

# A Literature survey and Classification Framework of TRIZ Methodology

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**Abstract-** TRIZ is an emerging theory which deals with innovative solutions to the problems challenging the industry. Though originally developed for machine designing purposes to remove the contradictions arising in the designing, TRIZ has found its feet in other areas as well. The underlying principle of the theory- "patterns of technical evolution are repeated across industries and sciences", makes its applications limitless. Taking into account the above facts, the authors were prompted to carry out an expansive survey. A classification framework was constructed which classified the literature dealing with the TRIZ applications according to various areas. This framework will help in furthering quality research in this field and augment the work of finding its applications in other fields as well.

## I. INTRODUCTION

TRIZ (Teorijz Rezhenija Iobretatel' skich Zadach in Russian, theory of inventive problem solving) was invented by G. Altshuller of the former USSR and his colleagues by analyzing millions of patents all over the world. Bae [1] in his paper on creative problem solving with TRIZ states that "TRIZ problem solving methods are especially suited for rapidly, identifying innovative solutions that are more both robust and economical than conventional methods". This theory proposed by Altshuller was based on the fact that innovations, be it in any field, are governed by certain repetitive patterns.

Substance field models and 40 inventive principles are some of the tools used to find innovative and creative solutions to problems. Chen et al [4] states that where there is a challenging problem in an engineering system, there is a contradiction. It can be classified as a technical or physical contradiction. TRIZ uses contradiction matrix to resolve contradictions with the help of 40 inventive principles and 39 engineering parameters.

Extensive research has been done on TRIZ over the past 60 years and it has found its applications varied and numerous fields such as patent analysis, computer aided design, conflict resolution, machine designing, E-security etc. In this literature survey paper,

authors tried to give a brief synopsis of such areas and its applications. We deduce the main areas in which the research has been going and further classify them based on their specific applications. This paper first describes the Theory of Inventive problem solving, how it is applied, then it divulges into the various application fields of TRIZ. A special attention is given to its application in Computer Science. We classify the no of articles studied on the basis of findings, areas, and year of publication.

## II. UNDERSTANDING TRIZ

The TRIZ-Journal [22] States that Theory of Inventive Problem Solving is based on the hypothesis that there are universal principles that govern creative innovations that are responsible for technological advancements in all fields. A simple understanding of this hypothesis could be:-

*Somebody someplace has already solved this problem (or one very similar to it.)*

*Creativity is now finding that solution and adapting it to this particular problem.*

The three primary findings of Altschuller's research were

- Problems and solutions are same for all industries and sciences.
- Patterns of technical evolution are also repeated across industries and sciences
- The Innovations used scientific effects outside the field in which they were developed.

The research's primary discovery was that: an innovative solution is an outcome of a problem that had a contradiction, in some form, in the requirements of the solution. The process of finding an innovative solution to a given problem through TRIZ is: finding the specific problem, modeling a general problem out of it, find general solution to the general problem and transforming it into a specific solution which is the fix to problem at hand [Fig 1].

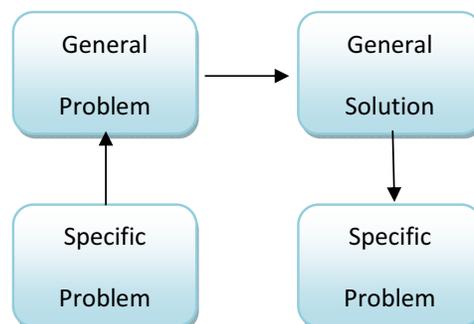


Figure 1. Overview of processes involved in TRIZ

The “General TRIZ Solutions” referred to in Fig 1 have been developed over a span of the 60 years of TRIZ research, and have been classified in different ways. Some of them are:-

- The 40 Inventive Principles of Problem Solving,
- The Separation Principles,
- Laws of Technical Evolution and Technology Forecasting and
- 76 Standard Solutions.

The Fundamental logic behind solving any problem through is that the contradictions should be eliminated. Ellen Domb[8] classifies contradictions as :-

- **Physical contradictions** are situation where one object contradictory, opposite requirements. Example, A

software should be easy to use but should have many complex features and options.

- **Technical contradictions** are classical engineering "trade-offs". when something gets better something else gets worse. Example: the vehicle has high acceleration but uses more fuel.

The research on TRIZ and the consequent patent analysis has narrowed it down to 40 inventive principles that are used to solve the technical contradictions and four separation principles that remove the physical contradictions. Alan Webb [28] States and describes each of the 40 principles.

For the analysis of contradictions, the problem is broken down into fragments and each fragment is categorized into one of the 39 features or characteristics of technological systems. The entire process of finding an innovative solution to a given problem through TRIZ given by the Fig 2.

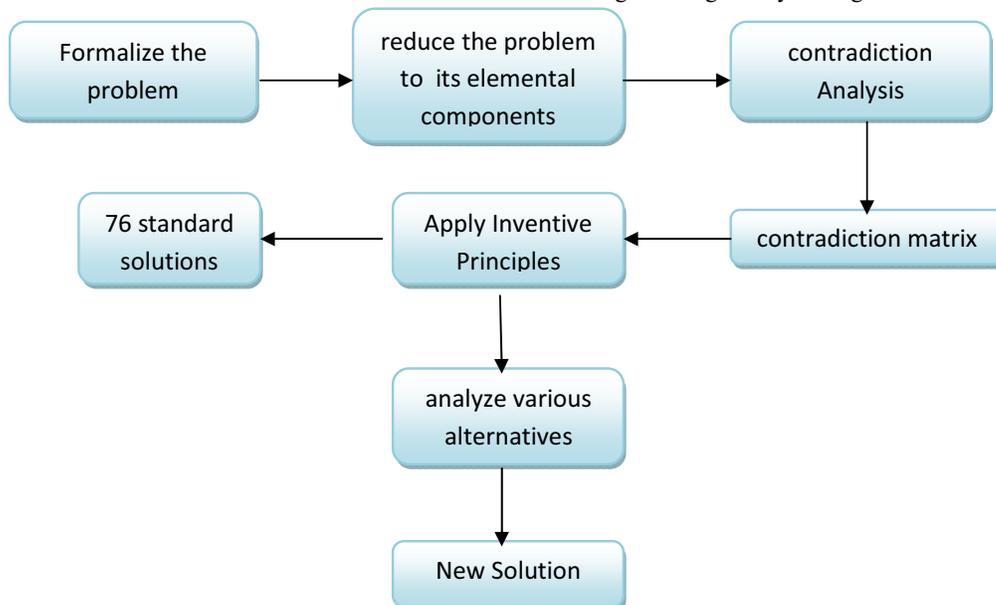


Figure 2 Block Diagram Representation of processes involved in TRIZ

### III. CLASSIFICATION FRAMEWORK

The classification of TRIZ application is primarily based on extensive study and review of the papers available on TRIZ. This analysis of the papers led us to devise a framework. Figure 3 shows the classification framework for the application fields of

The second layer of the framework describes the sub categories. For example Designing can be classified as eco-machine Design, software design, semiconducting device and product innovation. Similarly Management into E-commerce, agriculture, poultry management and conflict resolution. Computer Science is the most recent field in which TRIZ has

TRIZ. The framework has been divided into two layers, the first layer consists of three major areas of application namely

- Designing
- Management
- Computer Science

found its use and digital resource management, software debugging, artificial intelligence and E-banking security are some of the areas where it has been applied.

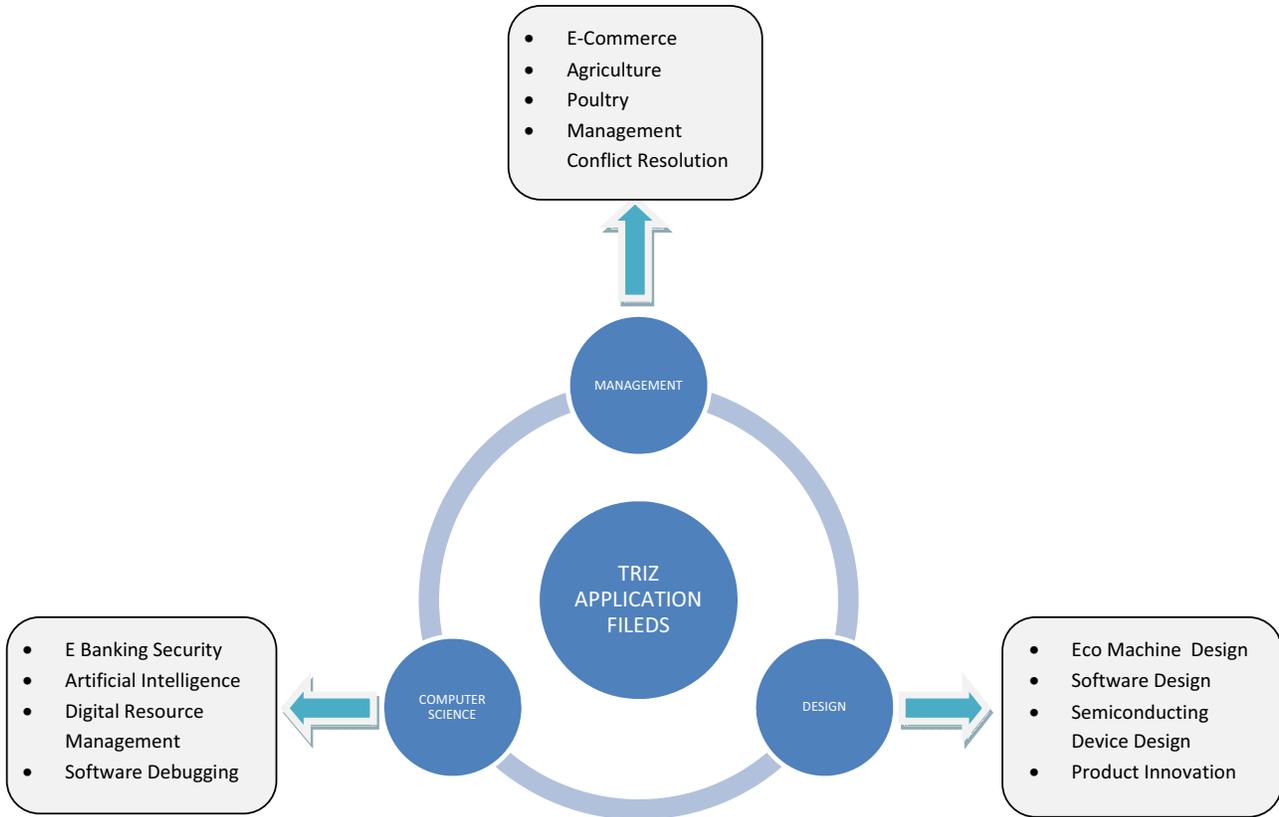


Figure 3 Classification Framework

#### A. Classification of Designing Applications

TRIZ was originally developed based on the patent analysis in order to find some patterns in innovation [29]. Applications of TRIZ in designing are vast and varied. It has been used to design Environment friendly machines removing contradictions of performance and reduced environmental burden[4]. Machine designing is another aspect where TRIZ has found its feet to improve the product quality and enhance the product innovation [2]. In recent years TRIZ has found its application in the software industry as well where it is applied to improve the quality of software architecture[14]. Prasad and Sudha [23] propose the TRIZ system for innovation in submersible pump system specially when they are used in series and parallel operations required for drainage and large irrigation purposes. Another area of application is Computer Aided Innovation which has been partially derived from the principles of TRIZ along with other theories such as QFD and axiomatic design. According to Noel [18] "The goal of these new CAI tools under development is to assist innovators, inventors, designers, process developers and managers in their creative performance, with the expectation of changes in paradigms through the use of this new category of software tools " .

#### B. Classification of Managerial Applications

TRIZ has been applied to many of the 500 companies of USA and Europe. Companies like LG and Samsung have been applying TRIZ for a few years to achieve the desired levels of cost saving

and product innovation[16]. The problems that arise in the field of management such as increasing profitability, improving service quality, reduced costs, better utilization of resources can be solved using TRIZ . Liu and Lu [19] applied TRIZ to the agricultural model of Wen, China which suffered from problems like huge risks, high costs, low co-ordination and bad agility. They concluded that the service profit chain model was an effective solution agricultural woes of Wen.

TRIZ is used to deal with the problems of service quality improvement. Wirawan and Aiu [30] use TRIZ to find effective solutions to improve the public bus service quality (DAMIRI) of Indonesia. They propose changes in seat arrangements , air-conditioning , cleanliness etc to public service systems.

The primary objective of any organization and its management is to maximize its profits without compromising on the service and product qualities. TRIZ has been applied to find effective solutions to such contradictions in the field of management. E-Commerce is an area which has found an avid use of TRIZ to solve its problems of inventory management, use of resources increasing its markets share and braking out of loss making paradigms. Ellen Domb and Darallel Mann[7] look into these problems through the lenses of TRIZ show how it "gives us specific tools to help companies ensure their survival" by solving the contradictions. Similarly problems of China's Witkey model [20],new control system of water quality for aquarium exhibition tank of TAIWAN's nation museum of marine and biology [21] has been developed.

### C. Classification of Computer Science Applications

In recent times TRIZ has found its usefulness in the field of Computer Science [1,25,14,24,11]. TRIZ has been very smartly adapted by the people working in the field of computer sciences. The major areas where TRIZ has been incorporated successfully are network and security, software debugging, artificial intelligence, event driven DRM, etc.

According to a study conducted by Ming QI and Chang-Yi ZOU[24], on anti phishing strategies, TRIZ has been used to solve the problem of phishing. Phishing posing a great threat to E-banking, E-commerce and E-transactions was solved using the forty inventive principles of TRIZ. The contradictions that arose from the solutions were that the user should provide as much details as possible, at the same time ease of operations should be maintained. To deal with this, the principles that were used:

- 27: Cheap and short living objects
- 22: Blessing in disguise
- 17: Another dimension
- 40: Composite materials

Solutions such as OTP, high level encryption, double cryptographic authentications, training programs were proposed.

TRIZ problem solving methods are specially suited for rapidly identifying innovative solutions that are more robust and economical than conventional methods. Hence, TRIZ has been incorporated into the problem solving methods in the CS area of Artificial Intelligence. Bae[1], shows, with the help of A-pointing Pennies game, how TRIZ can be applied to solve problems in AI.

Kim[11], proposes event driven digital right management as a new a new DRM technology using method of innovative problem solving to overcome the problems of traditional DRM models

## IV. CLASSIFICATION OF OBJECTS

### A. Distribution of articles by topic

The articles on applications of TRIZ, that have been accessed, have been classified according to the field of application. The classifications are based on the practical applications which include , eco-design, anti-phishing strategies, machine design, managerial applications etc. Table 1. shows the classifications of articles according to the fields of applications and findings of each article are also mentioned

**TABLE 1 :** classification of articles according o the area of application and their findings

AUTHOR	APPLICATION FIELD	YEAR	FINDINGS	REF NO
Ellen Domb, Darrell Mann	E COMMERCE	2001	TRIZ inventive Principles 6 and 35 were used to eliminate contractions in order to achieve a profitable e-commerce	7
Qing Liu Fengjun Lu	Agriculture	2008	Problems in china's agriculture scenario were removed by suggesting that service profit chain model has a potential application in the field of agricultural management.	19
C. Wirawan, A.P. Ayu	Bus Service quality	2014	TRIZ Inventive principles were used to improve the bus service quality by considering the example of Indonesian Perum DAMRI transport company	30
Tai Lin Chiang, Chin-Yun Yi	E commerce	2013	Combined the five service quality dimensions TRIZ business evolution trends, and Kano model to improve the E-commerce service quality strategy	6
Song Kyo Kim	Effective Wifi Setting User design	2012	Dealt with technology enhancement in Wifi Setting using SU-Field analysis	12
Larry Jung-Hsing Lee et al	Service center management	2015	Proposed a value engineering based method to support the configuration of customer-service centers and improve call-center service quality	10
Chia-Nan Wang, Wen-Ching Lin	Water Tank Quality	2014	Used the TRIZ Innovation Principles to make solving water quality problems in the NMMBA (National Museum of Marine & Biology) Open ocean exhibition tank	21
Jae-Hak J. Bae	Artificial Intelligence	2005	Shows that TRIZ principles can be applied to solve AI problems	1

Bih Yaw Shih et al	Mobile learning system	2010	TRIZ theory provides a systematic and effective analysis for constructing a mobile mandarin learning system	25
Michal Kurelaa et al	Computer Role Playing Games Evolution	2006	It was possible to find a connection between examples of CRPG evolution paths with the laws of TRIZ which enhances the future prediction in CRPG development	15
Ming QI, Chang-Yi ZOU	Anti-Phishing	2009	Proposes anti phishing solutions based on TRIZ principles, bolstering security in E commerce	24
Kathleen L. Kitto	Creative Design	2000	The TRIZ method of encouraging creative solutions was used to solve design problems	13
Khadija Hmina, et al	Machine Design	2014	The TRIZ theory was used as an innovation support tool in the design process of Pahl and Beitz	9
Ren Gong-chang et al	Computer Aided Conceptual Design	2014	TRIZ standardized problem in order to solve the difficulty that could not be solved by Computer Aided Innovation System	3
Ali Taheri et al	Inventive Design	2014	A method to assess ideality of technical systems during inventive design activities for developing new systems is proposed using TRIZ.	27
Lujing. Yang Ke. Xing	Conceptual Design	2013	A technique of innovative concept generation for a PSS development was proposed	31
M. Babu Prasad M. Sudha	Machine Design	2012	A product design method was designed using contradiction method	23
Daniel Kluender	Software Design	2006	TRIZ can be used for software designing.	14
C. K. M. Lee et al	Eco-Design	2014	With TRIZ designing methodology, trial and error has been mostly eliminated and engineers have an ideal solution.	17
Chih-Chen Liu' Jahau Lewis Chen	Eco-Design	2001	Eco-friendly product designs can be innovated using TRIZ tools	4
M. Babu Prasad M. Sudha	Eco-Design	2012	TRIZ considers and reduces the contradiction factors in the submersible pump system and saves energy and makes it efficient.	24

#### B. Distribution of articles by the year published

Figure 4 shows the number of articles that were accessed by the number of years . It is found that the majority of the articles published dealt with designing of machines. There a steady no. of articles on machine designing throughout (2000-2015). However, there has been a significant rise in the number articles in the areas such as management and computer science since 2008 and there has been a surge in the in the number of articles in 2014 as compared to the previous years .

#### C. Distribution of articles by categories

Table 2 shows the no. articles that were accessed for each category. The maximum research has been in the field of designing and there has been a surge in the field of management and computer science in recent years. Figure 5 shows the number of articles versus categories bar chart.

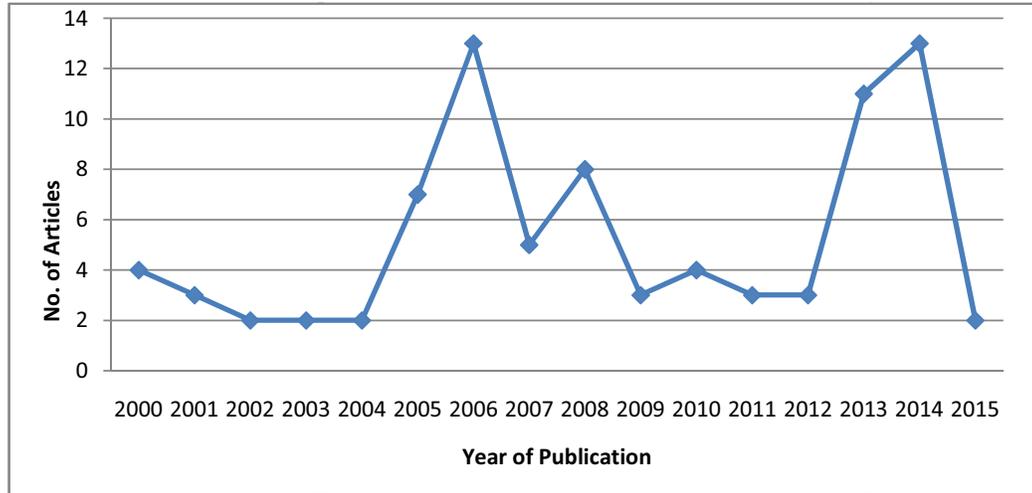


Figure 4. Number of articles by the years of publication which were examined

TABLE 2. No. of articles by categories

Categories	Application Fields	No. of articles
Management	E-Commerce	2
	Improving Service/Management Quality	7
Computer Science	Software Development	2
	Anti Phishing Measures	1
	Event Driven DRM	1
	Artificial Intelligence	2
Design	Machine Design	4
	Eco Design	11
	Creative Design	2
	Computer Aided Design	2
	Product Innovation	3

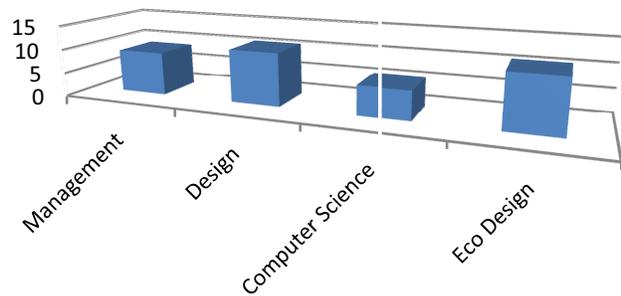


Figure 5. No. of articles versus categories

## V. LIMITATION

The review of literature has no definitive of demarcation as work in any field is never going to stop, same is true for TRIZ applications as well. Though the authors have tried to incorporate all possible areas through an extensive study of all the articles available, some limitations remain:-

1. The number of articles available on TRIZ applications in fields other than Designing were limited hence the data available for in other areas remains limited.
2. The extent of search for articles was limited to a few publishers thus the applications fields have not been covered in its entirety.
3. Through the research was thorough survey of all available papers of said publishers but we as authors cannot claim for exhaustive research considering the very fact that there could be more techniques and area of applications what our study pertains to.

## VI. CONCLUSION AND FUTURE RESEARCH

As evident from this survey the application areas of TRIZ are vast and varied. Due to the underlying principles of this theory, it has a vast potential for its application in new vistas. This theory is relatively novice and has been untouched until recently. This survey shows that TRIZ can be successfully applied to the current problems of computer science as well as management. This theory can be utilized to solve numerous problems that the scientific community faces today. Problems which have an inherit contradiction as its root can be effectively dealt with TRIZ. Some of these vistas in which TRIZ can find its use are:-

1. Research on the application of TRIZ in other areas based on the applicative areas.
2. Finding effective solutions to the security issues with the Internet Of Things technology.
3. Enhancing E-Banking and E-Commerce security using the 40 principles of inventive problem solving
4. Finding answers to the persistent problems of efficient designing, Eco- friendly machines.

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