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Evolution Navigator
For Technical System Innovation

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Technology innovation is critical for organizational and economic development and thus has been widely discussed. In spite of the extensive research, however, the research community has made few efforts to guide the direction of innovation, considering the general evolutionary patterns of technical systems. This research has a goal to develop a way of predicting priority directions of innovation as well as creating the most promising design of practical concept design especially for technology-based products.

Nevertheless, there is limit how to find new technology opportunities using TRIZ in the context of technology management, because most of TRIZ research has emphasized case studies, not a TRIZ-based new technique. As a part of effort to link TRIZ to technology management tools, this research proposes a novel unified approach to identify technology innovation opportunities by utilizing Su-field model together with technical evolution pattern based on patent information analysis. Su-field model is used to analyze the system functions and operation principle before TRIZ techniques are applied to the map and an Evolution Opportunity Map (TEOM), which helps identify innovation opportunities, which is a main idea of this research.

During several years of field experience of TRIZ and technology evolution study, Samsung Advanced Institute of Technology (SAIT) managers and researchers had provided the author many design points of novel TRIZ evolution techniques. Mandatory requirements from top managers were ‘something useful to make a decision’ based on industry/bibliographical basis. Usually top managers are so busy persons which mean ‘something’ should be very easy to understand at a glance. I’ve got requirements from the researchers who work to make such ‘something’ with TRIZ technique. They asked me that ‘method to make something’ should be very clear and consistent with minimal time/human resource with reliability to explain it to top manager. Analyzing existing methods and requirements I defined problem statements to solve as following:

- Poor technology evolution guide based on technical information (e.g. patent)
  - Structure, operation principle design guide is insufficient
- Diagnostic oriented evolution tool
  - New direction creation as well as diagnostic
- Complicated process and result
  - Hard for Chief Executive Officer(CEO) to make decision

– Hard for researchers to complete all step during 3~4 weeks planning stage

What the author intended in this study is to provide more concrete technology evolution guide of evolutionary forecasting as well as diagnostic with instinctive/visual result as well as affordable working process. I propose inventive strategy, based on the new matrix of evolution in order to discover new technology opportunities.

Whole procedures and features to solve above problem are as following:

- A unified approach composed of system operation principle modeling, patent information analyzing, evolution direction analyzing, future technological concept design method is provided with the name of Technology Evolution Opportunity Matrix (TEOM).
- These methods are complement and practical application way of the Theory of Evolution of Matter and Models (TEMM) as part of TRIZ. Unified approach of TEOM consists of 4 step working process:
  - Step 1. Analyze system function and evaluating patent information;
  - Step 2. Develop evolution matrix;
  - Step 3. Evaluate evolution opportunity;
  - Step 4. Design/suggest a new system concept with innovative operation principle.
- Source for TEOM comes from published bibliographical information for instance, patent, journal articles, conference proceedings to enhance reliability of the based information. Bibliographical information is evaluated by evolution lines before TEOM layout.
- Output of TEOM is the evolutionary opportunity map with clear direction for further innovation of technical principles.
- Su-field model can be used for analyzing operation principle to designated evolution axis of operation principle as well as morphological analysis, function model etc.
- Evolution lines matching component of substance and field might be selected and used to designate each evolution axis.

The suggested approach was applied to the new technology generation process in SAIT, a private research centre in Korea, and verified its feasibility and utility. Using the suggested approach, task force team developed the world's first ferrowax-based LOD, winning SAIT's

Frontier Award and Breakthrough Award in 2007. As the new concept of using electromagnetic fields enables a compact LOD design, it will help extend the application areas of LOD. At the same time, technical performance was greatly improved with the valve response time less than 0.1 second (the previous performance was 30 min) and the testing cost less than 0.01 cents. A number of technical solutions were produced during the concept development process when Su-field Analysis was repeatedly applied. They contributed a lot to the innovation of LOD, some of which were published in a cover story of the best journal in the relevant field, resulting in 39 international patent applications. Performance of valve enhanced dramatically of which open time from 1800s to less than 0.1 second. Figure 18 represents final version that I and team members suggested in this project.

This LOD project ensures that the proposed approach is feasible and effective, meaning that TRIZ tools can contribute a lot to the technology innovation process. In particular, the suggested approach is distinguished compared to the other tools in that it starts with defining the conditions of the ideal state according to the philosophy of technology evolution theory and then designs a concept to meet the conditions, whereas most of the other tools try to devise a new system by way of analyzing the existing system to improve.

And so, disruptive innovation can happen with the suggested approach. However, in order to get the most benefit from the suggested approach, it is critical to both select the main drivers of system evolution, and to apply a proper evolution theory to the trend of drivers. Therefore, not only TRIZ experts but also experts with domain knowledge should participate in the concept generation process. Finally, the suggested approach is isolated from the other planning techniques such as technology roadmap and QFD in SAIT up to now, but can be more powerful if integrated with them.

First in the world, this work introduces Su-Field analysis, patent analysis as unified form for practical prediction of technology evolution. It is the world first [tangible] guide for operational technology configuration as well as product/ function design with evolution line as a ruler of axis and su-field model as technology operation principle schema based on real patent information evaluation. It is a new methodology for patent analysis with using Su-Field model and lines of technology evolution. First in the world, this work provides the R&D researchers as well as top mangers clear opportunities map of technology evolution.

Implementation of results of this research had been proved useful for all R&D work because suggested methodology takes in consideration not only abstract categories but real conditions of each technological principles. It is based on bibliographical information as well as evolution theory, therefore it can provide the researchers and decision makers to have bigger confidence comparing to just bibliographical data only or evolution theory only.

TEOM provides unified step-by-step guideline for each activity, which minimize the mistakes to apply evolution lines toward real technical system. TEOM forecast future direction very clearly based on the vector of evolution axis so, which indicates innovation direction with minimal ambiguity. Usually conventional management tools such as QFD can provide only functional or very abstract level of design scheme but TEOM can provide tangible technological operation scheme design, so field engineers shows great friendliness for TEOM after patent analysis work for their own project planning as well as novel patent drafting.

If the operation principle is abstracted as a Su-field model, non-technical operation principle evolution can be deployed following same procedure for prediction. Since 2006, 6 years pilot runs of TEOM have been conducted in SAIT and showed successful result for especially very early stage of R&D projects. The suggested approach has been applied to the concept generation process in SAIT several times, which verified its feasibility and utility.

In the methodological perspectives, the suggested approach, which indicates the direction of evolution, is different from the previous approaches that identify technology opportunities with trial-and-error. Moreover, it tries to facilitate disruptive innovation by designing a new and ideal system rather than extending existing systems. In the practical perspective, this paper describes a methodology that has been used for several years in practice. Also, the real project application of TRIZ, which is frequently mentioned as a useful tool for technology innovation but lacks detailed guidelines on how to apply it to a new technology planning process is provided and thus will ensure the practicality of TRIZ.

This research will be developed following several liens of *evolution*: Firstly, the suggested approach focuses on only two dimensions in developing a TEOM and identifying new concepts, since it addresses only the functions with the most important technical operation principle that are the keys toward innovation. An extended version of TEOM will have multiple analysis axes for complex system with the aid of information analysis software. Secondly, this research is descriptive in nature and needs to be more systematized in its procedures, being combined with

other frequently used techniques of technology planning. For example, it will be helpful to develop guidelines for matching the evolutionary patterns to the features of innovation drivers. Future research should address such issues as how to select the main drivers and how to analyze technological opportunities in a TEOM more rigorously. Finally, this research was implemented for restricted numbers of R&D. More case studies should be conducted to define the technical fields or the characteristics of technical problems suitable for the approach.

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