01/2017 (03)

Journal of the European TRIZ Association

INNOVATOR

Special Issue:
Selected papers presented at the 16th International TRIZ Future Conference, October 24-27, 2016, Wroclaw, Poland

Journal of the European TRIZ Association – ETRIA e.V.
INNOVATOR, ISSN 1866-4180, 01/2017 (03)

All papers accepted for publication in this Special Issue were submitted to the Conference Organizing Committee as full papers and were double peer reviewed. Authors were given the opportunity to amend their paper in light of these reviews before the decision to accept and publish the paper.

The Journal of the European TRIZ Association (ETRIA) has been set up to accomplish the following tasks:

- Promotion of research and development on organization of innovation knowledge in general and particular fields by integrating conceptual approaches to classification developed by artificial intelligence and knowledge management communities,
- International observation, analysis, evaluation and reporting of progress in these directions,
- Promotion on an international level of the exchange of information and experience in the Theory of Inventive Problem Solving TRIZ of scientists and practitioners, of universities and other educational organizations,
- Development of TRIZ through contributions from dedicated experts and specialists in particular areas of expertise.

Imprint:
INNOVATOR
Journal of the European TRIZ Association
ISSN 1866-4180
Publisher: ETRIA e.V.
Editors: Gaetano Cascini, Pavel Livotov
Guest editors: Tomasz Arciszewski, Sebastian Koziołek
ETRIA e.V. - European TRIZ Association
Basler Str. 115
D-79115 Freiburg - Germany
Internet: www.etria.eu
E-Mail: info@etria.eu

INNOVATOR • ISSN 1866-4180 •Journal of the European TRIZ Association - ETRIA e.V.

Content

The European TRIZ Association ETRIA WWW.ETRIA.EU

Journal of the European TRIZ Association 01-2017 (03)

Journal of the European TRIZ Association INNOVATOR

Tech-Finder: a Dynamic Pointer to Effects

Davide Russo* [a], Tiziano Montecchi [b], and Antonio Caputi[a]

[a]*University of Bergamo, viale Marconi 5, Dalmine 24044, Italy* [a]

[b]*Bigflo srl, via Galvani 2E, Dalmine 24044, Italy*

* Corresponding author. Tel.: +39.035.205.2353; fax: +39.035.205.2077. *E-mail address: davide.russo@unibg.it*

Abstract

The dynamic pointer to effect is an IR tool that searches for a scientific effect capable of providing the required function. At difference from static pointers which are entirely pre-built databases, the dynamic type is based on the integration of a pre-built effects library with a semantic search engine that scans technical and scientific literature in order to suggest documents describing relevant effects to realize a certain function. As result, the search engine can use any function in form of a pair verb-object, where the relations between functions and effects are always updated with the updating of the literature and the suggested list of effects is always tailored only on the specific function of the user, avoiding huge lists that make the tool unusable for low precision. The key aspect of the dynamic database is that recall and precision problems can be decoupled, in fact, recall depends on the completeness of effect library and the expansion of the query, while precision is affected by the IR algorithms of the search engine. The present article presents a comparison of the most representative pointers to effects (developed by Altshuller and later) together with an analysis of the open problems and main limitations of these tools shown on three case studies selected in order to bring out the main limitations of effects databases.

ISSN 1866-4180
Peer-review under responsibility of scientific committee of Triz Future Conference 2016.

Keywords: Pointer to Effect, Effects Database, Patent, Technology Transfer, State-of-the-Art

1. Introduction

It is opinion of many that TRIZ is characterized by two peculiar aspects which are not present in any other problem solving method: (1) TRIZ is based on the axiom stating that technical systems evolve on the base of objective laws. Such laws, which are intelligible, may be identified and finally utilized in order to solve inventive problems consciously. (2) all systems grow according to the increase of contradictions. The quantity of contradictions rises, and their solutions are achieved as consequence of a quality gain, or, in other words, thanks to the introduction of a completely new idea. The fundamental condition to “know” an object, to represent its nature using ideal images, is the knowledge related to the “whole system of contradictions”, that even V.I. Lenin had described before as the determination of a concept passing through the contradictory nature of the thing itself, the contradictory forces and tendencies in each phenomenon.

However, aside of these two aspects, there is another important feature which is not normally highlighted as it should: TRIZ may be deeply integrated with several structures for the organization of knowledge, as inventive principles, guidelines, evolution trends, and, most important, physical, geometrical and chemical effects Dbs.

It is quite simple to understand that the introduction of “philosophical” and evolutionary perspectives are unique concepts in the landscape of problem solving methods, while it is very emblematic that no other method, except for TRIZ, has developed knowledge databases which are transversely useful to anyone who needs to solve a problem.

Outside the TRIZ, in the last 10-15 years, web portals increased in number and diffusion, and many have been developed in order to allow the access to a growing number of Dbs, mostly containing technical information about materials. More in detail, specialized sites are more than 40 focused on different types of materials: metallic, ceramic, plastic, glass, eco-sustainable, thermal, chemical, textile, nanocomposites, semiconductors, crystal structures and others. Further examples are sites organizing information on the base of the application field, such as architecture, additive manufacturing, optics, and many other fields of engineering.

Moreover, great interest comes from the recent rise of repositories of “natural solutions” inspired by the biological world. Although more than 40 years ago, TRIZ already predicted the potential of such approach to support the design by analogy, only recently remarkable portals have been developed (i.e. Asknature, Biomimicry, Dilab).

Regarding Dbs of geometric effects, the last relevant work is dated last 80’s, more precisely the Vikentiev’s article “In rules of a game without rule” [1]. In such a work, different objects are classified according to the way their shape influences their behavior, in order to generate some specific function or physical effect. Even for what concerns the chemical effects, very few sources of information can be found; an example is given with Salamatov’s study [2].

Finally, we report on the Dbs of physical effects. Such Dbs hardly caused an interest in the scientific environments, with the exception of TRIZ community, which has deeply investigated them, before and even after the Altshuller’s death.

Next section presents an introduction of effects Dbs together with a review of a selection of 5 Dbs available in literature. The third section is dedicated to compare these Dbs and highlight their main limitations using three different case studies. In the last section, conclusions are drawn.

2. State of art on Pointers to Effects

The goal of Pointers to effects (also called effects databases) is to simplify the search of a physical or chemical effect, factor, or method capable of providing the required function or property. From the point of view of simplicity of effects application, the database of effects is built on a functional principle: it contains a list of functions (applications) commonly encountered in practice, and a corresponding list of effects that may be employed to realize these functions. This structure helps engineers to resolve technical problems. For all of Dbs, procedure is the same:

- Define what function you want to achieve in your product/system.
- Select, from the list of functions, the function which is closer to what you defined as your desired function. Then select the object or attribute of that function.
- The database extracts a list of physical effects and phenomena which can be used as physical principles to deliver the selected function.
- Visualize the information about the selected effect or phenomena, in some case equipped with examples, case studies, patents, images and formulas.

The main differences stand in the quantity of physical effects considered, and the strategy to use them. The present paper takes into account only a selection of the most known and representative portals. For example, the authors do not consider Dbs in Russian language, because they are not particularly relevant in terms of number of effects. Even the original list of effects of Altshuller is not reported, since further versions enlarged by his disciplines have been preferred because more complete and organized, such as the Korean web portal realized under the supervision of Nikolay Khomenko (Triz.ko.kr).

Regarding the comparison with commercial software, Tech optimizer v. 3,0 have been chosen, which is provided with the same effects library as the more famous Goldfire. Whereas, we consider its functioning for what concerns the semantic research. Moreover, two software have been taken as reference, since they are of recent conception, and due to the diffusion of internet and open source philosophy: Oxford Creativity and Production Inspiration of Aulive (connected to Creax).

Finally, Tech-Finder is presented as the new tool developed in collaboration with the University of Bergamo.

For the comparison, three different case studies have been properly selected in order to show the main limitations of effects Dbs, these are reported in the following:

1) in order to improve a product or an object, the functional decomposition of the same may be a critical passage, because the MUF (Main Useful Function) may be expressed in many ways, according to the level of detail of the description, or the function may be referred to different (but equivalent) objects (for instance, “sterilize vessel” is conceptually equivalent to “kill bacteria”);
2) the definition of the function is not trivial, due to the problems of polysemy, the same term (verb) may specify many different functions (for instance, the term “separate”, may be interpreted as “disconnect”, “divide”, “discharge” or “extract/remove”);
3) there is not a unique and common library of physical effects, as well as, a definition of physical effect unanimously accepted in literature. Thus, each Db has its own library, leading to a proliferation of many different libraries that in some cases are not updated.
4) there is not a proven way to suggest physical effects. The way of providing and visualizing the trigger result changes from software to software (from simple list of effects to detailed explanations, images, formulas, applications, patents, etc.)

The authors, propose an analysis (see table 1) of 5 Dbs based on four features that we explain in the following to facilitate the understanding of the analysis:

- Query: is the input of the Db, and it coincides with the functions which are the way of using these Effects known to the database.
- Effects: are the result of the database depending on the query.
- Relation: link between query and effects, in case of a database is a linking table that holds the many-to-many relationships between Queries and Effects.
- Type of database: in this article, the authors divide the DBs in two types, static Dbs using a prebuilt database with pre-

set queries, effects and relations. Dynamic Dbs are based on a pre-set library of effects, while queries are any available functions and relations are created from time to time by a search engine that retrieves documents linking that function with the effects.

Table 1 Pointer to Effect comparison

	Altshuller Db/ (Triz korea)	Tech-Optimizer 3.0	Oxford creativity	Aulive	TechFinder
DB Type	static	static / (dinamic in Goldfire)	static	static	dynamic
Number of Effects	130 (approx)/ (141)	600	936	300 (estimated)	163
Number of query (function and attribute search):	30 /(51)	216	441	148	∞
Number of relations	224 /(398)	6500 (estimated)	19693	1000 (estimated)	∞

2.1. Triz.ko.kr - Altshuller Pointers to effect

Altshuller Pointers to effect in the latest version proposed by Savransky [3] is a static database containing a limited list of very general actions (e.g. measure, move, formate, etc.) commonly encountered in practice, and provides three types of object (solid, liquid, gas). Definitions of effects are not precise (e.g. Thermal-electrical phenomena, Electro-hydraulic effect), no effects description is available and the Db is not kept updated. A larger and updated version has been proposed by TRIZ Korea (http://www.triz.co.kr). The number of results for each query stands in a range between 2 and 30, and normally are in the form of "verb" and "object", and possibly a "parameter". The visualization of results contains the effects description, and in some cases images and formulas.

2.2. Tech-Optimizer 3.0

It has been conceived as a stand-alone software for supporting a creative thinking of engineers and researchers inside a more ambitious projects combining artificial intelligence with the theory of inventive problem solving [4, 5]. From 1999 to 2010 Tech-Optimizer was a part of Goldfier Innovator by Invention Machine. It works in a static way but together with Knowledgist + CoBrain, the Semantic processors retrieve "grains" in a dynamic way from patent literature or preprocessed knowledge based. A detail explanation about Tech-Optimizer functioning is offered by Nakagawa paper [6].

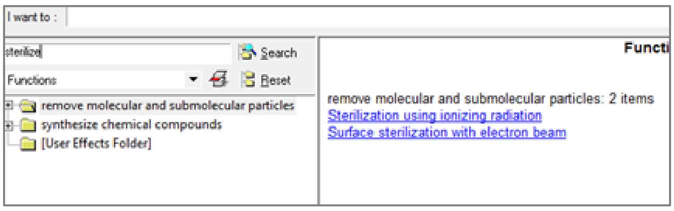

Figure 1. Tech-Optimizer 3.0: screenshot of input and results classification

There are two main modes of searching inside the Db:

- "Functions Groups" consists of browsing effects that are categorized in two hierarchical levels: general functions performed on field, parameter and substances (example of functions "accumulate", "detect", "prevent", etc.) and sub-functions (example of sub-functions of "accumulate field": "absorb electromagnetic waves or light", "absorb forces, energy and momentum", etc.).
- "Search" consists of a keyword search on effects titles and descriptions. The effect is retrieved only if the query exactly matches the text.

2.3. Oxford creativity

TRIZ effects database provided by Oxford Creativity (https://www.triz.co.uk/triz-effects-database) and presented by Martin [7] offers (as of May 2016):

There are three main modes of operation in order to consult the Db: Function, Parameter and Transform:

- The "function" mode, allows to select one of the 175 queries, which are generated by the combination of 35 verbs (e.g. "absorb", " accumulate", " bend",…) and 5 objects ("divided solid", "solid", "liquid", "gas" and "field").
- The "parameter" mode, is advantageous when the request is to modify a specific technical parameter. The Db allows to formulate 185 queries, combining 37 parameters (e.g. "brightness", "color", "concentration",…) and 5 basic verbs describing the desired modification (e.g. "change", "decrease", "increase", "measure", "stabilize").
- Finally, if the goal regards the transformation of energy, 9 forms are available as input and output (e.g. acoustic, chemical, electrical energy, etc.), so it is possible to formulate 81 queries.

Figure 2. Oxford Creativity: screenshot of input of the "function" mode

Regarding the visualization, usually queries produce an average of 50 effects and applications. Results are presented as a list of suggested Effects and Applications, each of which is linked to a short description of the effect and, in some cases, a short application note. Most of effects and applications are linked to a definition page of Wikipedia or other web resources.

2.4. Production Inspiration

Production inspiration is an effects Db by Aulive (http://www.productioninspiration.com/), it provides (as of May 2016). The queries are the composition of 37 functions over 4 different objects (“solid”, “liquid”, “gas”, “field”).

Regarding the results and their visualization, usually queries produce from 1 to 20 effects, which are explained by using an animation of an applicative example, a brief description and the explanation of a case study.

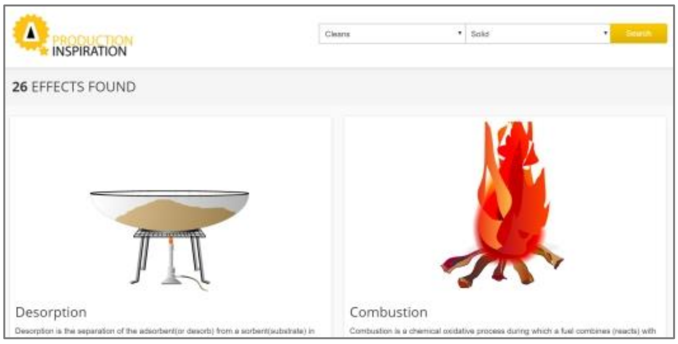

Figure 3. Production Inspiration of Aulive (Creax): screenshot of input and resulting effects

2.5. Tech-Finder

Tech-Finder is a dynamic effects database developed by BiGFLO in collaboration with the University of Bergamo [7].

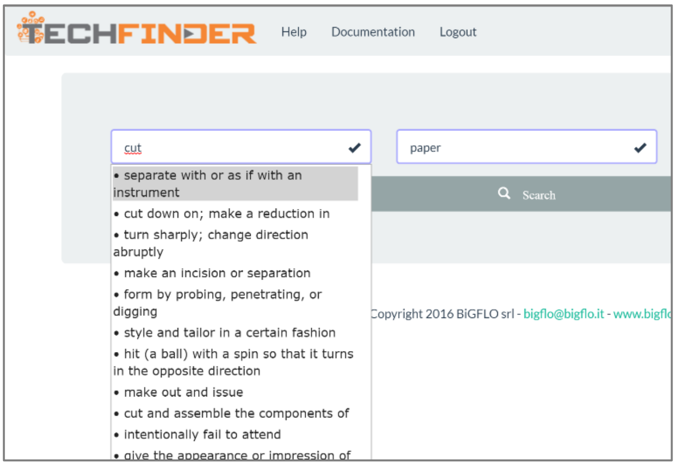

Figure 4. Tech-Finder: screenshot of semantic input. Verbs and objects are not chosen from a predefined list.

The software works with any query in form of a pair: verb-object: these terms are conveniently “expanded” (in order to improve the recall), and the semantic engine carries out a search on technical or scientific literature, such as patents and internal knowledge bases. The result of such procedure is processed using a (static) set of more than 150 physical effects, so that the relation between query and physical effect is created. The link between query and effect is the patent document (or any other kind of documentation) and this relation is created only if the use of the physical effect to perform the function (query) is described at least in one patent of the domain. The output consists in a list of physical effects, which satisfy specific semantic relations occurring between the search terms in the query, and the searched effects. The number of provided effects changes according to the specific query, so that the pair “sterilize” and “lens” will produce a different result compared to the pair “sterilize” and “surface”, or “sterilize” and “solid” [8, 9].

In a dynamic pointer the quantity and quality of results depends on the nature of the data source. Patents have been selected because, even if their content may be sometimes misleading regarding the object of the patents themselves, the control provided by examiners ensure the accuracy of the description of the physical processes reported anyway; moreover, the number of patents (more than 90 millions), and the variety of fields treated makes such data source very interesting.

The visualization of results is provided by visualizing the physical effects classified in five fields, according to M-A-T-Ch-EM scheme; furthermore, there is the possibility to visualize the more pertinent patents, potential technological trends, possible competitors and related infographics.

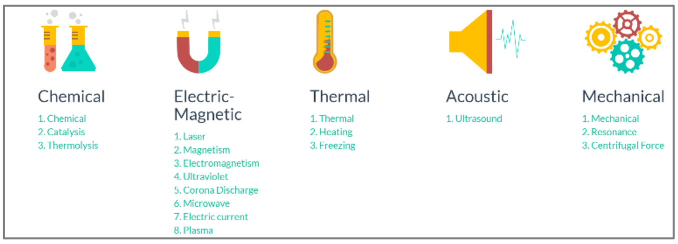

Figure 5. Tech-Finder: screenshot of effects classified according to MATChEM

3. Case studies

Three case studies have been selected from a pool of many real professional activities: the choice depends on the request of the customer to investigate completely new operating principles for their products, introducing new physical effects.

Cut paper: “to cut” is a very precise indication, mostly without homonymies, and the noun “paper” makes the function not compatible with most of physical effects.

Reduce noise: this test is done in order to search features in a domain which is well known, but generally not enough covered from effects Dbs.

Sterilize lens: the query is very relevant, and, moreover, functional analysis may be set up using different couples of terms for the verb and the object (“sterilize” and “lens”, “kill” and bacteria”, etc.). This particular case study is ideal in order to test the Dbs because the authors have already built an exhaustive patent collection related to contact lenses sterilization which has been already classified into physical effects by a manual selection [8]. This pool, called “Sterilization Pool”, has been updated and it contains around 1300 patent families only with English text and obtained from the IPC patent class (A61L12: Methods or apparatus for disinfecting or sterilising contact lenses; Accessories therefor). Each document has been manually classified according to physical effects used to setrilize. The final result is a list of 22 physical effects, subdivided according to the MATChEM as shown in Table 2.

Table 2. List of 22 physical effects manually found inside the Sterilization Pool and classified according to MATChEM

PHYSICAL EFFECTS		
MECHANICAL	**CHEMICAL**	**ELECTRO-MAG.**
1. Centrif. force	9. Catalysis	17. Gamma radiat.
2. Pressure	10. Electrolysis	18. Laser
3. Vibration	11. Chemical general	19. Led
ACOUSTIC	**ELECTRIC**	20. Microwave
4. Ultrasound	12. Corona discharge	21. Plasma
THERMAL	13. Electric current	22. UV light
5. Boiling	14. Electrophoresis	
6. Freezing	15. Electron beam	
7. Vaporizing	**MAGNETIC**	
8. Heating	16. Magnetic field	

Figure 6 presents the comparison of results for the three case studies. The first one was about the lens sterilization. Relevant effects, recall and precision are calculated in relation with the 22 effects manually identified inside the Sterilization Pool (Table 1). These 22 effects are considered the total number of effects available to sterilize contact lenses, thus if a Db suggests all these 22 effects it reaches 100% of recall.

Since the primary purpose of an effects database is to provide knowledge of relevant effects, recall value is the most important index. In this specific case study, among all the static Db, Oxford creativity reaches the best recall.

As we can see, the compromise for having a high recall (54%) is to suggest a huge list of effects for each query, this often leads to report many irrelevant effects (low precision, 14%). We can observe the same behavior with Tech-Optimizer, which has high recall (41%) but very low precision (5%). This contradiction between recall and precision of static Dbs can be overcome through dynamic Db that, for every query, searches all the effects of the library, selecting from patents only those that are really relevant for the query/application field.

The case study about cutting paper, shows the general inefficiency of pointers for this kind of application. Most of tools are capable of providing a large number of effects but unfortunately many of them are not relevant and at the same time the most widespread and known are missing (i.e. laser cutting, water cutting, etc.). One of the main reason to explain that resides in the fact that “ to cut” is not present. Using “separating something” instead of “cutting” produces a list of effects more related to the meaning of “ differentiating one solid to another one” that cutting it.

In order to solve this problem, it is not sufficient to move from static to the dynamic database, but it also necessary a semantic search engine.

Finally the case about reduce noise. Altshuller’s list of effect doesn’t allow to translate the problem into any functional query. The other pointers provide a short list of effects, all related to sound domain but not applicable to noise reduction. It seems this topic conceived for describing a phenomenon instead of using the suggested effect for solving a problem

4. Conclusion

Existing pointers to effects can be divided in static and dynamic according to the way the query can be built.

Until now only Goldfire was able to provide a dynamic pointers even if its kernel was based on a static database as Tech Optimizer.

In this work a new dynamic pointer of effect, called Tech Finder is proposed. It allows the user to insert a specific function without worrying to convert it in a preset query, suggesting effects always tailored to the specific field of investigation and supporting idea generation by a sample of patents or other documents describing the application of that effect to the specific user function.

While the benefits provided by a dynamic pointer are countless, the other we have a much more complex tool, whose effectiveness depends on the richness of the knowledge base and effectiveness of research strategies and search engine to overcome problems of homonymy, polysemy and effects interpretation.

.TechFinder works on patents and has integrated both language filters for semantic disambiguation and typical filters from patent search engines (such as the IPC code for patent classes identification).

Indeed, a specific library for searching effects have been developed including technologies and units in the list of keywords used for expanding the concept related to all effects to be searched.

In addition, the classification of scientific effects according to MATChEM fields enhances also the capability of integration with other TRIZ tools (e.g. 76 Standard Solutions).

Finally, the dynamic pointer can be easily used for several purposes such as state-of-the-art, technology transfer and idea generation activities, just playing on the abstraction level of the function (e.g. sterilize-lens, sterilize-surface, clean-object).

Pointers Comparison		Altshuller	Tech-Optimizer	Oxford	Aulive	Tech-Finder
STERILIZE LENS	Results Relevant/Tot	4 /15	9 / 173	13/96	6/26	18/22
	Recall	17 %	41 %	54 %	27 %	75 %
	Precision	27 %	5 %	14 %	23 %	82 %
	Query	• destroy object: 11 • purify substance: 4 *Many inappropriate effects, e.g. cutting by water, laser, mech., Coanda effect, etc.*	• clean solid substances: 30 • destroy substances: 22 • destroy tech. objects : 9 • remove solid sub: 11 • remove molec. parts: 22 • remove particles: 32 • remove solid subst.: 57	• clean solid: 90 • purify solid: 27 *Function mode has been used*	• clean solid *20 effects may be relevant even if hardly applicable to the lens field.*	• Sterilize lens *3 irrelevant effects + 1 very general effect (thermal)*
CUT PAPER	Results	22	99	188	16	18
	Precision	*Only ultrasound is relevant*	*Most of effects are irrelevant because not applicable to the function cut*	*Most of effects are irrelevant* (39 duplicates removed)	*The most common effects are missing, e.g. laser, water jet, plasma cutting,*	
	Query	• change objects size: 6 • separate substance: 16	• separate particles: 63 • separate solid substances: 44	• Separate solid: 115 • Break down solid: 112 *Function mode has been used*	• separate solid *"separate" is "differentiate one solid from another solid."*	• cut paper
DECREASE NOISE	Results	0	26	12	8	28
	Precision	*There is not query related to acoustic*	*Most of effects describe the phenomena of sound without explain how to reduce it.*	*Most common effects suggested by other Dbs are missing. Most of effects describe the phenomena of sound without explain how to reduce it.*	*All effects are irrelevant with the noise field (e.g. Birefringence, Prism, Aerosol, Battery, Capacitor, Corona Discharge, Fly-wheel, Fuel-cell).*	
	Query	• No query	• Absorb mechanical and sound waves	• Decrease sound *Parameter mode has been used.*	• Absorb field: 6 • Remove field: 2 *It is very challenge to choose the appropriate function describing this case.*	• Decrease noise

Figure 6 Software comparison on 3 different case studies

References

[1] Vikentiev I.L. About using geometrical effects in the inventive problem solving process*; In rules of a game without rule, S. Petrozavodsk: Karelia,* 1989. ISBN 5-7545-0108-0

[2] Salamatov, Y.P. Heroic Deeds at Molecular Level: Chemistry Helps Solve Difficult Inventive Problems. - A Thread in the Labyrinth / Compiled by Selyutsky, A.B. - Petrozavodsk: Karelia, 1988.

[3] Savransky SD. Engineering of creativity: introduction to TRIZ methodology of inventive problem solving. 2000. Ed: Boca Raton, Fla.

[4] Kucharavy D. Thoughts about history of Inventive Machine Projects, Presentation at LICIA / LGECO - Design Engineering Laboratory INSA Strasbourg, 2011. http://www.seecore.org/d/20110923(2).pdf

[5] Tsourikov V.M., Inventive machine: Second generation. AI & SOCIETY, 1993. 7(1), pp.62-77

[6] Nakagawa T., Software Tools for TRIZ - Mechanism, Usage, and Methodology Learning -- Invention Machine's TechOptimizer Pro Version 2.5, 1998.

[7] Martin A. Brewing Free Beer: Using Ideality to develop a 'free-to-use'TRIZ Effects Database. Procedia Engineering. 2015 Dec 31;131:312-26.

[8] Montecchi T., Russo D. Dynamic and Semantic Database of Effects for Technology Transfer. Innovator: Journal of the European TRIZ Association. 2016. ISSN 1866-4180

[9] Russo D, Montecchi T, Liu Y. Functional-based search for patent technology transfer. In ASME 2012 International Design Engineering Technical Conferences and Computers and Information in Engineering Conference 2012 Aug 12 (pp. 529-539). American Society of Mechanical Engineers.

[10] Montecchi T, Russo D. FBOS: function/behaviour–oriented search. Procedia Engineering. 2015 Dec 31;131:140-9.