The I-TRIZ Difference:
Making the Average Person an Innovator

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ABSTRACT

Wouldn't it be nice to have Yoshiro Nakamatsu, the world record holder for the most number of patents, look over any new idea you had? Would it not be wonderful to be able to hire Thomas Edison anytime you needed some innovative insight for a day? What if you could consult with Nikola Tesla when faced with your next critical problem? How much better would it be if you could bring the collective inventive force of the entire human race to bear on your next project? Well, now you can with I-TRIZ. I-TRIZ is the ongoing development of TRIZ begun over 60 years ago and represents the distillation of human innovative thought and comprises a set of principles, tools, and methodologies making it possible for anyone to innovate on demand in any subject domain.

1. INTRODUCTION

TRIZ (pronounced "trees") is a Russian acronym for "Teoriya Resheniya Izobretatelskikh Zadatch", the Theory of Inventive Problem Solving; an effort began by Genrich Altshuller [9] in 1946 and continued through to today by numerous colleagues [1][3]. TRIZ is a broad title representing methodologies, tool sets, knowledge bases, and model-based technologies for generating innovative ideas and solutions. TRIZ aims to create an algorithmic approach to the invention of new systems and the refinement of existing systems and is based on the study of the patterns of evolution of various technological systems, scientific theories, organizations, and works of art. The motivation behind all TRIZ efforts is the belief that universal methods can be developed, based on the discovered patterns of evolution, and when applied to future problems in a systematic way can stimulate new ideas thereby leading to innovative solutions to difficult problems. As [10] states:

> The most important result…is that Altshuller set out to develop a method that would help technical individuals handle difficult technological problems. In fact, he accomplished much more than this, revealing the basic patterns and principles of evolution and creativity that are applicable to any field of human activity requiring creative solutions. He also succeeded in systematizing these patterns and principles, making them available for wider use.

There have been three distinct phases in the 60-year history of TRIZ [10]:

- *Classical TRIZ* – development led by Altshuller from the mid-1940s to the mid 1980s.
- *Contemporary TRIZ Phase I* – development during perestroika in the former Soviet Union from the mid-1980s to the early 1990s.
- *Contemporary TRIZ Phase II* – penetration into the Western world from the early 1990s to the present.

Following the fall of the Berlin wall and the collapse of the Soviet Union, in 1989, many TRIZ researchers and practitioners moved to the West, established their own companies, and have served as consultants and educators. Many have continued to extend TRIZ. Today, TRIZ encompasses a vibrant culture employed by large corporations and individual practitioners alike. A large selection of TRIZ-centric Web sites, workshops, books, tutorials, journals, and seminars are available. Every year, the number of TRIZ devotees grows.

One of the companies formed in the early 1990s is Ideation International, Inc. in Southfield, Michigan. Composed of a number of the original Altshuller team members, Ideation has developed extensions to classical TRIZ and entirely new TRIZ-based methods and tools collectively called *I-TRIZ*. I-TRIZ has been applied to a large number of application domains including, but not limited to: scientific work [12], quality management [5], and other non-technical areas [4][13].

2. THE IMPORTANCE OF TOOLS

Humans' creation and use of tools is one thing that differentiates mankind from other animals. Indeed, modern man has become symbiotic with technology. Remove technology and the average person is unable to survive for more than a few days. Man's technology is embodied in the tools he invents allowing him to manipulate the environment.

Not only does new technology create new cultural and social roles, new professions, and new types of workers, it also changes the fabric of culture and society. Some of the first tools invented were used for hunting. Hunting transformed man into a predator instead of being just a gatherer and scavenger. The role of *hunter* could have been the first technology-enabled human and led to a transformation of mankind. The same can be said for many of mankind's achievements. Farming technology, both plants and livestock, allowed man to form stationary settlements instead of having to migrate to follow game. New *farmer* roles such as ranchers and agrarian workers were created. Freeing society from the day-to-day worries of feeding oneself allowed man time to pursue other pursuits such as art, science, and math. Metal working technology created various *smithing* roles. Metal weaponry transformed warfare and changed the balance of world power. Mastery over construction and civil infrastructure allowed cities to develop. Congregations of this many people required innovations like government, laws, and courts. Some professions created thousands of years ago are still viable: carpenters, masons, artists, musicians, scientists, mathematicians, politicians, judges, lawyers, etc.

As a set of tools and methodologies, I-TRIZ should be viewed as an enabling technology on par with inventions like the hammer and saw. However, instead of allowing man to manipulate physical objects like wood and metal, i-TRIZ technology allows humans to work with innovative ideas intended to incrementally improve an object or system under study.

3. THE INNOVATION AGE

Historians tend to partition time into technologically-defined eras such as the *Iron Age* and *Bronze Age*. For example, the *Industrial Age* was defined by the creation of complex tools and machines. Whereas simple tools like hammers, axes, knives, and clubs helped the user perform a specific task, industrial age machines performed entire functions or processes on their own did the majority of the work themselves. Not only did the industrial revolution once again change the balance of global power, it also ushered in a new kind of role—the *factory worker*—and a host of new professions.

In the 20th century, a new kind of machine was developed—the computer. Until the computer, machines were constructed to perform a specific function. In order to achieve a new function, one had to construct a different machine. The computer is revolutionary for two reasons: it is a general-purpose tool and it is a machine that transforms information. (Interestingly, even the first electronic computers were not general purpose machines, but were hardwired to perform a fixed task.) General purpose computers execute a sequence of instructions, a program, and it is the program that determines the function performed by the computer. Instead of having to construct a different computer for each task, one simply crafts a different set of instructions. As always, this new technology created new professional roles like *computer engineer*, *software engineer*, and *computer programmer* but also opened up an entirely new realm—information engineering.

The computer and its software allow humans to manipulate information. Tools like hammers, axes, saws, and plows manipulate physical, tangible objects and materials but information is a "virtual object" that exists beyond the realm of our normal 3-dimensional perception. Having the tools to manipulate information has led to the *Computer Age* and the *Information Age* and has created new kinds of workers like the *information worker* and the *knowledge worker*. Information technology is the new technology and the corresponding revolution this new technology brings is still in progress. In only the last 25 years, information technology has changed the way we communicate and do business with each other. One has to look no further than the cell phone and the Internet to appreciate how the current generation is different than any generation that has come before.

As the science of innovation and technological innovation, I-TRIZ represents another kind of revolutionary technology and one that could usher in a new era—the *Innovation Age.* Capturing and making available the body of human innovative thought through a set of software tools is a prime example of applied information management. Built on top of the computer revolution and the information revolution, I-TRIZ makes it possible for humans to apply themselves to the "smithing" of innovative ideas. We are moving toward a future where innovation is no longer done by a selected few "innovative people" or "research and development people." In the Innovation Age, the average person and the average employee will have command of a set of tools and techniques that make everyone able to innovate on demand.

4. "INNOVATION TECHNOLOGY"

The engine that drives the creation of new technology is *innovation*. Innovation workers in the Innovation Age will use domain-specific technology collectively called *innovation technology*. I-TRIZ-methodologies, tools, and knowledgebase comprise this new technology. In much the same way the computer and software empowered humans to work within the information realm, innovation technology tools enable humans to work within the innovation realm.

If we learn our lessons from history, we should expect the growth of an innovation infrastructure to arise to support this new technology. We call this the *innostructure.* This innostructure, akin to IT infrastructures in companies today, will comprise a myriad of new tools and derivative technologies. We should also expect the creation of new roles, jobs, professions, changes in business practices, and even the creation of a new *innovation industry*. Indeed, the innovation industry is already underway, but still in its infancy. Just like information technology spawned the information worker, we can expect the *innovation worker* to be a new kind of employee —a person adept at using the tools of innovation technology and possessing the ability to innovate.

5. CLASSICAL TRIZ

The classical TRIZ era started in 1946 with Altshuller's seminal research on creativity and ranged to the mid-1980s when Altshuller reasoned that development of TRIZ was complete [10]. Altshuller and his colleagues analyzed over 40,000 patents looking for recurring patterns and documenting human innovation. Altshuller realized that technical systems develop according to certain patterns and that these "patterns of evolution" for different systems have much in common. The main accomplishments during the Classical TRIZ era were:

- The Principle of Ideality—that we desire to engineer systems to a perfect state of having only beneficial impact and no undesirable effects—is the goal of any system's evolution.
- The realization that resolving those conditions keeping systems from being ideal (called contradictions) is vital to the evolution of a system.
- The development of a systematic approach (a methodological approach) to the problem-solving and inventive process.
- Formal problem models and standard solutions.
- An innovation knowledge base featuring case studies illustrating the application of fundamental innovative concepts.
- Methods for reducing psychological inertia.
- 40 Innovation Principles and the Contradiction Table.
- Separation Principles.
- Patterns of Evolution.
- Substance-Field Analysis.

Size constraints prevent this paper from discussing each of these in detail, but books, journals, workshops, and seminars are widely available. [6] and [1] are works well-suited to the beginner. The idea behind TRIZ is to stimulate alternative thinking. Often, TRIZ leads to solutions that would never have been conceived by conventional means. As such, TRIZ is also a way to overcome psychological inertia—thinking that artificially constricts our thinking so we do not entertain potential creative solutions.

6. I-TRIZ

The freedom of perestroika in the 1980s permitted, for the first time, the use of classical TRIZ in a commercial way and it was quickly realized that TRIZ was too cumbersome for the mass market. Proficiency required hundreds of hours of training and years of experience. It was also realized that TRIZ did not cover the entire innovative process. In response, TRIZ schools and researchers began modifying TRIZ to enhance its usability and expand its applicability to the entire innovative process. This effort marks the beginning of contemporary phase of TRIZ, begun in the mid 1980s, and which continues to the present [8][11].

Ideation International was formed in the United States in the early 1990s and consists of a group of original TRIZ colleagues. The result of the last fifteen years of work is collectively called I-TRIZ (for Ideation TRIZ) and consists of four modules [7][8][10]:

- **IPS** Inventive Problem Solving
- **AFD** Anticipatory Failure Determination
- **DE** Directed Evolution
- **IP** Control of Intellectual Property

Directed Evolution is used to identify future versions of a product and help manufacturers of the product select one of the future incarnations as the goal of future production efforts. The IP module allows one to protect future inventions from encroachment by competitors. AFD not only helps identify the causes of problems, but also helps to predict critical failure points in a system [7].

6.1 Operators

Underlying all of I-TRIZ is a collection of suggestions for incremental changes called *operators*. By definition, an operator

> is a transformation as denoted by a TRIZ principle, method, standard solution, or utilization of an effect

I-TRIZ operators are similar to the classical TRIZ principles. However, where 40 principles are identified in classical TRIZ, over 400 operators have been defined in I-TRIZ. I-TRIZ operators are more detailed in nature and tend to focus thinking toward a specific change. For example, the Segmentation principle in classical TRIZ is replaced by a group of five operators in I-TRIZ including four different ways to achieve segmentation (partitioning, pulverization, degeneration, and integration).

An operator is intended to:

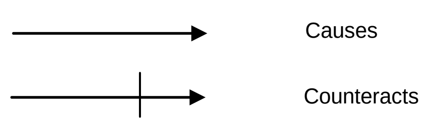
- Help overcome psychological inertia
- View the problem in a different way
- Offer a solution containing an already solved problem
- Identify a resource needed to solve a problem
- Suggest an evolutionary step

As can be seen, an operator offers a specific suggestion. We believe the set of I-TRIZ operators represents the most comprehensive abstraction of patents (measured in the millions by the 1990s) and technological/scientific history. As a result, the database of operators and associated illustrative examples represents a distillation of human innovative thought and is a knowledge base unparalleled in history.

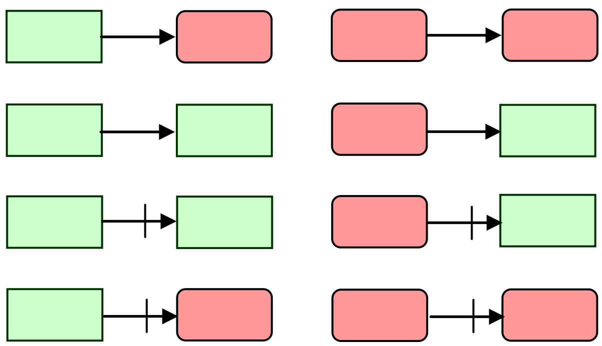
6.2 The Problem Formulator™

One could generate ideas by simply browsing though the operators. However, with such a large number of operators and many inter-relationships, the space of operators is overwhelming. Practitioners need a way to intelligently find a trajectory through the operators that identifies the subset of operators most likely to be beneficial to a problem. Ideation International sells a software tool called the Innovative WorkBench (IWB) that does just this. One tool in the IWB is the Problem Formulator (PF). PF is a graphical modeling technique with a deceptively simple graphical vocabulary. To begin analysis of a system, one uses the PF to construct a cause-effect diagram. Each function or effect of the system is classified as either as *harmful* (undesirable) or *useful* desirable) depending on whether or not the function moves the system toward ideality or away from ideality. Useful and harmful functions are represented as nodes in the diagram following the form:

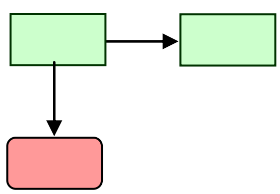
Something can always produce or counteract something else, so these relationships are encoded using:



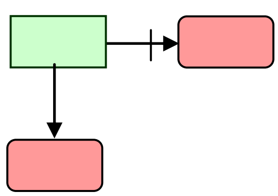
Sometimes, something useful in a system causes something else useful to happen—a desirable occurrence. However, sometimes, something useful has undesirable side effects and causes something harmful to happen. (The vice-versa is true too.) These are undesirable occurrences and are called *contradictions*. One can enumerate all outcomes using this modeling technique:



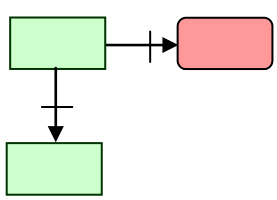
A diagram in the Problem Formulator boils down to a collection of cause/effect relationships describing various situations. Contradictions are the undesirable situations and fall into three categories:



Type 1:
A useful function produces another useful function (desirable) but also produces a harmful function (undesirable).



Type 2:
A useful function counteracts a harmful function (desirable) but also produces a harmful function (undesirable).



Type 3:
A useful function counteracts a harmful function (desirable) but also counteracts another useful function (undesirable).

A system without contradictions would be an ideal system, since no harmful effects would be present. In reality, though, there is no such thing as a completely ideal system, so all systems have at least one contradiction. In fact, the reason why one would be analyzing a system in I-TRIZ in the first place would be to solve some problem with the system. In I-TRIZ, the essence of an innovative solution is to resolve as many contradictions as possible.

6.3 Software Tools

Ideation International produces a set of software applications automating much of the operator search and match activity. The tool for the IPS module is called the Innovative WorkBench (IWB) and incorporates a tool called the Innovation Situation Questionnaire (ISQ), the Problem Formulator (PF), the I-TRIZ operators, and the knowledge base consisting of case studies and examples. The ISQ is used to document descriptive information about the system under study. After completing the ISQ, the user draws the PF diagram. From the diagram, the IWB software makes suggestions leading to the most promising set of operators. By considering the suggestions within the operators, one is stimulated to think of alternative solutions improving the system.

Dating back to classical TRIZ, researchers realized there are four ways to resolve contradictions:

- **Separate in space**
  Physically distance the harmful from the useful
- **Separate in time**
  Perform harmful actions at different time
- **Separate in structure**
  Build the system to isolate the harmful from the useful
- **Separate on conditions**
  Alter the conditions under which harmful is acting

Using the IWB, the user selects one or more contradictions shown on the PF diagram. In some cases, the software can make operator suggestions directly. In other cases, the user selects one or more of the contradiction resolution directions to pursue. A systematic IWB analysis will probe all possible avenues.

7. REFERENCES

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