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About Journal of Inventive Problem Solving

The Journal of Inventive Problem Solving (JRIZ) was officially launched in 2026. It is an official peer-reviewed open access journal of the Malaysia TRIZ Innovation Association (MyTRIZ). The publication is half-yearly, with issues released in June and December of each year.

JRIZ is a journal that serves a growing Theory of Inventive Problem Solving (TRIZ) practitioner readership. It focuses on structured problem solving and systematic innovation in various scientific fields and industrial domains.

The journal features methodology research, article reviews, usage case studies, and best practices that are of importance to the problem-solving, invention, and innovation communities.

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Enhancing TRIZ: Discovering new inventive principles through generative artificial intelligence

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Abstract.

The Theory of Inventive Problem Solving (TRIZ) is a methodology that many companies in diverse industries have successfully used to develop innovative design solutions. The 40 Inventive Principles are one of the most popular tools used under TRIZ. The founder of TRIZ, Genrich Altshuller, and his team synthesized these Inventive Principles from studying large volumes of over 200,000 patents from the 1940s to the 1970s. Since then, technologies have evolved rapidly, and many more new patents have been filed globally. More Inventive Principles could probably be identified. With the emergence of Generative Artificial Intelligence (GAI) and Large Language Model (LLM), the tedious task of analyzing many patents can now be automated. This research aims to develop a customized GAI based on ChatGPT, an LLM by OpenAI, to synthesize new Inventive Principles from a dataset of patents. It is determined if GAI can be customized, trained, and utilized to develop new design tools, such as the addition to the TRIZ Inventive Principles. The methodology begins with fine-tuning the chosen LLM on a dataset of existing TRIZ Inventive Principles. Then, Natural Language Processing (NLP) techniques were used to pre-process and analyze the unstructured text data of 5000 patents, which were obtained from the United States Patent and Trademark Office (USPTO). Any recurring solution pattern is then identified as an Inventive Principle. A new Inventive Principle known as “Interoperability” was discovered. It is compared to the other 40 Inventive Principles and is determined to be distinctly different. The model processed the patent texts in 46 hours using a single GPU cloud computing setup. In comparison, Altshuller and his team took over 30 years to identify the 40 Inventive Principles. This research shows that there is potential for GAI to assist in synthesizing large volumes of patents and synthesizing new Inventive Principles in a relatively short period. Future work would include the study of more patents and even scientific journals to add to the list of Inventive Principles as well as other TRIZ tools such as the Trends of Engineering System Evolution and the 76 Standard Solutions of Substance Field Analysis.

1. Introduction

1.1. Historical development of the inventive principles

The 40 Inventive Principles is synonymous with TRIZ. It is the most well-known and also the most used tool within the TRIZ methodology. Genrich Altshuller who is the founder of TRIZ first discovered that there are common solutions amongst the patents that he reviewed. From the study of over 200,000 patents, Altshuller and his team manually identified, synthesized, and indexed these common solutions and then termed them as Inventive Principles. The current list of 40 Inventive Principles was developed over a period of time between the year 1956 to 1971.

1.2. Patent mining

The Inventive Principles are very abstract. Most research work focus in finding more examples of specific domain, function, or problems (Russo & Spreafico, 2015). In the past decade, patent mining is done to automate the manual task of extracting these examples of interest from the patent documents. Patent mining is generally done via Artificial Intelligence using Natural Language Processing (NLP) techniques. NLP deals with linguistic data and the processing of human language.

In the search of more examples of problems, contradictions are identified (Cascini & Russo, 2007). Some research work also mine the solutions related to the contradictions (Guarino, Samet & Cavallucci, 2022). To assist in applying the abstract Inventive Principles, more examples of solutions for the Inventive Principles (Lian, Tan & Ma, 2008) of either specific product (Wang, Chang & Kao, 2010) (Loh, He & Shen, 2006), technology area (Chan et al., 2021), function across fields (Verhaegen, et al., 2011) (Liang, Wang & Li, 2009), or theme (Cao, Wang & Yang, 2016) are mined. Patent mining is also used for other TRIZ tools like Trends of Engineering System Evolution (Wang, Chang & Kao, 2010) and scientific effects (Chan et al., 2021). Patent mining using NLP still leads to complex results that require effort for analysis. (Liang & Tan, 2007). NLP requires more detailed configuration and tuning

for each specific application. This is good when there is a clear definition. The recent development of Large Language Model (LLM), which can perform advanced summarization, and understand complex queries can be potentially used to mine more relevant examples for each of the existing Inventive Principles. It could even mine for new Inventive Principles.

1.3. Expansion need

Considering that the list of 40 Inventive Principles has not been updated for over 50 years, there are limitations to the application of the current principles given the vast technological advancements made since then. With also new patented inventions and in new technologies that were not present at the time of TRIZ development, there is likely that there are new Inventive Principles that are to be discovered. This research aims to develop a customized Generative Artificial Intelligence (GAI) to synthesize new Inventive Principles from a dataset of patents. It is determined if GAI can be customized, trained, and utilized to develop identify existing as well as new Inventive Principles.

2. Methodology

This methodology section provides details on the four main steps carried out in identifying a new Inventive Principle from the synthesis of patents using GAI. The steps begin with data collection, and followed by pre-processing, model fine-tuning, and pattern identification

2.1. Data collection

The dataset consists of patent documents. Patents were sourced from the from the United States Patent and Trademark Office (USPTO) database. The keyword used in the patent search was on manufacturing. A total of 5,000 patents related to this were selected.

2.2. Pre-processing

Natural Language Processing (NLP) techniques were used to pre-process the dataset. The first technique is text cleaning. Unnecessary characters, stop words, and punctuation from the patent documents were removed. The next technique used is tokenization. Long sentences were tokenized into single words. After that, stemming and lemmatization techniques were used to reduce the words to their base or root form.

2.3. Model fine-tuning

The chosen LLM model is GPT-3 which runs OpenAI's Generative Artificial Intelligence (GAI) known as ChatGPT. It was chosen because it was the most used model and there are regular upgrades. The model underwent initial training on the dataset of the definitions and examples of the TRIZ Inventive Principles. The Inventive Principles and related patent texts were formatted into a structured format suitable for training. The model was also fine-tuned with the cleaned and preprocessed patent texts. The training process was done on a cloud computing platform with a single graphic processing unit (GPU) to minimize cost.

2.4. Pattern identification

The fine-tuned model was then used to analyze the patent dataset. Recurring solution patterns within the patent texts were identified. Cross-referencing was done between the identified patterns and the existing Inventive Principles. The fine-tuned model also highlights text segments that match known Inventive Principles. For text segments that do not match with the known Inventive Principle, it will suggest a new principle.

3. Results

A report on the newly discovered Inventive Principle was generated by the model after 46 hours of processing 5000 patents using a single GPU cloud computing setup. The 444-word long report contains the name of the new Inventive Principle, its definition, and a detailed explanation on how it can be applied as a solution.

The Inventive Principle is named "Interoperability". It is defined as the exchange of information between each layer which carries out independent or interdependent tasks in the architecture, for the functionality of the whole system. The report went on to describe in detail the system integration of smart sensors, advanced actuators, and intelligent control systems. Advantages to a system in terms of enhanced adaptability, flexibility, scalability, and economic viability are also discussed.

4. Discussion

For this “Interoperability” principle to be considered as a new Inventive Principle, the following criteria of uniqueness, repeatability, and contradiction resolution were followed.

4.1. Uniqueness

The proposed principle has to be distinctly different from the 40 other existing Inventive Principles. Based on its definition, the closest comparison came to Inventive Principles #5 Merging, #6 Universality, #23 Feedback, #24 Intermediary, and #25 Self-Service. The table below lists the comparisons that describe the distinct differences between these Inventive Principles and the proposed “Interoperability” principle. From these comparisons, the proposed principle is unique from the existing Inventive Principles.

4.2. Repeatability

An Inventive Principle should have universal application. It should not be only applicable to a specific industry. There are diverse application areas for the “Interoperability” principle. Examples are interoperating systems for smart wearable devices, smart homes, smart cities, smart manufacturing, and smart farming. In the future when practical as well as affordable smart sensors, advanced actuators, and intelligent control systems are readily available, all products could communicate with each other. Thus, enabling products to evolve according to this principle.

4.3. Contradiction resolution

It is required of an Inventive Principle to solve a technical contradiction. The proposed Inventive Principle of “Interoperability” aims to enhance the system’s adaptability, flexibility, scalability, and economic viability. These enhancements can be represented in terms of the following list of engineering parameters in Table 2. Almost a quarter of the total list of 39 engineering parameters could be represented. This suggests that the proposed principle would be useful in solving technical contradictions.

5. Conclusion

The use of GAI significantly reduces the time needed to analyze the large volume of patent information and with lesser bias. In this preliminary work of utilizing GAI to synthesize 5000 patents, a new Inventive Principle called “Interoperability” is proposed. Its uniqueness is validated after comparing its definition with the other existing Inventive Principles. A universal application to potentially all products also support its proposal to be a new Inventive Principle. Finally, it is usable for solving technical contradictions, as evidenced by its direct relation to numerous engineering parameters. There are future improvements to be made. Firstly, different LLM and GAI models will be used. The datasets will also increase to encompass more patents and even scientific journals. Besides Inventive Principles, new expansion proposals are to be made for other TRIZ tools such as the Trends of Engineering System Evolution and the 76 Standard Solutions of Substance Field Analysis. Any new proposals will also be cross-checked by TRIZ experts and applied in case studies.

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Designing an aerodynamic cover for vehicle wheels by using TRIZ

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Abstract.

Approximately 25 % of a vehicle's aerodynamic drag comes directly or indirectly from its wheels. The fully covered wheel rims reduce that vehicle's aerodynamic drag thereby the vehicle range or fuel efficiency gets improved. But at the same time, the fully covered wheel rims invite the problem in brake cooling ventilation. In this paper, we discuss a case study of designing an aerodynamic cover for vehicle wheels by using TRIZ which solves the contradiction of aerodynamic drag Vs Brake cooling in vehicle wheels. We employed multiple TRIZ techniques including TRIZ Principles evolution to solve the technical contradiction and to identify the optimum solution for reducing the aerodynamic drag of wheels with efficient brake cooling ventilation.

Keywords: TRIZ, vehicle wheel cover, aerodynamic cover, vehicle aerodynamic drag, brake cooling, brake ventilation.

1. Introduction

Automobile product manufacturers of the current era need to concentrate on one major challenge, which is a vehicle's aerodynamic drag. The geometric shape of an automobile upper body, lower body and the wheels played a key role in the aerodynamic drag. A study says the automobile upper body accounts for approximately 45% of aerodynamic drag, the lower body accounts for approximately 30% and the wheels and wheelhouses account for approximately 25% of passenger car aerodynamic drag. Reducing the drag will increase the fuel efficiency in the case of ICE vehicles and range in case of EV. The major approaches towards achieving these vehicle's aerodynamic drag include optimized design of automobile upper body, lower body, and the wheel cover with less drag.

2. Problem statement

This paper discusses the solution for designing the aerodynamic wheel cover for reducing the drag due to wheel and wheel housing. The fully covered wheel rims reduce the vehicle's aerodynamic drag significantly thereby the vehicle range or fuel efficiency gets improved. But at the same time, the fully covered wheel rims invite the problem in brake cooling ventilation. If we design a semi covered / fully opened wheel rim, the brake cooling ventilation will be good, but it creates high aerodynamic drag force that affects the range of the vehicle.

3. What is TRIZ?

TRIZ (the Russian acronym for the 'theory of inventive problem solving') was developed by a Soviet Engineer Genrich Altshuller. TRIZ is a powerful tool for generating innovative ideas in a problem-solving process. For a given problem, the way of TRIZ is to identify and formulate a generic problem, then to use an appropriate tool to determine the generic solutions, and finally to interpret these generic solutions to choose a specific solution. The basic constituents of TRIZ are the contradictions, forty inventive principles, the TRIZ matrix, and the trends of evolution, the substance-field analysis modeling, substance field resources. In this paper, we employed TRIZ techniques including TRIZ Principles to solve the technical contradiction and to identify the optimum solution for reducing the aerodynamic drag of wheels with efficient brake cooling ventilation.

4. Function Analysis

The three stages of function analysis include component analysis, interaction analysis and function modelling.

4.1. Component Analysis

An object that constitutes a part of an engineering system or supersystem is a component.

4.2. Interaction Analysis

Interaction analysis is used to identify the interactions of the components of an engineering system with each other and with the components of the supersystem.

4.3. Function modeling

Function modelling is the stage in function analysis where a function model of the analyzed engineering system is built. The function model describes the functions, their usefulness and performance level, and costs of the system and supersystem components.

4.4. Cause and Effect Chain Analysis (CECA)

Cause-Effect Chain Analysis is an analytical tool that identifies the key disadvantages of the analyzed engineering system. Air drags vehicle body and wheel. Drag due to shape of the vehicle upper body, lower body, and wheels. Air particles hit on the front surfaces, being more compressed and creates turbulent flow. Brake dissipates heat □ Friction between brake drums and linings generates heat. Heat must be dissipated to avoid excessive temperature rise of the brake lining. Wheel cover resists brake ventilation.

5. Technical Contradiction

Two different technical contradictions identified as shown.

TC 1: IF we design a fully covered wheel rim, THEN incredibly low aerodynamic drag force & that helps to increase the range BUT cannot meet the brake cooling ventilation & aesthetically not good.

TC 2: IF we design a semi covered / fully opened wheel rim, THEN can do the brake cooling ventilation & achieve good aesthetics BUT high aerodynamic drag force that affects the range.

6. TRIZ solution

The next step is to identify the improving parameter and worsening parameter from the technical contradictions and to find the relevant TRIZ inventive principles by using the TRIZ Matrix for solving the contradiction.

The TRIZ contradiction matrix used to select the most appropriate TRIZ inventive principle to resolve a specific contradiction. Based on the improving parameter and worsening parameter.

We have identified the top 3 most relevant TRIZ inventive principles.

Taking out (2)

Equipotentiality (12)

Skipping or Rushing Through (21)

Based on the identified inventive principles, we found the following solutions to solve the contradiction.

6.1. Taking out

Separate the conventional friction brake from the vehicle wheels fully or partially. Vehicles can be stopped by using only/majorly with engine/motor braking. The several types of motor braking include regenerative braking, dynamic braking and plugging braking can be applied either individually or together to stop the vehicle. In that scenario, the vehicle wheels can be covered fully with better aerodynamics.

6.2. Equipotentiality

An aerodynamic cover that is partially opened at high brake temperatures and fully closed when there is no temperature. A vehicle wheel has closeable ventilation openings which may have flow through them in the open state in the axial direction to the wheel axle, an actuator being provided which is implemented to open and close the ventilation openings. A temperature sensor along with ECU is used to provide signal to the actuation system. The actuator is a stepper motor connected to the vehicle BIW through a power/signal cable which has a swivel and a spring joint. ECU has an algorithm calibrated for percentage opening vs brake temperature.

6.3. Skipping or rushing through

Friction between brake drums and linings generates heat. Faster and efficient applying of liquid cooled brake generates very less friction with the support of electronic control unit may help to reduce the heat generation and there can be a fully covered wheels with small holes can help to solve the contradiction.

7. Summary

The multiple TRIZ based solution provides a way to design the aerodynamic cover for vehicle wheels by solving the technical contradictions involved. The optimum solution could be the aerodynamic cover that is partially opened at high brake temperatures and fully closed when there is no temperature which reduces the aerodynamic drag of the moving vehicle and by that increases the fuel efficiency in case of ICE vehicle and range in case of EV.

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Everything - from nothing, or a children's algorithm for solving inventive tasks - in action

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Abstract

Pedagogical practice has shown that the technique of team creative TRIZ games is an important element of educating a child's creative personality, forming systemic, functional, paradoxical thinking, as well as moral qualities such as responsibility, benevolence, purposefulness and the desire to benefit.

Keywords: TRIZ, methodology, team games, creative thinking.

Introduction

We all want to be successful. Every person, every company or organization, every country wants to achieve prosperity and a high level of development. What does it depend on? If we compare statistical data by country for 1990-2018, then we will see that one of the factors of the country's well-being is the high inventive activity in this country.

From these graphs, it becomes obvious that the higher the patent activity in a country, the higher the per capita income. Indeed, from 2009 to 2015, the Republic of Korea was recognized as the most innovative economy in the world.

Thus, a successful person, a successful company, and a successful country are conditioned by the level of inventive thinking. Inventive, creative thinking includes semantic, logical, dialectical, paradoxical, systemic, and functional styles of thinking. All these types of thinking are a kind of “power booster” of thinking in the modern world of rapid development of information and other technologies, allowing you to solve many daily tasks in non-standard situations that require unusual, innovative ideas.

Method

The theory of inventive problem solving (hereinafter - TRIZ), founded by the Soviet engineer, writer, inventor Genrikh Saulovich Altshuller, is a tool for the development of all components of inventive thinking. And TRIZ pedagogy, created on the basis of TRIZ, allows not only to develop creative thinking in a person, but also to harmoniously form a personality as a whole, laying moral foundations and striving to achieve a worthy goal.

The approaches used in TRIZ pedagogy correspond to the main approaches of TRIZ:

- Semantic;
- Functional;
- Dialectical;
- System;
- Psychological.

Semantic, functional and dialectical approaches help to develop logical, dialectical, paradoxical, functionally ideal styles of thinking. After all, without logic, without a vision of cause-and-effect relationships between events, effective tools, and without the ability not to give in to emerging paradoxes, creativity and effective development of creative thinking are impossible.

Systemic and functional approaches ensure the development of systemic, system-functional, functional and functional-dialectical styles of thinking, the possession of which allows one to see the structure of objects in the surrounding world, the laws of their development, see the results of their interaction and give the ability to predict their further changes.

The psychological approach covers all styles of thinking, since the atmosphere of the learning process, the nature of the relationship between students and the teacher, the conditions for creating a situation of success, a situation of joy from the discovering of any knowledge and the acquisition of any skill depended on it.

Results

The TRIZ teacher creates situations in which the student HIMSELF is happy to acquire knowledge. How can this be done? By playing creative team games, of course!

In the process of team play, people are more willing to engage in creative activities, in a team they interact with each other, helping the team reach a common goal, while they evolve creative thinking and create a creative product.

An example of such a team creative game with pupils of the TRIZ Laboratory children's studio from the Komi Republic is presented in Appendix 1.

How to develop a team creative TRIZ game? There can be no creative game without a creative task that is relevant for children, motivating them to creative activity. According to the method developed by Marat Semyonovich Gafitulin, to prepare such a task, only a little theoretical training needed, and the children do everything else themselves, just like hardworking bees:

- 1) The teacher pre-selects an array of words or a coherent text, based on the subject of this lesson (it can be a set of words from the windows of the system operator, or a solution of a problem, solved with a DARIZ algorithm, etc.).
- 2) The teacher divides the text into one-word fragments (for example, the words are printed on cards) and these fragments are shuffled.
- 3) The teacher invites the children to join unite in groups of 2-3 people to play a team game and explains them rules of the game:
 - The teams independently establish connections between text fragments.
 - The members of each team try to restore the original text.
 - Players analyze the derived text, fill the missing fragments or remove inappropriate fragments, if necessary.
- 4) Next, as a homework assignment or an additional project, the teacher offers children in teams to create their own creative product based on a creative task (for example, a game or a similar creative task).
- 5) If the children decide to create their own game, they are offered the following methodology for developing a creative game:
 - The teacher invites children to analyze the creative task cards in terms of what kind of game can be made with these cards.
 - Children offer game variants similar to the existing board games: bee, walker, lotto, memo, findings, constructor, etc. Or they come up with their own kind of game with these cards. The method for each type of game are described below (Appendix 2).
 - Teaming up, the children make cards for their game, design a box or envelope for cards, and the rules of the game.
 - Each team presents its new game and invites all teams to play it.
 - The game remains in the children's studio and can be played by all groups of children.

The results of the team creative TRIZ games. Team TRIZ games can achieve pedagogical super-effect and motivate children to independent team creative project activities of creating original games.

Appendix 1

A brief summary of the lesson: «Out of nothing - everything, or a children's algorithm for solving inventive tasks - in action»

Greeting,

The game (Find connections).

The children see a set of words on the cards on the blackboard. It is necessary to catch the connections and put the words in a certain order according to these connections. Teams take turns putting the cards in the right places (Fig. 4).

As a result, a solution of a problem, solved with a to the DARIZ algorithm, should be get. This solution needs to be supplemented with pupil's solutions.

The initial situation (hidden): There is joy in the family: an hour later, unexpectedly, the younger brother, the birthday boy, returns from the sanatorium, he turns 7 years old! But there is no gift.

Problem: How can Kolya prepare a gift for his brother in an hour?

CP (conflicting pair): Kolya and the gift

IFR1 (ideal final result): Kolya creates a gift for his brother himself

IFR2 (ideal final result): A gift for a brother appears by himself

Resources: Kolya, cardboard, paper, hot glue, scotch tape, styrofoam, polyethylene foam, scissors, glue pencil, rubber bands, skewers, bushings, toothpicks, plasticine, pencils, foil, foam, markers.

The CP (conflicting pair) option, and therefore the DARIZ solution, may be different:

The problem: How can I prepare a gift for my brother in an hour?

CP: Brother and gift

IFR1 (ideal final result): The brother creates the gift himself

IFR2 (ideal final result): The gift itself appears in the brother

Resources: Kolya, cardboard, paper, hot glue, scotch tape, styrofoam, polyethylene foam, scissors, glue pencil, rubber bands, skewers, bushings, toothpicks, plasticine, pencils, foil, foam, markers.

Solution: Kolya can make a set of materials for creating models, and his brother will be able to make a gift for himself at will, here a super effect is achieved - the development of his brother's creative abilities.

The children understand that a part of DARIZ is in front of them.

The teacher tells the initial situation.

Brainstorming: what could be a gift for a seven-year-old brother?

The teacher writes down ideas on the blackboard.

Guessing game:

The children in the team think of a thing that can be made as a gift, take resources to the desks: The task for the players is to guess what kind of thing the rest of the teams will do with the selected resources? The alleged versions are fixed by the teacher.

Creative project: the children creating a gift with available resources in half an hour: The teams present their gift, show how to use it, and convince the audience why it should have been made from these resources, explaining what properties of materials are needed to perform certain functions of the model.

The rest of the children are checking themselves to see if they guessed correctly what was done from this set of resources (Fig.4).

Summing up, reflection:

- Which gift idea did you like the most, why?
- What was the most difficult part?
- Where can the skills and abilities acquired today be useful?
- What surprised you the most?
- Do you have any new ideas for further use?
- What would you thank each member of your team for?

A result of a series of creative team games:

The children proposed to create an exhibition of models «Scientific toy» for the children of the Republican Center for Additional Education (Fig. 6).

The children also organized the exhibition «City of the Future» for the children of the Republican Center for Additional Education (Fig. 7.).

In addition, the children have created a whole game library of TRIZ games (Fig.8):

- Bee «DARIZ»
- Lotto «Mono-bi-poly»
- Magic Lotto
- System Lotto. History of Inventions. Writing utensils
- System Lotto. Lamps
- Function Constructor

Appendix 2

Games created by children after the participation in team TRIZ games using the «Bee» method.

1. «Function Constructor»

The board game consists of cards with images of objects and cards with inscriptions of functional verbs. The game trains the ability to make a model of function according to the scheme (Leningrad TRIZ School) (Fig. 9).

The rules of the game:

- a) «Make a function» - players team up, receive the same number of cards with objects and functional verbs, and compete to see whose team will make up more functions in 10 minutes, explaining their choice.
- b) «Functional chains» - the children team up, receive the same number of cards with objects and verbs and compete to see, whose team will make the longest continuous functional chain in 10 minutes, explaining their choice:
- c) «Functional sun» - the children team up, get the same number of cards with objects and verbs and compete whose team will make the largest «sun» in 10 minutes - functions are built like rays with verb and other objects cards around central card with an object.
- d) «Functional tree» - the children team up, get the same number of cards with objects and verbs and compete whose team will make the largest «tree» in 10 minutes - above one card with an object, useful functions of this object are compiled on the one side, and on the other - harmful ones.
- e) «Functional houses» - the children join teams, compete, whose team in 10 minutes will make up more functions with the same verbs - «populate» all more «residents» - functions into functional houses with names, for example, «Connectors», «Movers», «Divider», etc.».

The methodology of preparation of the game «Function Constructor»:

- The teacher offers the children a creative task using the «Bee» method: on the cards there are objects of the man-made world and functional verbs. As a result of completing the task, the children create models of functions by teams.
- The teacher invites children to analyze the creative task cards in terms of what kind of game can be made with these cards.
- Children offer game options similar to existing board games: bee, walker, lotto, memo, findings, constructor, etc. Or they come up with their own kind of game with these cards.
- Teaming up, the children make cards for their game, design a box or envelope for cards, and the rules of the game.
- Each team presents its new game and invites all teams to play it.
- The game remains in the children's studio, and all groups of children at the center can play

Conclusions

Thus, TRIZ pedagogy, and, in particular, the methodology of team creative TRIZ games, is an important element in the upbringing of a child's creative personality, forming systemic, functional, paradoxical thinking, as well as moral qualities such as responsibility, benevolence, purposefulness, and the desire to benefit. By mastering TRIZ, a child learns to set a worthy life goal and to live and work for the benefit of people.

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Tools to enhance creativity in "Modern TRIZ"

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Abstract

The article deals with the peculiarities of using the "Ideal Final Result" tool in Modern TRIZ roadmap. The article proposes a classification of types of IFR and points of their use in typical roadmap.

Keywords: Ideal Final Result, Modern TRIZ, ARIZ, psychological inertia, creativity.

1. Introduction

At present, it is customary to distinguish two time periods of development, which correspond to "Classical TRIZ" and "Modern TRIZ". The "Classical TRIZ" refers to the set of tools developed under the leadership of Genrikh Altshuller. The ARIZ-85 version combines all the basic tools known at that time (technical and physical contradiction, 40 principles, Su-Field analysis and Standards). In Modern TRIZ, analytical and solving tools were added.

In general, Modern TRIZ demonstrates a much higher instrumentality and presents us with the ability to analyze and solve very complex problems. The tools are described in a clear, logical and consistent manner, which makes it easier for new practitioners to learn. However, the pursuit of higher instrumentality has led to the loss of some important features that are available in Classical TRIZ.

First of all, we are talking about tools aimed at overcoming psychological inertia and "pushing" creative thinking. One of such tools is the formulation of the Ideal Final Result (IFR). This tool is formally included in the training program for Level 1. However, real roadmaps (in Appendix 1 we specify which versions of roadmaps we are talking about below) do not include it as an independent tool. IFR is used only in ARIZ-85, and a very narrow formulation of IFR is used.

The article analyzes the history of changes in the concept of IFR in different versions of ARIZ (from ARIZ-56 to ARIZ-85), formulates several types of IFR and suggests ways to use them in the Modern TRIZ Roadmap.

In our Glossary we can find this definition: "Ideal Final Result (IFR): A model of the best solution to an inventive problem, whereby the problem is fully eliminated with minimal changes to the System and without any deterioration of System parameters. (It is a term used in ARIZ). Where did this definition come from? What is its history?"

2. Problem history

IFR (Ideal Final Result) as an independent tool first appeared in ARIZ-59 [1]. This is the second (after ARIZ-56 [2]) version of the algorithm. It is very compact, occupying a little more than a page of text. The IFR is used in the second and third steps of the analytical stage. The wording of the steps is concise: Step 2: Visualize the ideal end result.

Step 3: Determine what is preventing the achievement of this result (i.e., find the contradiction).

Note that the concept of IFR is given without any explanation of the term. It is assumed that the concept is used in the generally accepted sense, without specificity.

The version of ARIZ-61 [3] uses the same wording; in ARIZ-64 [4] (and, further, in ARIZ-65 [5]) the wording becomes a bit more elaborate:

Step 1: Determine the ideal end result (answer the question: "What would be desirable in the most ideal case?").

Step 2: Identify what prevents the ideal outcome from being achieved (answer the question: "What is the 'hindrance'?").

In ARIZ-68 [6] the first step is supplemented by building a graphical model (we would now call this sketching) and simplifying the IFR model.

Step 1: Determine the ideal end result (answer the question: "What would be desirable in the most ideal case?").

Schematically show what was and what has become (in the ideal case). Simplify the final scheme to the limit at which it is still operable.

It should be noted that all listed versions of ARIZ use a very similar description of IFR. It is a certain situation (state, property of the system) that we would like to obtain. It is important to emphasize that in ARIZ texts and books published at that time, Genrikh Altshuller avoids precise definitions of what IFR is. For example, in the 1961 book [7] the term "Ideal Final Result" appears in the text without any further explanation at all. A minimal description of the term appears in later books.

Thus, in the book 1979 [8] one can find the following fragment: The problem model describes a technical system (more precisely, its "sick" fragment) and its inherent contradiction. It is not known in advance how to actually eliminate this contradiction, but there is always a possibility to formulate an ideal solution, an imaginary final result (IER). The meaning of this operation is to get a reference point for transition to strong solutions. The ideal solution, by its very definition, is the strongest of all conceivable and inconceivable solutions (for a given problem model). It is, as it were, the solution of the nonexistent sixth level. The tactics of problem solving with the help of IFR consists in "clinging" to this single superstrong variant and, if possible, deviating from it as little as possible.

At the same time, the concept of IFR undergoes important transformations in ARIZ texts. In ARIZ71 [9] the formulation of IFR is significantly changed

Step 3.1. Prepare a formulation of the IFR in the following form:

- a. Object (take the item selected in step 2.5);
- b. What does.
- c. How does the do-it-yourselfer.
- d. When does.
- e. Under what mandatory conditions (restrictions, requirements, etc.).

Step3.2. Make two drawings: "was" (before IFR) and "became" (IFR).

Notes:

- a. The drawings can be conventional - as long as they reflect the essence of "was" and "became".
- b. The "has become" figure should match the verbal wording of the IFR.

Verification:

The figures should contain all the elements listed in step 2.3a. If an external environment is selected in step 2.5, it should be indicated in the figure "became". 3.3. In the figure "became" find the element indicated in step 3.1a and select the part of it that cannot perform the required action under the required conditions. Mark this part (by hatching, different color, outline, etc.).

Let's note the most important changes:

- Implicit in the formulation of the IFR is a description of the function (what it does) and the way it is realized (how it does it), operational time (when it does it), and resource constraints (under what mandatory conditions).

- A component (or part of a component) is identified that cannot fulfill the requirements of the IFR.

The next important change is that in ARIZ-77 [10] the requirement of "independent performance by the component" of the required functions appears:

Step 3.2. Write down the standard formulation of the IFR (ideal end result).

The element (specify the element selected in step 3.1) itself eliminates the harmful interaction while retaining the ability to perform (specify the beneficial interaction). Rule 8. The word "itself" should always be in the wording of the IFR.

Examples:

The Grinding wheel adapts itself to the curved surface of the workpiece while retaining its grinding ability.

The missing lightning rod itself provides the "catching" of the lightning while retaining the ability to not cause radio interference.

Step 3.3. Identify the zone of the element (specified in step 3.2), which cannot cope with the complex of two interactions required by the IFR. What is in this zone – substance or field? Show this zone on a schematic drawing, marking it with color, shading, etc.

At about the same time, the books appear to have a very similar requirement for “self-fulfillment” [11], with the achievement of IFR being tied to the utilization of resources available in the ES. An ideal solution in TRIZ is called an ideal end result (IER). A distinctive feature of the IFR in TRIZ is its "free of charge", when the result is achieved without excessive expenditures of energy, materials, and time.

We have been introduced to two extremely important concepts:

1. When solving a problem, one should be oriented towards an ideal answer. Such an answer is not always fully achievable, but it is necessary to achieve maximum approximation to it. The formulation of an ideal answer made according to certain rules is called an ideal end result (IER).
2. To approach the IFR, it is necessary to maximize the use of available resources - material and energy resources. Substances and fields, as well as "gift" substances and fields, given by the task conditions are called material-field resources (MFR). The maximum use of MFR for the maximum progress towards the IFR is the formula of victory over the task in the most general form ARIZ-82 [12] gives us a very important addition to the IFR formulation - we introduce the notion of X-element, which eliminates the problem and brings the ES closer to the requirements of IFR:

Step 3.2 Write down the wording of the IFR (ideal end result). If in 3.1 the tool is selected: (specify tool) itself eliminates (specify harmful action) while retaining the ability to perform (specify beneficial action).

If X-element is selected on 3.1: The X-element, without complicating the system, eliminates (specify harmful action) while retaining the ability to perform (specify beneficial action).

Note, the requirement to solve the problem without introducing new (additional) problems is emphasized:

Note 11 Besides the conflict "harmful action is related to beneficial action", other conflicts are possible, such as "the introduction of a new beneficial action causes complexity of the system" or "one beneficial action is incompatible with another". Therefore, the IFR formulations given in Step 3.2 should be considered only as samples of the type of IFRs to be written.

The general sense of these formulations is that the acquisition of a useful quality (or the elimination of a harmful quality) should not be accompanied by the deterioration of other qualities (or the appearance of a harmful quality). In addition, the ability to introduce restrictions on the use of extraneous resources into the problem has been added:

Note 12 The IFR formulation can be strengthened by an additional requirement: no extraneous substances can be introduced into the system. Finally, a very important tool called "Step Back from IFR" appears:

Note 13 If from the problem conditions it is known what the finished product should be, and the problem is reduced to determination of the method of obtaining this product, the method "step back from the IFR" can be used. The finished product is depicted, and then a minimal disassembling change is introduced into the drawing. For example, if two parts are touching in the IFR, then with a minimum step back from the IFR, a gap must be shown between the parts.

A new problem (micro-problem) arises: how to eliminate the defect? The solution of such a micro-task usually does not cause difficulties and often suggests a way to solve the general problem.

The transformation of the concept of IFR is completed in ARIZ-85 [13]. We get the well-known formulation of IFR in two variants:

Step 3.1. Write down the wording of IFR-1:

X-element, without complicating the system at all and without causing harmful phenomena, eliminates (specify harmful action) during operational time (OT) within the operational area (OZ), preserving the tool's ability to perform (specify useful action).

Step 3.2. Strengthen the wording of IFR-1 with an additional requirement: no new substances and fields may be introduced into the system, and the available substance - field resources must be used.

Step 3.5. Write down the formulation of the ideal end result of IFR-2: - operational zone (specify) - during operational time (specify) - must itself provide (specify opposite physical macro- or micro-states).

In fact, we have two different formulations of IFR, the first one concerning the properties of some X-element, the second one concerning the properties of the operational area as a whole. Moreover, in the course of further work we can pass to the enhanced IFR:

Step 1.5. Reinforce the conflict by specifying the limit state (action) of the elements.

Rule 3: Most of the tasks contain conflicts of "many elements" and "few elements" types ("strong element" - "weak element", etc.). Conflicts of the "few elements" type should be reduced to one type - "zero elements" ("missing element"). And we can formulate the IFR-2 at two system levels (macro-level and micro-level):

Step 3.3. Write down the formulation of the physical contradiction at the macro level:

An operational zone during operational time must (specify a physical macro state, e.g. "be hot") to perform (specify one of the conflicting actions), and must not (specify the opposite physical macro state, e.g. "be cold"), to perform (specify other conflicting action or requirement).

Step 3.4. Write down the formulation of the physical contradiction at the micro-level:

in the operational zone there must be particles of matter (specify their physical state or action) to provide (specify the macrostate required by 3.3.), and there must be no such particles (or there must be particles with the opposite state or action) to provide (specify another macrostate required by 3.3.).

Step 3.5. Write down the formulation of the ideal end result of IFR-2:

the operational zone (specify) during operational time (specify) should itself provide (specify opposite physical macro- or micro-states).

3. Problem analysis

We've got a pretty extensive analysis of primary sources, let's summarize:

- Over the 30 years of ARIZ development, the formulation of IFR has undergone significant changes.
- We can conditionally distinguish three types of IFR formulations used in different versions of ARIZ: - "IFR as a dream". A formulation that in the most general form describes an image of a solution (ARIZ-59, -61, -64, -65, -68), in recent versions supplemented with a graphical image of such a solution. It is obvious that this type of IFR is the best way to overcome psychological inertia. We remove any prohibitions to change the TC, we are ready to consider any principle of action at any level of the system. At the same time, the instrumentality of this version of the IFR is small, its formulation does not help much to see the image of the solution. However, this type of IFR has a very high potential to fight psychological inertia - "IFR as a function". This formulation describes the expected result as a certain ideal function (ARIZ-71, -77). This version of IFR is much more instrumental. We describe the solution image in the form of some component that performs the necessary function inside the operational time- "IFR as X-element". This is the most instrumental formulation (ARIZ-82, -85), it actually describes the solution to the problem. This solution is tied to the operational area, operational time, and resources of the problem. In addition, the formulation includes two options regarding the fulfillment of the function required to achieve the IFR (IFR1 / IFR2), and the IFR2 option is formulated at two system levels (macro and micro level).

- All three types of IFR formulations have their own merits and are useful in solving practical problems. However, in the most widespread roadmaps we use only the third type, within the framework of ARIZ-85 at the solving stage. Given the fact that ARIZ is not always used, the IFR tool has been practically excluded from roadmaps.

Let's formulate the problem: how to return all three types of IFR to the roadmap and maximize the possibilities of this instrument? The contradiction between instrumentality and creativity itself reflects the dialectical essence of TRIZ.

We propose two ways to resolve this contradiction. The first way is to locally include the formulation of one of the three types of IRRs into roadmap. The situation with the "IFR as X-element" version is the simplest. It is effectively used in ARIZ-85 and does not require additional inclusion in the roadmap.

The version "IFR as a function" can be included in functional analysis and trimming. Two possible points of formulating the IFR can be distinguished:

- Once the list of functional deficiencies has been identified, an attempt can be made to formulate an IFR for each deficiency. In doing so, it is possible to formulate with preserving the existing principle of operation and with changing the principle of operation.
- When formulating trimming tasks, include in the consideration of versions of "ideal trimming", including with transition to the supersystem.

The most difficult thing is to find the right place to use the version "IFR as a dream". It is obvious (by analogy with earlier versions of ARIZ) that this formulation should be used in the initial part of the analytical stage. The authors suggest focusing on two points of the roadmap:

Benchmarking. This tool is at the beginning of the analytical stage and is used to identify prototype systems and alternative systems. We can formulate an IFR (in the IFR-dream format) and evaluate the analyzed TCs, including proximity to this IFR.

TESE. There are at least two possibilities here:

- In the course of the C-curve analysis, use the IFR to choose the way of increasing the IFR. Re-call that depending on the stage of TC development, we have several ways to increase ideality, depending on the direction of change in functionality F and payback factors C. The choice of a particular way may (among other things) depend on the IFR formulated by us.

Standard methodological recommendations link the way of increasing ideality with the stage of the C-shaped curve (see figure), but the IFR is formulated for a specific task and can make adjustments to the standard recommendations.

- In the course of analysis for compliance with the law of transition to the supersystem, use IFR to clarify possible variants of realization of this trend. In practice, we often encounter formulations of IFR of the type "ES is absent, but its function is performed". Such versions of IFR are successfully realized by transferring the function performed to the supersystem (in fact, we are talking about one of the trimming models). In this case, to search for a solution, we can use the way formulated in the IFR. This way is good because it allows us to quickly and unambiguously determine which type of IFR should be formulated in this or that case. The disadvantage of this way is a sharp narrowing of the creative search (even for experienced solvers).

The second way is the sequential inclusion of all three types of IRRs into the roadmap in the order "from less instrumentality to more instrumentality". Let us explain this idea.

The solver's thought process can be described as a deductive movement from the general to the particular with the identification of key points affecting the result. Let us visualize this movement as three levels of immersion into the problem: "general", "middle" and "deep". Then, in the course of this movement, the breadth of the search (its creativity) - decreases, and accuracy (instrumentality) - increases.

At the first stage - "general" - the level of development of an individual's creative abilities determines the breadth of his search. Therefore, the formulation of "IFR-dream" at this stage is most appropriate (as the first step of the algorithm of IFR formulation). The dream is not limited by anything, any desires can be voiced. This is also where the "search for enemies" takes place: the factors preventing the fulfillment of desires are named. The significance of this stage is to create psychological conditions for creative upsurge - a base for not obvious earlier, original solutions, in maximum overcoming of psychological inertia.

At the same time, for quite a long time the operation of formulating the "IFR-dream" should be unfolded, i.e. performed in full, and then, being perfected after multiple variant repetitions, it is gradually minimized, in accordance with the concept of phased formation of mental actions by Peter Galperin (1966) and Nina Talyzina (1984) and goes to the inner plan. Thus, at some point, the "IFR as a dream" will probably be automatically minimized and will not be consciously formulated but will continue to have an indirect influence on the efficiency of the problem-solving process, remaining a "hidden" element of the algorithm of actions.

It is necessary to distinguish automatic skill minimization from attempts to avoid unnecessary work on formulating an additional IFR (which is precisely a sign of psychological inertia). This can be quite difficult. It should be noted that at this level there is a danger of detachment from reality (however, inversely proportional to the solver's practical experience). Perhaps this danger itself falls away in the second and third stages as one becomes more immersed in the problem. Then, at the second stage, the “middle” stage, the search is refined, narrowed down. The “IFR as a function” is defined: how and when the previously formulated desire is fulfilled.

At the third - “deep” - stage, the “IFR as an X-element” is formulated: where, in what form and at what moment the previously formulated desire is fulfilled, what resources are used.

We consider it important to note the following.

- The described three stages can be clarified and extended by moving between types of formulations of the IFR within each type.
- In this case, most likely, there is no need to go through all new sub-stages, but we need an algorithm for selecting the type of formulation of the IRR within a stage.
- The task of identifying the marker that separates the manifestation of psychological inertia and the process of winding down the skill of formulating “IFRs as dreams” arises.
- There may be a need to find a marker that allows one to stay within the bounds of reality (which in turn creates a new contradiction related to the goals of “IKR as a dream”). The strength of this way is that it will allow to overcome the difficulties of formulating more and more “instrumental” IKRs due to step-by-step “launching” of creative abilities. The disadvantage is that it takes a lot of time to go through all the stages.

4. Conclusion

It is shown that the concept of IFR has undergone significant transformations over 30 years. At the moment, at least 3 formats of IFR can be distinguished. Each of these formats has advantages and disadvantages and can be used effectively in analyzing and solving technical problems. Unfortunately, the current roadmaps only use one of these formats. The authors suggest that all IFR formats should be included in the roadmap and suggest possible points of inclusion.

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