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New product identification and design through super-system trimming

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ABSTRACT

TRIZ device trimming has been used when components within a system are trimmed. This research proposes a novel trimming strategy and process for identifying new product concept by trimming and integrating various systems at super-system level using affinity index and Dendrogram. The 9/12-window and Scenario Analysis were used to identify potential relevant systems to form a large "virtual" system. Then components of the virtual system are transformed into an integrated system. The affinity relationship matrix is built to manifest the affinity between components in 6 different aspects. Dendrograms are then built to determine the best component set for integration through trimming. The final integrated system will have fewer components than the sum of the components within the original systems while maintaining the cumulative main functions.

The contributions include: (1) Proposing an integration process to identify multiple systems to be integrated into a more functional system yet with less components; (2) Proposing a mathematical technique to assess the likelihood for integration of component groups, assisting users in identifying the priority for trimming. This will also make the trimming process more objective instead of relying on human individual judgement; (3) Extending the traditional scope of TRIZ trimming from within system to super-system integration.

1. Introduction

Ideality of any system defined by Altshuller in TRIZ (Theory of Inventive Problem Solving) is total benefits of a system perceived by a customer divided by total cost and harm generated by the system. It is the widely accepted criterion for a user to judge a system when making a purchase decision.

Trimming is a method of deleting components while increasing product ideality to undergo innovation. It allows the system to create a product at a lower cost while still fulfilling the customer's requirements. Studies have shown that more than 90% of engineers solve problem either by replacing component or by adding components to solve product problems and fulfilling customer requirements rather than removing components from the system. Even in the trimming situations, all methods are focused on trimming within the system to resolve problem or deduce costs, etc.

Trimming problems can be categorized into two types: Product-Based Problems and Process-Based Problems. Product-Based Problems is to trim components in order to achieve its goals such as solving product problems, reduce costs, or circumvent a patent. Process-Based Problems refers to removing processes to achieve its goals such as removing problems/operations or saving costs. The great majority of trimming are product-based within a system. That is, to trim components of a target system. Sheu and Ho developed a set of device trimming method for system level component trimming with substantial impact (Sheu & Hou, 2012).

This research is regarding a systematic approach to identify multiple systems outside the current system, have them merged with less components while keeping the total functionality of the multiple systems the same or improved. By doing so, several advantages can be achieved: (1) The set of approaches can be used to systematically identify new products by merging various systems at the super-system level; (2) the resulting system will have less total number of components and occupy less space than the cumulative non-integrated systems with same or better benefits. That is, the resulting system will have better Ideality for customers; (3) it provides guidance on how to identify more likely components for integration and trimming at the super-system level instead of regular system level.

2. Background

In the Innovation-TRIZ Newsletter, (Hipple, 2010) stated that the most effective tools in TRIZ are Trimming and Upward System

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Integration. It can be done by observing the system, identifying the lost functions, and linking the needed functions to external system using the super-system resources. Li et al. (2009) proposed the products innovation based on four types of function integrations. They are: integration of the same function, integration of similar functions, integration of opposite functions, and integration of different functions. TRIZ can be used to integrate similar, the same, opposite, and different functions to generate a new system with the expected functions, creating a complementary action, or producing more accurate control. Wang and Ma (1997) defined "Innovation from combination" as the process of uniting two or more technical elements to produce a new product. The elements of integration include materials, components, processes, structures, etc. The concept of combining technical elements is practically doable. However, there has not been any specific process to systematically identifying and integrating those elements.

The current method of trimming is at the system level. On the contrary, the proposed method in this paper provides concrete ways to deals with super-system integration and trimming. It has below usage: (1) providing methods to identify suitable systems for integration and super-system trimming. This is a method of identifying innovative new products for development; (2) when the products are very simple with few components, it is very difficult to trim an already simple system. Therefore, it makes sense to integrate multiple systems at the super-system level to form a system capable of performing integrated functions while, through trimming at the super-system level, make the resultant system to use less components.

3. Research methods

3.1. Overall process

Refer to Fig. 1. The overall process of identifying new products through super-system trimming can be described as follows:

Stage 1: Identify and select target systems in the super-system for potential integration. 12 Windows and Scenario Analysis tools are used to identify potential systems for integration. Verify utilities of the selected systems. This is explained in Section 3.2.

Stage 2: Perform Component Analysis for all systems selected as target for trimming and integration. By breaking down all the first level of components for each super-system, potential components for trimming and merging are exposed. Details are explained in Section 3.3.

Stage 3: Calculate affinity measures for each component pairs of all relevant systems. The affinity indices represent the suitability for the corresponding components to be integrated or merged. The higher the affinity between two components, the more suitable that the two components can be merged. Definition of affinity index between any two components, regardless if they were from the same or different systems, are calculated based on six aspects of indices. They are: Function similarity, Time Compatibility, Space Compatibility, Material Compatibility, Connectivity Closeness, and Product Hierarchy Closeness. The affinity sub-indices from each of the above-mentioned categories are weighted and added to form the final affinity index between each pair of the components. These indices are indications for integration suitability. The strategy is that the components of higher affinity indices are better suitable for merging and integration through component trimming. Definitions for those indices are explained in Section 3.4.

Stage 4: Establish dendrogram for grouping and ranking of the affinity indices. A dendrogram is a representation map of affinities between components showing the "closer" components being putting together for merging and integration. The dendrogram is used to identify compo-

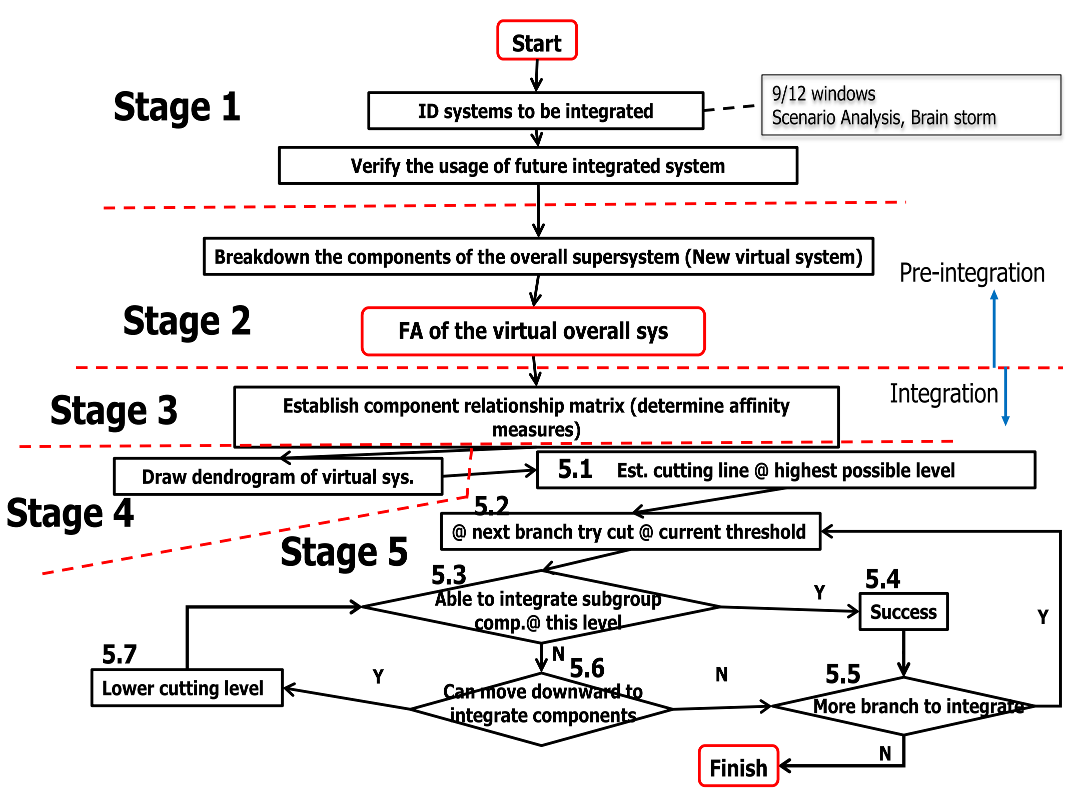

Fig. 1. Overall product ID and trimming process.