones. The system behaviour was modelled by Design of Experiments and it is shown in table 4.

The objectives that have been established to build the DoE are:

- the satisfaction of at least one evaluation parameter in each experiment;
- each of the action parameters has at least one time each of its possible values;
- to minimize the number of experiments.

Even if the assumption is not totally consistent, the action parameters have been considered independent in the limits of their defined domains.

	x1	x2	x3	x4	x5	y1	y2	y3	y4	y5	y6
e1	1	1	0	0	1	1	0	1	1	1	1
e2	0	1	1	1	1	0	1	0	0	1	1
e3	1	0	1	0	0	1	0	1	0	0	0
e4	1	1	0	0	0	1	1	1	1	0	0
e5	1	0	1	0	1	1	0	1	0	1	1
e6	0	1	0	1	2	0	1	0	1	1	1
e7	1	0	1	1	0	1	0	1	0	0	0
e8	1	0	0	0	1	1	0	0	1	1	1
e9	0	1	0	0	2	0	1	0	1	1	1

Table 4: DoE for the circuit breaker

First evidence is that no solution can be found in the defined DoE, as no experiment enables the satisfaction of all the evaluation parameters. Looking for Generalized System of Contradictions in such a table could lead to several ones, at least one per evaluation parameter, as soon as each evaluation parameter is at least satisfied once.

Assuming that the choice of action parameters is done such a way that each evaluation parameter will be satisfy at least in one experiment, and assuming that no solution is found in the table, one can say that each evaluation parameter will have at least one experiment in which it will be satisfied and one experiment in which it won't be. Thus a contradiction could be formulated for each of the evaluation parameters. But of course the Generalized System of Contradictions also enables the formulation of more complex Generalized System of Contradictions, implying two combinations of evaluation parameters. Thus a set of Generalized System of Contradictions can be formulated for one solutionless DoE.

One question becomes underlying: should all the Generalized System of Contradictions be elicited? If no, how to choose the Generalized System of Contradictions, or set of contradictions to be considered?

The application of Rank Order Clustering algorithm leads to the following reorganisation of the DoE matrix:
After two steps and the stabilisation of rows and columns the final matrix is shown on table 5.

	x1	x2	x3	x4	x5	y1	y3	y4	y2	y5	y6
e4	1	1	0	0	0	1	1	1	1	0	0
e1	1	1	0	0	1	1	1	1	0	1	1
e5	1	0	1	0	1	1	1	0	0	1	1
e7	1	0	1	1	0	1	1	0	0	0	0
e3	1	0	1	0	0	1	1	0	0	0	0
e8	1	0	0	0	1	1	0	1	0	1	1
e9	0	1	0	0	2	0	0	1	1	1	1
e6	0	1	0	1	2	0	0	1	1	1	1
e2	0	1	1	1	1	0	0	0	1	1	1

Table 5: Final reorganisation issued from ROC algorithm

As one can see, different possible blocks of ones can be identified in the part of evaluation parameters Y. The choice of these blocks and so the choice of the GSC should be done according to some criterion. Two criterions were presented above – one minimizing the set of E_0 and the second minimizing the set of Y_0.

5.2 Criterion of minimizing E_0

The first postulate is to choose the Generalized System of Contradictions that minimizes E_0, as it is composed by the experiments that won't be considered in the contradiction model. The hypothesis is that the more experiments the Generalized System of Contradictions will include, the more representative of the problem it will be.

Thus, the minimization of E_0 leads to a Generalized System of Contradictions where

- E_0 is empty.
- E_1 groups the experiments where y_1 and y_3 are simultaneously satisfied, $E_1=(e_1;e_3;e_4;e_5;e_7)$
- E_2 corresponds to the experiments where the evaluation parameters y_5 and y_6 are satisfied, $E_2=(e_2;e_6;e_8,e_9)$.

Therefore the DoE is organised, as shown on table 6, to graphically represent the Generalized System of Contradictions.

	x1	x2	x3	x4	x5	y1	y3	y4	y2	y5	y6
e4	1	1	0	0	0	1	1	1	1	0	0
e1	1	1	0	0	1	1	1	1	0	1	1
e5	1	0	1	0	1	1	1	0	0	1	1
e7	1	0 E1	1	1	0	1	1	0 Y0	0	0	0
e3	1	0	1	0	0	1	1	0	0	0	0
e8	1	0	0	0	1	1	0	1	0	1	1
e9	0	1	0	0	2	0	0	1	1	1	1
e6	0	1 E2	0	1	2	0	0	1	1	1	1
e2	0	1	1	1	1	0	0	0	1	1	1

Table 6: Illustration of the Generalized System of Contradictions minimizing E_0 in DoE

A first way to interpret the Generalized System of Contradictions model out of the reorganized DoE is to simply enumerate all the states of the action parameters that are characterized by E_1 and E_2. For the domain experts, the matrix representation of the concepts is not really meaningful, but the translation into the physical terms is more comprehensive. So the set of the evaluation parameters that consists of the normal mode release and the firing pin initial position return is in contradiction with circuit breaker disrepair and the spring core mounting.

5.3 Criterion of minimizing Y_0

The second postulate is to choose the Generalized System of Contradictions that minimizes Y_0, as it is composed by the evaluation parameters that won't be considered in the contradiction model. The hypothesis is to solve the problem in a "one-shot" contradiction resolution and to obtain an efficient GSC.

Thus, the minimization of Y_0 leads to a Generalized System of Contradictions where

- Y_0 is empty, $E_0=(e_2,e_8)$
- Y_1 groups the experiments where y_1 and y_3 are simultaneously satisfied, $E_1=(e_1;e_3;e_4;e_5;e_7)$
- Y_2 corresponds to the experiments where the evaluation parameters y_2, y_4, y_5 and y_6 are satisfied, $E_2=(e_6,e_9)$.

Therefore the DoE is organised, as shown on table 7, to graphically represent the Generalized System of Contradictions.

	x1	x2	x3	x4	x5	y1	y3	y4	y2	y5	y6
e4	1	1	0	0	0	1	1	1	1	0	0
e1	1	1	0	0	1	1	1	1	0	1	1
e5	1	0 E1	1	0	1	1	1	0	0	1	1
e7	1	0	1	1	0	1	1	0	0	0	0
e3	1	0	1	0	0	1	1	0	0	0	0
e8	1	0	0 E0	0	1	1	0	1	0	1	1
e9	0	1	0	0	2	0	0	1	1	1	1
e6	0	1 E2	0	1	2	0	0	1	1	1	1
e2	0	1	1 E0	1	1	0	0	0	1	1	1

Table 7: Illustration of the Generalized System of Contradictions minimizing Y_0 in DoE

When the normal mode release and the firing pin initial position return are satisfied the circuit breaker disrepair, the circuit breaker reusability, the spring core mounting and the firing pin bobbin mounting are not.

6 CONCLUSION AND PERSPECTIVES

The proposed Generalized System of Contradictions model is a model that covers both optimisation and inventive problems. As soon as no solution can be found by optimisation algorithms, a set of Generalized System of Contradictions can be formulated.

The first interest is to enable a linking between optimisation tools and inventive problems resolution tools such as those from TRIZ-based approach. As most of the time, the nature of the problem is not known at the beginning of the problem resolution process, it is interesting to be able to shift from one family of resolution tools to the second one.

The proposal of different data analysis to extract automatically contradiction out of optimisation models has been tackled in this paper. The use of Rank Order Clustering algorithm was proposed because of its simplicity and not time consuming. However this algorithm does not enable to extract automatically the different GSC and this should be done manually.

The question of the contradiction to take into account has also to be considered. In this paper two hypothesis was to consider the Generalized System of Contradictions minimizing the size of E_0 and the Generalized System of Contradictions minimizing the size of Y_0. Other different hypothesises should be tested. Another question is the evaluation of the meaning of the contradiction; it is represented currently by the dimension of E_0, but what if this dimension is high? What if its dimension is higher than the ones of E1 and E2? The same question appears for the dimension of Y_0. As the resolution phases have not been tackled for the moment, it is difficult to propose an answer, but the relevancy of the Generalized System of Contradictions will be evaluated in accordance to the benefits of its resolution. This means also that one important criterion to evaluate the relevance of a Generalized System of Contradictions is the number of considered evaluation parameters.

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