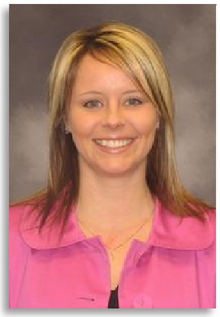
INNOVATION WITH I-TRIZ IN A 3D VIRTUAL WORLD

ABSTRACT

Would it not be exciting to step into a three dimensional virtual reality and have Yoshiro Nakamatsu, the world record holder for number of patents, Nikola Tesla, the inventor of efficient power transmission, and Thomas Edison, provide their innovative insight on a problem we were trying to solve? We are a few years away, but the essence of those and thousands of other innovators has been captured in a knowledgebase and toolset known as I-TRIZ. I-TRIZ is the result of sixty-five years of development beginning in the Soviet Union just after World War II. The I-TRIZ methodology allows anyone to innovate on demand by employing this vast collection of knowledge to help stimulate new innovative ideas and nonlinear thinking. In this paper, we describe an exploratory project in which we experimented with the idea of performing an I-TRIZ analysis in a three dimensional virtual world called Teleplace. We sought to discover whether or not working in such an environment could make us better innovators. We also explored using the third dimension in the immersive environment to allow us to use I-TRIZ tools in new and different ways.

KEYWORDS: Innovative Problem Solving, Computer-Aided Innovation, Alternative Thinking, 3D Virtual Worlds



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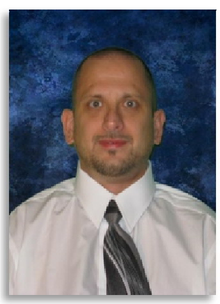

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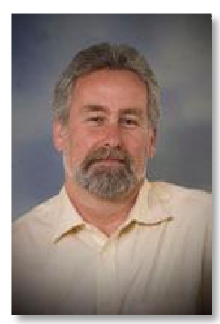

1. INTRODUCTION

TRIZ (pronounced “trees”) is a Romanized Russian acronym for "Teoriya Resheniya Izobretatelskikh Zadatch," or the Theory of Inventive Problem Solving, an effort began by Genrich Altshuller (Altshuller, 2007, 2005, 1999, and 1996; Kaplan, 1996) in 1946 that continues today through numerous practitioners and former Altshuller colleagues (Altshuller, 1999 and 1996). TRIZ and its derivatives are only recently gaining scholarly interest in Western universities.

TRIZ is a broad title representing methodologies, tool sets, knowledgebases, and model-based technologies for generating innovative ideas and inventive solutions. The longtime goal has been the development of an algorithmic approach to invention and innovation. TRIZ is based on the study of the patterns of innovative thought and technological systems evolution. Indeed, the motivation behind all of TRIZ is the belief that universal methods can be developed based on observed patterns. As Zusman (1999a) states:

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 at a much larger scale.

There have been three distinct phases in the 65-year history of TRIZ (Zusman, 1999a):

- *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

TRIZ development took place for over forty years under government-imposed secrecy behind the Iron Curtain. Following the collapse of the Soviet Union, many TRIZ researchers, scholars, and practitioners moved to the West and since have established their own companies serving as consultants and trainers. Many have continued to develop and expand classical TRIZ resulting in several modern extensions. Today, the TRIZ community is a vibrant culture comprising large corporations, and individual practitioners alike around the world. A large selection of TRIZ-centric Web sites, workshops, books, tutorials, journals, and seminars are available.

2. CLASSICAL TRIZ

The classical TRIZ era began in 1946, launched by Altshuller’s seminal research into what differentiates innovators from everyone else, and continued to the mid-1980s (Zusman, 1999a). Altshuller and his colleagues analyzed over forty-thousand patents looking for recurring patterns and documenting human innovation. Altshuller realized that technical systems are developed 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 features—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 knowledgebase 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

3. I-TRIZ

Ideation International formed in the early 1990s and is located in Southfield, Michigan, near Detroit. Composed of a number of the original Altshuller team members, Ideation has developed extensions to classical TRIZ and created 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 (Zainiev, 1999), quality management (Halliburton, 2005), and other non-technical areas (Halliburton, 2005; Zlotin et al., 2000; Zusman, 1999b; Clark, 1999; Zainiev, 1999).

I-TRIZ aims to facilitate innovative thinking. Often, I-TRIZ leads to solutions that would have never been conceived by conventional means. As such, I-TRIZ is a way to overcome psychological inertia—the kind of thinking that artificially constricts our creativity and prevents us from entertaining potential creative solutions. I-TRIZ consists of four modules (Kaplan et al., 1999; Mizrachi, 1999; Zusman, 1999a):

- **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, years in advance, while also helping manufacturers of the product select one of the future incarnations as the goal of production efforts. The IP module allows one to protect inventions from encroachment by competitors. AFD not only helps identify causes of problems, but also helps to predict critical failure points in a system (Kaplan, 1999). In this project, we used IPS which includes an extensive knowledgebase, and a set of tools, one of which is a graphical modeling tool called the Problem Formulator.

3.1 Operators

At the heart of I-TRIZ is a knowledgebase comprised of a collection of suggestions for incremental changes called *operators*. These operators were identified by studying over two million patents. Each operator encapsulates an innovative idea employed in previous inventions. There are currently over four-hundred operators defined. 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

We believe the set of I-TRIZ operators represents the most comprehensive distillation of innovative thought in human history.

3.2 The Problem Formulator™

One could generate ideas by simply browsing though the operators. However, the large number of operators and many inter-relationships are overwhelming. Practitioners need a way to find a trajectory through the operators identifying the subset of operators most likely to be beneficial to a problem. Ideation International sells a software tool called the Innovative WorkBench (IWB) that serves this purpose. One tool in the IWB is the Problem Formulator (PF). PF is a graphical modeling tool with a deceptively simple graphical vocabulary. I-TRIZ views systems as collections of *harmful functions* (undesirable features) and *useful functions* (desirable features). Useful and harmful functions are represented as nodes as shown in Figure 1.

A function either produces (causes) or counteracts (inhibits) another function. These relationships are represented as shown in Figure 2. Sometimes, a useful function causes another useful function which is a desirable occurrence. However, sometimes a useful function has undesirable side effects and causes something harmful to happen as shown in Figure 3. A diagram in the Problem Formulator is essentially a collection of cause/effect relationships describing various situations. Contradictions are the undesirable situations and fall into three categories as shown in Figure 4.

Figure 1 – Useful and harmful functions in Problem Formulator diagrams

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. Therefore, all systems have at least one contradiction. In fact, the reason for analyzing a system in I-TRIZ is to solve some problem with the system. In I-TRIZ, the essence of an innovative solution is to resolve as many contradictions as possible.

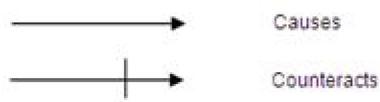

Figure 2 – "Produces" and "Inhibits" relationships in Problem Formulator diagrams

4. Virtual Worlds and Teleplace

A virtual world is a computer-generated simulated environment allowing users to interact with objects and with each other, via digital representatives called avatars, in an immersive 3D space. Simulated reality video games like Halo and Call of Duty have used 3D virtual worlds for years, and many 3D virtual communities such as Second Life and World of Warcraft are available via the Internet. Indeed, today's college students have grown up in these virtual worlds. These students are increasingly expecting their college education to be available in online formats and via distance education. Educators in higher education are just beginning to explore the possibilities of immersive 3D virtual education.

Teleplace, Inc. creates application collaboration solutions to help enterprises manage data-intensive operations across multiple locations. Teleplace provides application collaboration solutions to over one-hundred global five-hundred and mid-size customers, including leading firms in the semiconductor, financial, energy, consulting, IT, and manufacturing sectors.

Teleplace has made available a secure virtual workspace just for educational purposes combining voice, video and chat communications with multi-application and document sharing (Teleplace, 2010).

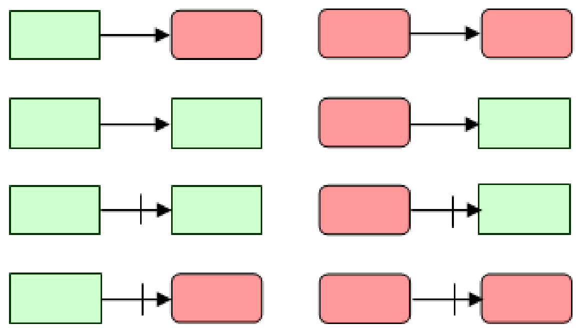

Figure 3 – Two functions can be related in eight ways

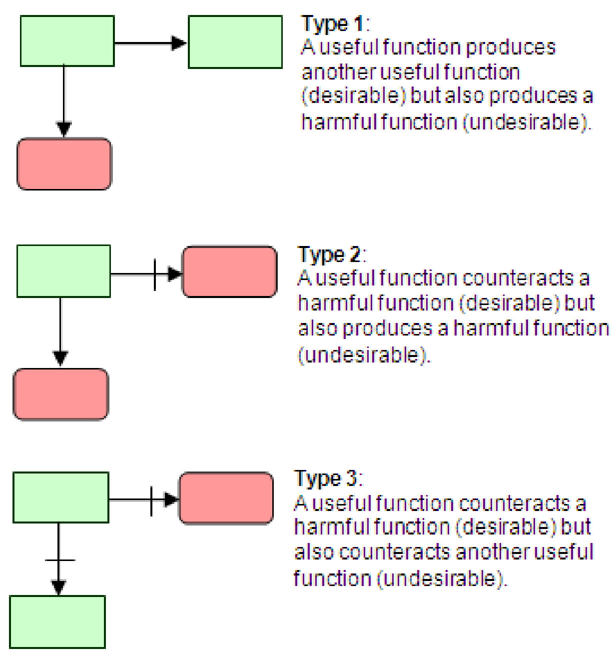

Figure 4 – Contradictions either produce harm or inhibit good

5. The Carolina Virtual Worlds Consortium

The Carolina Virtual Worlds Consortium (CVWC) was established in 2007 to explore 3D virtual worlds and immersive technologies for education (Consortium, 2010). The CVWC has partnered with the University Center of Greenville (UCG), a consortium of higher education institutions bringing undergraduate and graduate education to Greenville County in the Upstate region of South Carolina (UCG, 2010). In September of 2010, UCG opened the SimHub Immersive Technology Center in collaboration with the CVWC for faculty to gain access to, and gain experience in, using 3D virtual worlds for educational purposes. During the months of June and July of 2010, UCG and CVWC sponsored several teams, including ours, to explore using 3D virtual worlds to support our respective programs.

6. I-TRIZ IN TELEPLACE

We were faced with the challenge to study how to use I-TRIZ in a 3D virtual space and especially to investigate the opportunities and advantages related to the third dimension. We chose Teleplace as the 3D environment, to take advantage of existing resources and local expertise. Our initial activities focused on developing Problem Formulator diagrams within the virtual environment. Traditional Problem Formulator diagrams are two dimensional existing either on a piece of paper or on a computer screen. Our goal was to explore the opportunities with the virtual world and the advantages of collaborating in a third dimension. We wanted to see if a 3D diagram facilitates analysis in new and interesting ways. We examined the concept of being “immersed in the diagram” then surveyed the benefits gained from the ability to walk through and around a Problem Formulator diagram in the virtual world. We also explored the collaborative possibilities of Teleplace. We analyzed the virtual space to determine if it is an appropriate meeting place for individuals located across the globe to come together and participate in a collaborative I-TRIZ analysis effort.

6.1 Collaborative I-TRIZ in 3D Virtual Worlds

The business environment is shifting towards a quicker, more efficient platform and businesses are demanding information, communication, and collaboration at much higher levels. Virtual I-TRIZ would offer businesses an opportunity to collaborate in real time interactive meetings and provide a stage for innovative development. The allure of virtual collaboration is based on the promise of:

- 24/7 access (Internet connectivity required)
- Removes time zone barriers
- Overcomes geographic boundaries
- Translation features to overcome language barriers
- Facilitates global ad-hoc meetings
- Increases information exchange both in quantity and quality in “face-to-face” meetings (even virtual)
- Document sharing with multiple viewers and editors
- Spatial advantages – representing information in a three dimensional space that looks like a real room

First, we observed that it will be critical to overcome the preconception that all 3D virtual worlds look and feel like a video game. Until people experience it themselves, they assume that anything in a virtual world is not a serious business utility.

Second, it will be necessary to convince people that 3D virtual world collaboration offers a higher value than traditional audio/video conferencing solutions.

Third, we observed that learning how to navigate, look around, speak, emote, and manipulate in-world objects requires a non-trivial learning curve. People with some experience in video games will have less trouble, but those who do not, will have to learn new skills. However, we observed that those in our group and other research groups had fun learning these skills. This enjoyable experience may mitigate the initial feeling of “being lost” or “paralyzed” because one does not know how to navigate through such an environment.

Fourth, we experienced some of the benefits of virtual collaboration ourselves. During the project, we met physically only two times. The schedules of the team members were vastly different, yet we managed to work effectively together using the 3D virtual world in Teleplace.

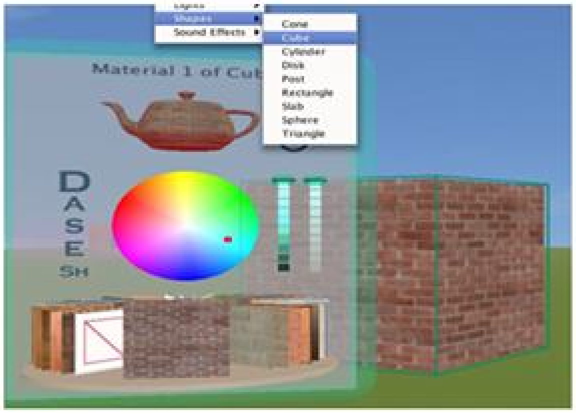

Figure 5 – Color and texture selections for the cube primitive

6.2 Synthesizing New Objects In-World

The version of Teleplace we used was limited in the number and kind of native in-world objects. To develop Problem Formulator diagrams, we needed the ability to create basic shapes, label these shapes with text, and assign the shapes with relational and functional attributes, developing relationships.

We quickly found that Teleplace did not have a mechanism for designing or modeling objects, like a rectangle, the basic component of the Problem Formulator. However, Teleplace does have a mechanism for adding objects. Any Teleplace user can choose from a wide variety of textures, colors, light reflectivity, and opacity using a rotary-bookshelf tool. The closest option to our rectangle was the cube. Examples of these are shown in Figure 5.

The second step in developing the Problem Formulator diagrams is adding text to the shapes. Teleplace offers various options related to the text, including post-it notes and bulletin boards. Originally, the bulletin boards, as shown in Figure 6, held our initial findings as we explored Teleplace and climbed the learning curve gaining experience in navigating through the world, manipulating objects, and sharing information.

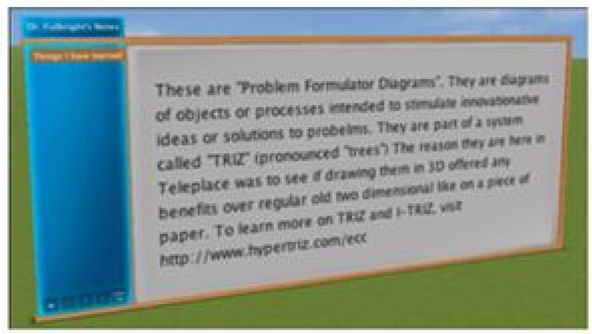

Figure 6 – Interactive bulletin boards allow us to leave notes for others

Teleplace also offers document sharing. OpenOffice is built into the environment allowing us to upload, display, and share normal office documents. Documents can be linked into the virtual world to allow reference material such as information related to the operators and case studies. As a result, we were also able to post a 2D problem formulator diagram completed with traditional software.

Teleplace allows the import of objects in Google's 3D warehouse. Again, we found that none of these objects were appropriate for building diagrams, although we could setup a virtual room complete with simulated furniture, display boards, and interactive note boards.

Google offers a free 3D modeling software package called Google SketchUp. Using SketchUp, we were able to create 3D objects inside the editor and easily import them into Teleplace. Therefore, the Google Sketchup tool was a logical workaround for Teleplace's object creation deficiencies. As we learned to work within Sketchup, our diagrams began to take form.

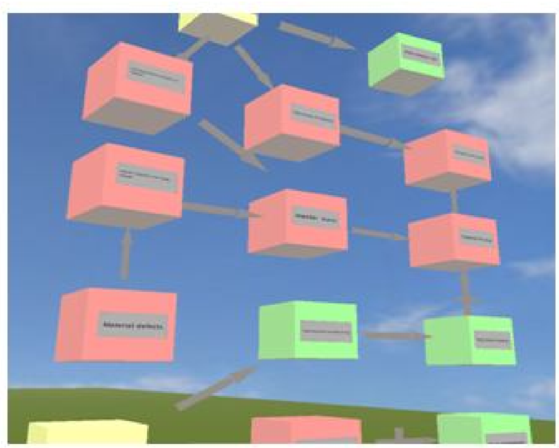

Figure 7 – A 3D version of a 2D problem formulator diagram

6.3 Drawing 3D Problem Formulator Diagrams

We began by building sample formulator diagrams resembling Ideation's Problem Formulator, but in 3D. The first diagrams we developed simply used 3D rectangular boxes instead of the traditional 2D rectangles. Thus, the diagram was still essentially a 2D diagram, just rendered in three dimensions as shown in Figure 7.

We decided it to be more efficient to model the diagrams using spheres. Spheres can be viewed and linked to from any angle in 3D. We knew from previous diagrams that the post-it style notes were insufficient, but Google Sketchup provided a solution. We were able to bind 3D text, superimposed on the spherical object primitive. Therefore, when we dropped the objects into Teleplace, it became one object with dimensional text faces as shown in Figure 8.

Figure 8 – A composite object with dimensional text faces to facilitate viewing from multiple angles

Drawing the diagrams in Teleplace requires building them cube by cube, note by note, and arrow by arrow, as well as positioning them very carefully within the environment. Teleplace does not currently have intelligence built into the system to programmatically formulate the diagrams. If we were to pursue this effort with Teleplace, automated object creation would be a requirement.

The 3D virtual world gives us the opportunity to walk *around* an object and see it from different angles. We wanted to know if we could take advantage of this characteristic to draw new kinds of problem formulator diagrams. We opted to build the diagram based on spheres atop a native object called the pedestal as seen in Figure 9. The pedestal gave us the ability to rotate the diagram in front of the avatar without having to walk around the diagram, which we found to be cumbersome and tedious. It became possible to view the diagram from one angle analyzing useful functions, and then rotate the diagram ninety degrees to view the harmful functions.

This discovery proved that the third dimension can provide a unique analytical benefit. It is possible to let each axis represent a different qualitative view of the system modeled in the diagram.

In Teleplace, there are no boundaries to the virtual space. This means there is no limit to the size of neither diagrams nor the number of diagrams. Diagrams could literally go on forever.

In order to create an environment for clients and customers to work, it is important that we build intelligent software to quickly formulate desired results for sharing. During this study, the research assistants manually built each model devoting a lot of time to each design. Within Teleplace, we believe we can implement in-world specialized tools, with platforms such as Python API, to quickly develop diagrams. Python is an extensive application programming interface (API), with many sample applications, support for both choreographing and scripting objects and events within Teleplace, and integration with outside systems (Guide, 2010).

For example, Python provides access to avatar movement and actions taken by avatars. It also enables programmatic import and instantiation of 3D models. Additionally, it provides thorough support for drawing custom 3D objects and responding to user actions, such as drag-and-drop. The native multiuser interactive whiteboard object included in Teleplace is written using the Python API.

Through the large body of existing Python libraries, integration with most types of databases, Web services, cloud computing, and legacy systems is possible; for example, for tying into Enterprise Application Integration (EAI) infrastructures. This supports applications such as virtual datacenter management and live data visualization applications. Very exciting are ideas such as linking Problem Formulator diagrams with live data.

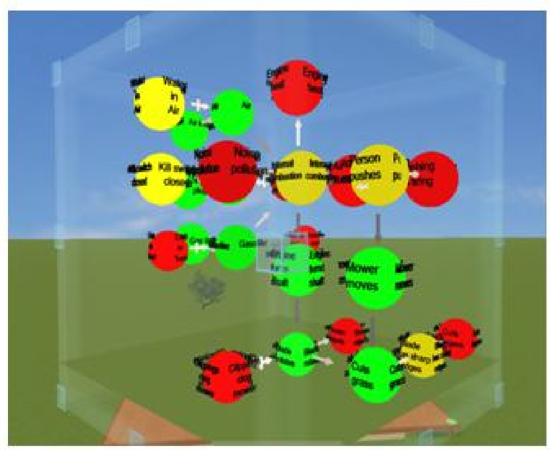

Figure 9 – A 3D problem formulator diagram on an automatically rotating "rotisserie" display pedestal

7. THE PATH FORWARD

Before determining that Teleplace is the solution, we think it would be beneficial to spend some time researching other competing environments (i.e. Second Life). With this additional research, we will learn more about the capability of 3D environments and weigh the advantages of Teleplace against other virtual worlds.

It is important that we maintain relationships between elements, case studies, and operators while working with the Problem Formulator diagrams. In a subsequent project, we need to develop standards that define these relationships and processes. In addition, we should consider developing a structure for the data (i.e. Information Objects, Information Packs, Information Network, Forums, Blog Spots, etc) to enhance collaboration and provide a platform for housing and exchanging information. An interesting idea is to link a 3D innovation workspace with an Internet-based social network built to support the I-TRIZ community. We envision being able to launch searches and queries into "community space" directly from within the 3D diagram while we are doing our innovative analysis. This could facilitate the dynamic import of information from anywhere on the Internet without having to leave the 3D virtual world.

We have learned a lot about the virtual world experience and capabilities within Teleplace. We would like to further explore the programming language and capabilities before determining our path forward using 2D versus 3D, but 3D looks like a promising future. One day soon, we will be able to not only collaborate with Thomas Edison, or rather Edison's knowledge, but any of our collaborators from across the globe in a virtual 3D collaborative space full of innovation-supporting in-world tools.

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