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THE THEORY AND ALGORITHM OF INVENTIVE PROBLEM SOLVING (TRIZ AND ARIZ) (Their Modern Interpretation in the Local Innovation Process of Beachwear Set Design Within a Startup Company)

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Abstract

This publication examines the application of the Theory of Inventive Problem Solving (TRIZ) as a systematic methodology for accelerating innovation within startup companies operating under significant financial, technical, organizational, and professional resource constraints. The article analyzes the relationship between inventive methodology and innate creative abilities, demonstrating that successful innovation can be substantially enhanced through structured engineering approaches based on established principles of technical system evolution.

Drawing upon the pioneering work of Genrich Altshuller and the analysis of more than 40,000 inventor's certificates and patents, the publication explains how recurring patterns of successful inventions led to the development of TRIZ as a practical framework for engineering innovation. Particular attention is given to the transformation of an initial inventive situation into a clearly defined engineering problem by eliminating inefficient solution paths and reducing dependence on trial-and-error approaches.

The article further examines the concept of the Ideal Final Result (IFR) as a fundamental TRIZ principle, emphasizing the achievement of optimal technical solutions through the effective utilization of existing system and environmental resources. The presented methodology provides practical guidance for startup organizations seeking to develop innovative technologies and engineering solutions while minimizing development costs, technical risks, and resource consumption.

Keywords: *Technology Incubator; Innovation Ecosystem; Effective Technology Implementation; Innovative Development Model for Industrial and Agricultural Production; Ecosystem Infrastructure Architecture; Quantum Computing; Augmented Reality Visualization; Testing Laboratories; Laws of Technical System Evolution; Standardization; Technology Transfer*

Introduction

In a typical startup company, resources at the initial stage of development are significantly limited. This applies equally to financial, professional, technical, and organizational resources.

Within the framework of such a startup, is it possible to develop more effective and systematic inventive capabilities by drawing upon the extensive experience accumulated by previous innovators working in similar technological fields under comparable initial conditions? If so, what constitutes this accumulated experience?

What is the actual relationship between inventive methodology – which can be identified, studied, and mastered – and the natural, innate creative abilities of an inventor that cannot be acquired through education alone?

The Soviet patent engineer, inventor, writer, and scientist Genrich Altshuller believed that it was possible to identify consistently recurring patterns underlying successful inventions and to teach these systematic inventive techniques to individuals capable of mastering them. To validate this concept, more than 40,000 inventor's certificates and patents were analyzed. Based on the identified patterns governing the evolution of technical systems and inventive methodologies, the Theory of Inventive Problem Solving (TRIZ) was developed.

When an inventor encounters a technical problem for the first time – particularly during the initial stages of an innovation project – the problem is typically formulated in broad and ambiguous terms and provides no clear indication of an appropriate solution.

Furthermore, startup companies generally possess neither prior manufacturing experience nor production facilities capable of supporting experimental verification of potential solutions.

Within the TRIZ methodology, this initial form of problem formulation is referred to as an **inventive situation**. Its principal disadvantage is that it presents engineers with an excessive number of possible solution paths. Evaluating every alternative is both labor-intensive and costly, while selecting approaches by intuition alone inevitably results in an inefficient trial-and-error process.

Consequently, the first step toward an effective invention is to reformulate the inventive situation in such a way that the problem statement itself eliminates ineffective and unpromising solution paths. This naturally raises an important question: which solutions should be regarded as truly effective?

Genrich Altshuller proposed that the most effective solution is one that is achieved virtually "by itself" through the optimal utilization of resources already available within the system or its surrounding environment. This concept led to the formulation of the Ideal Final Result (IFR), defined as follows:

"An element (the X-element) of the system or its environment independently eliminates the harmful effect while preserving the system's useful function."

In practice, the Ideal Final Result is rarely achieved in its absolute form. Nevertheless, it serves as the fundamental benchmark guiding inventive thinking. The closer a proposed solution approaches the Ideal Final Result, the more effective and elegant that solution is considered to be.

Having established a criterion for eliminating ineffective solutions, the inventor can reformulate the inventive situation into a standard mini-problem within the TRIZ framework:

"According to the Ideal Final Result, the system should remain essentially unchanged; however, either an existing harmful property must disappear or a new beneficial property must emerge."

The primary objective of the mini-problem is to avoid significant – and often costly – modifications to the system while directing inventive efforts toward the simplest, most efficient, and most resource-effective solutions.

The formulation of the **mini-problem** facilitates a more precise definition of the engineering challenge by addressing several fundamental questions:

- What are the components of the system, and how do they interact?
- Which interactions are harmful, obstructive, neutral, or beneficial?
- Which system components and relationships may be modified, and which must remain unchanged?

- Which modifications improve system performance, and which result in deterioration?

These questions provide a sufficient foundation for initiating inventive work. However, during the early stages of an innovation project that is ultimately intended to become a commercially viable product, an additional challenge arises: how can one anticipate the transformation of the invention's most valuable technical characteristics into a set of consumer-oriented properties capable of ensuring not only technological excellence but also commercial success?

To answer this question, let us examine the innovation process step by step.

Once the mini-problem has been formulated and the system has been analyzed, it generally becomes apparent that attempts to improve one system parameter inevitably lead to the deterioration of another. For example, increasing the structural strength of an aircraft wing typically results in greater weight, whereas reducing its weight often decreases structural strength. At this point, a conflict – or contradiction – emerges within the system.

According to the **Theory of Inventive Problem Solving (TRIZ)**, contradictions are classified into three categories, arranged in order of increasing complexity.

Administrative contradiction. This contradiction may be expressed as follows: *"The system must be improved, but I do not know how – or I lack the authority, resources, or capability to implement the required changes."* This represents the least complex form of contradiction and can often be resolved through the acquisition of additional knowledge, organizational changes, or appropriate management decisions. In today's innovation environment, many administrative contradictions arise not only from organizational constraints but also from commercial requirements and market conditions that influence the future implementation and commercialization of an innovative product.

Technical contradiction. This occurs when *improving one parameter of a technical system inevitably causes the deterioration of another parameter*. The technical contradiction constitutes the formal statement of the inventive problem. Reformulating an administrative contradiction into a technical contradiction significantly reduces the complexity of the problem, narrows the search space for possible solutions, and replaces inefficient trial-and-error approaches with the structured methodology of the Algorithm of Inventive Problem Solving (ARIZ). Depending on the complexity of the problem, ARIZ recommends one or more standardized inventive principles or identifies one or more underlying physical contradictions that must ultimately be resolved. In the modern innovation environment, technical contradictions should also be evaluated in light of commercial requirements governing the successful implementation of innovative products.

Physical contradiction. This represents the most fundamental level of contradiction and arises when *a particular component of a system must simultaneously possess two mutually exclusive physical states in order to achieve the desired improvement*. Because such conditions violate the fundamental laws of physics, the inventor must identify alternative physical effects or engineering principles capable of eliminating the contradiction. Classical TRIZ addresses this challenge through the systematic application of physical effects databases and engineering knowledge bases.

This was the traditional approach. What has changed in the modern technological environment?

The emergence of advanced computer modeling technologies, digital engineering platforms, computer-aided design (CAD) systems, simulation software, digital twins, and integrated engineering environments has substantially expanded the repertoire of tools available for inventive problem solving. These technologies enable engineers to evaluate numerous design alternatives rapidly, simulate complex system behavior, predict technical performance before physical prototyping, and significantly reduce the time, cost, and technical risks associated with the innovation process. As a result, modern computational technologies have become an important complement to the classical TRIZ methodology, substantially enhancing both the efficiency and practical applicability of systematic inventive problem solving.

System of Inventive Principles

The analysis of many thousands of inventions has demonstrated that, despite the enormous diversity of technical contradictions, the vast majority can be resolved through the application of 40 fundamental inventive principles.

The development of this system was initiated by Genrich S. Altshuller during the early stages of the Theory of Inventive Problem Solving (TRIZ). Identifying these principles required the systematic analysis of more than 40,000 inventor's certificates and patents, through which recurring patterns of successful inventive solutions were identified.

These inventive principles continue to possess significant heuristic value for engineers and innovators. Their understanding substantially facilitates the search for effective solutions. However, in today's highly competitive commercial environment, their application alone is no longer sufficient to ensure the successful development of innovative products.

The inventive principles primarily indicate the direction in which strong engineering solutions are likely to be found. They do not generate the final solution themselves; the responsibility for selecting and developing the optimal engineering concept remains with the inventor.

The TRIZ system distinguishes between simple inventive principles and paired inventive principles (principle–anti-principle pairs).

Simple inventive principles are primarily intended to resolve technical contradictions, with the forty classical principles representing the most widely applied tools within the TRIZ methodology.

Paired inventive principles consist of a principle and its opposite counterpart and are used to resolve physical contradictions, where mutually exclusive properties, states, or actions must coexist within a technical system.

Standards for Inventive Problem Solving

The Standards for Inventive Problem Solving constitute a structured collection of solution models that employ physical, chemical, or other scientific effects to eliminate contradictions within technical systems. These standards function as generalized engineering solution patterns applicable to broad classes of inventive problems.

To describe the structure of these solution models, Genrich Altshuller developed Substance-Field Analysis (Su-Field Analysis), one of the fundamental analytical tools within TRIZ.

The complete system comprises multiple classes, subclasses, and 76 standardized solution models. Beyond supporting the resolution of inventive problems, the standards also facilitate the identification of previously unrecognized engineering challenges and enable the prediction of future technological evolution.

Technological Effects

A **technological effect** is defined as the transformation of one technological process or engineering action into another. In many cases, technological effects are achieved through the application of underlying physical, chemical, biological, or other scientific phenomena.

Physical Effects

More than 5,000 physical effects and phenomena have been identified within the scientific literature. Different engineering disciplines utilize different groups of physical effects; however, approximately 300 to 500 of these effects are broadly applicable across multiple areas of engineering and technological innovation.

The systematic application of physical effects significantly expands the range of potential engineering solutions and constitutes an essential component of advanced inventive problem solving.

Chemical Effects

Chemical effects represent a specialized category of physical effects in which only the molecular structure of substances is modified, while the governing fields are generally limited to concentration, temperature, reaction rate, and related physicochemical parameters.

Restricting the search for solutions to appropriate chemical effects often enables engineers to identify practical and efficient solutions more rapidly.

Biological Effects

Biological effects are phenomena generated by biological systems, including plants, animals, microorganisms, and other living organisms.

The application of biological effects in engineering not only broadens the capabilities of technical systems but also supports environmentally sustainable innovation by enabling technical solutions that minimize adverse impacts on the natural environment.

Biological effects can be employed to perform a wide variety of engineering functions, including detection, transformation, generation, absorption of matter or energy, environmental adaptation, and numerous other technological operations. Their application has become increasingly important in the development of sustainable, bio-inspired, and next-generation engineering systems.

Mathematical Effects

Among the various categories of scientific effects employed within TRIZ, mathematical effects – particularly geometric effects – have been developed most extensively.

Geometric effects involve the application of geometric forms and relationships to achieve technological transformations. Well-known examples include the engineering use of the triangle, such as wedge mechanisms or systems utilizing two interacting sliding triangular elements. The systematic application of geometric principles frequently enables engineers to simplify technical solutions while improving their functionality and efficiency.

Resources

Substance-Field Resources (Su-Field Resources) are the physical, energetic, informational, spatial, temporal, and functional resources available within or surrounding a technical system that may be utilized during inventive problem solving or system development.

The effective utilization of existing resources increases the **ideality** of a technical system by achieving greater functionality with fewer modifications, lower costs, and reduced resource consumption.

Laws of Technical System Evolution

Through extensive analysis of the historical evolution of technical systems, Genrich Altshuller identified a set of Laws of Technical System Evolution. Knowledge of these laws enables engineers to predict probable directions for future technological development and to design innovations consistent with objective patterns of technological progress.

First presented in Altshuller's book *Creativity as an Exact Science* (Moscow: Soviet Radio, 1979), these laws are traditionally classified into three principal groups.

Statics

The first three laws describe the conditions necessary for the emergence, formation, and initial viability of technical systems.

Kinematics

Laws 4–6 and 9 describe patterns governing system development that are largely independent of specific physical phenomena. These laws are particularly important during the initial growth and maturity stages of technological evolution.

Dynamics

Laws 7 and 8 describe development driven by specific physical factors and become especially significant during the final stages of system evolution, when an existing technical system approaches its developmental limits and transitions toward a fundamentally new generation of technology.

Among all TRIZ principles, the Law of Increasing Ideality is considered the most fundamental. Ideality represents one of the core concepts of TRIZ and serves as the principal criterion guiding technological evolution toward increasingly efficient systems.

Substance-Field (Su-Field) Analysis

Substance-Field Analysis (Su-Field Analysis) is one of the principal analytical methods within TRIZ. A Su-Field model (Substance + Field) represents the minimal functional model describing interactions between system components through a standardized symbolic notation.

Genrich Altshuller developed Su-Field Analysis as a systematic methodology for identifying and utilizing available resources within technical systems. Several TRIZ solution standards employ different combinations of substances and fields to eliminate contradictions while increasing system ideality.

A classical example is the **teletext system**, which utilizes unused intervals within a conventional television broadcast signal to transmit digital information, thereby exploiting existing system resources without introducing additional transmission channels.

Another widely used TRIZ methodology involves the systematic identification and utilization of previously unused substances, fields, and other available resources located either within the technical system itself or in its surrounding environment.

ARIZ – Algorithm of Inventive Problem Solving

The Algorithm of Inventive Problem Solving (ARIZ) represents the most advanced methodological component of TRIZ. It is a structured, step-by-step procedure – consisting of approximately 85 sequential analytical steps – designed to identify, formulate, and systematically resolve contradictions underlying complex inventive problems.

ARIZ integrates three principal components:

- a structured problem-solving algorithm;
- an information support system utilizing the accumulated TRIZ knowledge base and information fund;
- psychological methods designed to overcome cognitive barriers through the **Development of Creative Imagination (DCI)** methodology, an integral component of advanced TRIZ practice.

Various alternative approaches have also been developed to assist inventors in expanding their creative capabilities. Most of these methods are heuristic in nature and are primarily based on principles of psychology and formal logic. Unlike TRIZ, however, none of these approaches claims the status of a comprehensive scientific theory of inventive problem solving.

Alternative Creative Problem-Solving Methods

In addition to TRIZ, a number of established methodologies have been developed to stimulate creative thinking and engineering innovation, including:

- Trial-and-Error Method;
- Brainstorming;
- Synectics;
- Morphological Analysis;
- Focal Objects Method;
- Checklist (Control Questions) Method.

Although these approaches can facilitate idea generation, they are primarily heuristic techniques and generally lack the systematic analytical framework that characterizes TRIZ.

Criticism of TRIZ

Following the death of Genrich Altshuller, the further development of TRIZ slowed considerably. Critics have attributed this stagnation, as well as the practical difficulties associated with applying the methodology, to several factors.

Among the principal criticisms are the following:

- the absence of a universally accepted methodology for solving inventive problems despite numerous attempts to derive one from observed patterns of technological evolution;
- departures from the original dialectical approach through the introduction of concepts regarded by some researchers as inconsistent with the theoretical foundations of TRIZ;
- successive modifications of the Algorithm of Inventive Problem Solving (ARIZ) often increased procedural complexity rather than eliminating previously identified shortcomings;
- the lack of sufficiently effective mechanisms for transforming a formally stated contradiction into a practical engineering solution;
- the continued reliance of many TRIZ tools on extensive exploration of alternative solutions despite the theory's declared objective of minimizing trial-and-error approaches;
- the use within Substance-Field (Su-Field) Analysis of certain theoretical physical fields whose practical applicability has been questioned;
- the difficulty of implementing TRIZ within industrial environments because successful application frequently

depends upon the individual experience, judgment, and creativity of the engineer.

Contemporary TRIZ

Modern TRIZ has evolved into a collection of schools and research directions that continue to develop the classical theory while introducing new concepts not originally included in Altshuller's work.

The core technical components of classical TRIZ – including the **40 Inventive Principles**, **ARIZ**, and **Substance-Field Analysis** – have remained largely unchanged. Consequently, much of the activity within contemporary TRIZ has focused on reinterpretation, restructuring, educational dissemination, and philosophical discussion rather than on significant advances in its engineering methodology.

For this reason, some researchers have criticized modern TRIZ for placing greater emphasis on theoretical interpretation, promotion, and educational activities than on the development of new technical methodologies.

Today, TRIZ is actively applied in fields extending well beyond engineering, including business strategy, marketing, advertising, management, education, the arts, and early childhood development, although it was originally conceived as a methodology for technical creativity and engineering innovation.

Classical TRIZ represents a **general engineering methodology**. However, effective practical implementation increasingly requires the development of specialized TRIZ frameworks tailored to specific industries, each supported by dedicated knowledge bases, information resources, and domain-specific solution models.

Several major international corporations have already developed proprietary adaptations of TRIZ for application within their own technological domains.

In the author's opinion, the same approach should be adopted for startup companies. A specialized version of TRIZ should be developed specifically for startup environments, emphasizing the rapid commercialization of innovations, efficient utilization of limited resources, accelerated product development, and market-oriented engineering decision-making.

At present, no comprehensive specialized versions of TRIZ exist for stimulating scientific discovery in disciplines such as physics, chemistry, biology, and related fields.

One of the principal limitations affecting the continued evolution of TRIZ is the absence of a comprehensive methodology for analyzing initial problem situations, diagnosing emerging technological challenges, and forecasting future innovation opportunities as a basis for defining development objectives within socio-technical systems.

Addressing this limitation has become one of the objectives of the emerging methodology known as Future Design (Futurodesign) – the systematic design of engineering solutions aligned with anticipated technological and societal developments.

Another significant trend influencing technological progress is the growing importance of intellectual property protection. As competition for ownership of innovative technologies intensifies, organizations increasingly require employees capable of generating patentable engineering solutions supported by advanced methodological and software tools.

From this perspective, the TRIZ knowledge base should be expanded to incorporate a broader spectrum of theoretical approaches and modern engineering methodologies.

At the same time, the intellectual successors of Altshuller have generally advocated preserving the original interpretation of classical TRIZ. They are fully entitled to protect the historical identity of the TRIZ methodology and to promote its educational, philosophical, and humanitarian applications.

An alternative approach is to encourage the integration of new methodologies reflecting the technological realities of the twenty-first century while preserving the fundamental scientific value and international recognition of the TRIZ brand.

To avoid unnecessary theoretical disputes, emerging approaches to innovation modeling may ultimately develop under new terminology, particularly since the concepts embodied in the phrase **Theory of Inventive Problem Solving** are broader than the historical framework established during the lifetime of Genrich Altshuller.

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