Similarity between TRIZ Principles

He Cong, Loh Han Tong
he.cong@gmail.com

Developed during the initial patent research by Altshuller and his colleagues, the 40 Inventive Principles (IP) [1, 2[1]] are one of the most important tools of TRIZ. As a basic tool of TRIZ, the IP were always introduced as the first concept to new comers to TRIZ. With the increasingly popular application of TRIZ in recent decades, experts have summarized numerous examples about application of IP in different technical and non-technical fields [3]. However, some criticisms have also been given upon the original list of Principles: they are too abstract and sometimes overlapped with each other [4]. In recent research, the relationship between IP has been analyzed. In 1998, Williams [5] analyzed the symmetry and asymmetry of IP and summarized several groups of Principles that are opposite to each other.   In 2002, Mann [4] proposed a 5*3 matrix to group most of the Principles into five different strategies by the space-time-interface entities.

In [6], an automatic patent classification system based on 40 IP has been proposed and analyzed upon a small set of patent documents. Elaborating on the idea of automatic patent classification according to IP, this paper analyzes the similarity between Principles based on the text information in the descriptions of examples using the Principles. 6 of 40 Principles are defined as 'Obscure Principles', which are hard to be analyzed by automatic classification system. In addition, two kinds of similarities between Principles are defined in this paper: text similarity and meaning similarity.

1. Text analysis of IP

1.1 Obscure Principles vs. Distinct Principles

As mentioned earlier, our analysis of Principles is based on the text information used in the descriptions of inventions. It is necessary for automatic patent classification according to IP in order to be able to assign the invention correctly. During our research, we found that for some Principles (34 of them), there are obvious descriptive text information, which hints at the Principles used. These Principles are defined as "Distinct Principles" in this paper. For instance, if an invention uses Principle 25, "self-service", its patent description usually mentions the text information such as "self-".

However, for the other 6 Principles, there is little text information that points towards the Principles used and inventions using such Principles share few similar or common words. These Principles are defined as "obscure Principles" in this paper.

Table 1   Obscure Principles

Obscure Principles[2]	Analysis
2	If #[3]2, extraction, is used, usually the descriptions only describe the extracted objects or systems, without specifying the relationship of extraction using obvious text information. e.g. • *Use the sound of a barking dog as a burglar alarm (the sound of the dog is extracted from a physical dog, thus we could get the benefit of the alarm without*

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[1] Translated from the original works of Altshuller in Russian, different English versions of 40 Principles were compiled by different authors. Although the basis idea is the same, there is small difference such as the way to split one Principle to several sections. To be consistent, we choose these two lists, to which all descriptions about the Principles in this paper refer.

 The analysis on TRIZ Principles in this paper is only based on English descriptions.

[2] Please refer to [1, 2] for details of descriptions of each Principle.

[3] "#" represents Principles.

	the difficulty of feeding, exercising, training, etc, but there is no clear text that describes this) • *Non-smoking areas*
3	The general idea of #3 is to enable local parts of a system to perform locally different or optimized functions. However, little distinct text information for this is contained in the example descriptions. e.g. • *Freezer compartment in refrigerator* • *Lunch box with special compartments for liquids.*
12	This Principle emphasizes on changing the conditions to achieve a certain effect. However the example description usually describes the condition after being changed, with little obvious text information about the relationship of changing.
13	The general idea of #13, inversion, is to make an object or action upside down. However, the example descriptions seldom specify the "upside down" relationship between two objects or actions. They instead directly describe the object or action after being changed. E.g. • *Cool the inner part (instead of heating the outer part)*
17	It is hard to cluster the examples using #17. To understand #17 needs deep analysis. e.g.(It's impossible to see from the examples text description itself that this principle is being applied.) • *Five-axis cutting tool* • *Infrared computer mouse* • *Cassette with 6 CD*
24	Documents involving #24, intermediary, usually do not specify that an object is used as an intermediary. They instead describe the usage or functions of the object. (no obvious text information) Furthermore, the intermediaries used in different inventions are not supposed to be the same or similar. (no common or similar text information shared) e.g. • *Play a guitar with a plectrum;* • *Joining papers with a paper clip.*

1.2 Text similarity

The descriptions of inventions using some Principles share superficially similar text information which is distinctive to identify a group of Principles but is hard for an automatic classification system to differentiate among the group of Principles. For example, "pre-shrunk jeans" uses Principle 9 (prior counteraction); "pre-deposited blade in a surgery cast facilitates removal" uses Principle 10 (prior action) [2]. The descriptions of both examples, like many typical examples using these two Principles, share similar text information like "pre", which is a typical descriptive text information for both Principles 9 and 10. However, deeper understanding is needed to differentiate between Principle 9 and 10. Groups of Principles like this are defined as "Principles with Text Similarity" in our paper. Other groups of Principles with text similarity are listed as in Table 2.

As shown in Table 2, the same Principle might appear in different groups. E.g. Principle 7 has relationship of text similarity with Principle 31: when Principle 7b is used, i.e. "an object passes through a cavity of another object", the description usually contains words like "cavity" or "pores" which are highly likely to appear in the description of a patent using Principle 31. However, another sub-Principle of Principle 7 is similar to Principle 30: when Principle 7a (an object is contained inside another one) is used, words like "inside", "outside" or "wrap" are usually contained in the descriptions, which appears when Principle 30b (an object is isolated from outside environment) is used. Like

Principle 7, most IP are subdivided into several sub-Principles to describe different ways the IP is implemented. Although these sub-Principles share a common macroscopic idea of the Principle, each sub-Principle has its own particular emphasis and the sub-Principles have a subtle difference with one another within the same broad IP. Therefore, the similarity between Principles is not necessarily transitive. For example, #7b is similar to #31; #7a is similar to #30. But #30 is not similar to #31. In total, 19 different Principles are contained in the 10 groups of Principles with text similarity.

Table 2   The Principles with text similarity

Principles	Similarity	Examples of similar text information[4]
1, 5, 6, 15b	#1 is about "segment"; #5 and #6 are about "merging". The words like "multiple" are contained in many patents using the three Principles. e.g. *#1, Multi-pin electrical connectors (US Patent Number 6,139,373);* *#5, Multi-color multi-point recorder (US Patent Number 4,343,007);* *#6, Multi-purpose knife (US Patent Number 6,006,433)*	"multiple", "section", "segment"
7, 31	#7, "make one part pass through a cavity in the other"; #31, "make an object porous", "if an object is already porous, add something useful into the pores". [2] It is highly possible that the words like "hole" are contained in the description of both Principles	"hole", "cavity"
9, 10, 11	All of the Principles are about implementing some action in advance. E.g. *#9, Pre-shrunk jeans* *#10, Pre-deposited blade in a surgery cast facilitates removal* *#11, Put an air-bag in a car in advance*	"pre-", "prior", "in advance"
8, 29	#8b, use "aerodynamic or hydrodynamic forces"; #29, use "pneumatic or hydraulic construction". [1] Both Principles involve something aerodynamic (or pneumatic) and hydraulic.	"aerodynamic", "hydraulic"
35, 36, 37	#35, parameter change [2], emphasizes on the facts of phase change (35a), temperature change (35d) or other parameters change; #36 and #37 emphasize on using the effect of phase transition. All of them are about phase changing. Usually if #36 or #37 is used, #35 is involved. (*Editor's note: 37 involves change of dimensions as a function of temperature, usually without a structural phase change*)	"temperature", "freeze", "thermal"
26, 28	#26b, replace an object, or action with an optical copy; #28a, replace an existing means with an optical system. [2] The "optical copy" involved by #26b is the copy of the "object", while the "optical system" involved by #28a replaces "existing system" and is different in nature from the former system. Although the deep meaning of both Principles is different, the common words like "optical" appear in many descriptions using both Principles.	"optical"
27, 34	#27, cheap disposable; #34, discard and recover. [2] Both Principles involved the idea of disposing or discarding something after fulfilling its functions.	"reject", "disposable"
7, 30	#7a, contain an object inside another, which in turn is placed inside the other; #30b, isolate an object from the outside environment with a thin film or fine membrane. [1]	"inside", "outside", "wrap"

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[4] The words listed here are only part of the similar text information. The words listed represent different word forms. E.g. "section", "sections" and "sectional" are all represented as "section". In our automatic classification experiment mentioned later, no phases are considered. Therefore, we only list the words here although similar phase

	Both Principles involve the position relationship of several objects: one is outside and the other is inside. The similarity between them is not very strong.	
29, 38, 39	#29, use air for inflation or cushions; #38, replace normal air with air, etc; #39, inert environment. [1] The words like "air" are contained in many descriptions of inventions using the three Principles.	"gas" "air"

1.3 Meaning Similarity

Some Principles partly overlap with others. E.g. Principle 25b, "make use of waste material and energy" is similar in nature to Principle 22, "convert harm into benefit". E.g. the main idea of the patent example, "waste heat conversion system" (US patent number 6,450,283), is to use waste heat energy and convert useless or harmful energy to benefit. Both Principle 22 and 25b can be used. We define such Principles as "Principles with similar meaning". Another group of Principles with meaning similarity is 13.b and 15.c.

Principles	Similarity
22, 25b	*Principle 22: convert harm into benefit;* *Principle 25b: make use of waste material and energy;* Both Principles are about "converting harm or waste into benefit".
13.b, 15c	*13b, Make object a moving part, or make nonmoving part movable and outside environment immovable;* *15c, if an object is immovable, make it movable or interchangeable;* 13.b contains 15c

2 Conclusion

In this paper, based on text description of inventions, we have divided 40 IPs into different categories. We have listed 6 'Obscure Principles' and 34 'Distinct Principles'. Then similarity between 'Distinct Principle' is analyzed. In Table 1 and 2, we have summarized 10 groups of IP with text similarity and 2 groups of IP with meaning similarity. This work will contribute towards the possibility of automatically classifying patent documents according to IP: the documents using 'Obscure Principles' are hard to be identified using superficial text information, thus hard to be automatically classified; however, the documents using 'Distinct Principles' are usually described by clear and similar text information, thus they are relatively easier to be automatically classified. However, the similarity between IP makes classification between similar IP hard and IPs may need to be clustered into groups.

To achieve automatic classification, based on the work done here, it is possible to analyze the text description of an invention and broadly classify the invention into a group of possible IPs if the IPs involved are distinct ones. However, research needs to be done to realize how to do so to the level of individual IP as well as how to treat Obscure ones.

Acknowledge

Reference

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About the Authors

He Cong is currently pursuing PhD in Department of Mechanical Engineering from the National University of Singapore, focusing on text mining and TRIZ. She has received her Bachelor in Engineering from the Huazhong University of Science and Technology in China. She can be reached at g0301107@nus.edu.sg.

Loh Han Tong received his Bachelor in Engineering from the University of Adelaide, his Master of Engineering from the National University of Singapore (NUS) and his Master of Science and PhD in Mechanical Engineering from the University of Michigan. He is an Associate Professor and Deputy Head in the Department of Mechanical Engineering at NUS. He is also a Fellow of the Singapore-MIT Alliance, which is an innovative engineering education and research collaboration between MIT, NUS and the Nanyang Technological University, to promote global education and research in engineering. His research interests include data mining, rapid prototyping, robust design and computer aided design.