

DIRECTED VARIATION: VARIATION OF PROPERTIES FOR NEW OR IMPROVED FUNCTION PRODUCT DNA, A BASE FOR ‘CONNECT AND DEVELOP’

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“The lexicon is really an appendix of the grammar, a list of basic irregularities”

Bloomfield (1933)

Abstract:

This paper builds up a procedure to connect previously unrelated domains in order to transfer existing knowledge to a given guest domain. The connections are based on properties: (what is or has) and functions (what does or undergoes). The abstraction of any system in its property – function strings reveals a system or ‘product DNA’ a base for charting out innovation directions as described in Directed Variation®. Based on product DNA, related domains and/or products can be identified that act as a source for knowledge transfer. Combining the strengths of language technology and directed variation, the process can largely be automated.

The process brings a new capability of TRIZ-based methodologies; the theory behind it is explored in this paper.

Keywords: properties, functions, directed variation, TRIZ, product DNA, computer aided innovation

1. Introduction

The methodology of TRIZ is rooted in the comparison of domains, products and systems, whilst extracting patterns for problem solving and idea generation. The way ‘how’ relevant domains are identified in order to connect to an existing domain is documented in this paper. This paper proposes a base for connection between products, processes and systems based on the comparison of their properties and functions. DNA is a breakdown of a system in genes (which represent properties) that are combined into amino acids that shape a protein, being the function. This model in abstract fits the theory of directed variation, through which the concept of ‘Product DNA’ was deduced.

What is brittle, shaped like a plate, transparent, mainly used to look through while insulating rain and wind. Not very difficult to find the riddle as ‘window’. By listing up properties of a system, one can distinguish one object from another. According to Princeton Wordnet (1) a property is an attribute, dimension (a construct whereby objects or individuals can be distinguished). This is the first part of our product DNA string. Secondly, adding the main use of the system ‘to look through’, brings the function, purpose, role or use (what something is used for) (1). In order to connect a ‘window’ with other products or systems, commonality is needed. A window is as transparent as glasses or it is as brittle as ceramic. Through the first connection, one could transfer the self shading glasses into windows, or add some strengthening coating developed in the ceramic area. A function connection also exists with glasses as both windows and glasses are made to look through. One might think of changing the optical properties of the window, similarly to corrective glasses, to see further through the window.

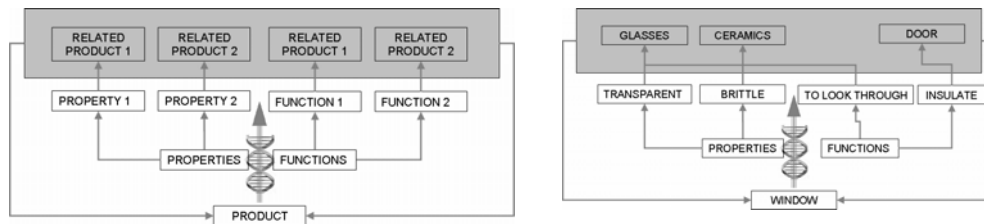


Fig. 1 General model for connection through property or function (left) . Example procedure for windows (right)

Figure 1 shows the basic model. Extracting abstract properties and functions from a product or system brings generic terms. These terms can connect to products or systems that abstract in a similar way. The connected products are surrounded by knowledge or technology (specifications, patents, ...) that can be transferred to the product or system of interest. A connection is defined as a relation between things, where as a relation is defined as an abstraction belonging to or characteristic of two entities or parts together. (1)

2. TRIZ Relation - Directed Variation

TRIZ relation –Trends

Genrich Altshuller's work relates to some 8 -12 original patterns of evolution in patents. Work at CREAX proposed 19 newly identified trends (2). The patterns (also referred to as trends of evolution), describe a path of changing property. An example of an original pattern can be *solid-hollow-porous-capillary- (active capillary)*. An example of a newly proposed pattern can be *opaque – translucent – semitransparent – transparent – (active transparent)* (2). These patterns uncover nothing more than paths of changing property, porosity and transparency in the quoted examples. This insight provides an efficient opening to identify eventual remaining patterns, just by evaluating all possible properties. Moreover, the finding reduces the trends to changing properties of systems or products. The approach has led to the development of the Directed Variation® method (3).

Some TRIZ patterns combine two properties. For example 'Dynamisation' combines flexibility with state, 'Object segmentation' combines fragmentation with state and 'Controllability' combines 'amount of information' with 'degree of automation'. Directed Variation has purified these patterns into single property patterns (3).

Changes in properties relate to changes in function of the product or system. This relates to 'benefits' (2) in trends of evolution, and will be elaborated below.

TRIZ relation – Principles

One of the oldest tools in the TRIZ methodology are the 40 inventive principles (77 including Special and Combined (4)). All principles, except 22 'Blessing in disguise' and 13 'The other way round' fit into a property change. For example 'self-service' → *automation*, 'hole' → *porosity*, 'dynamisation' → *flexibility*. 22 and 13 are more related to the thinking mechanism of a creative attitude. Reducing both principles and trends to property changes, reduces the tool to a straight forward procedure, being much more accessible to any

engineer. The relation between principles, trends and standards (discussed below) is thereby defined by their abstract relation to property changes. The theory of '40 inventive principles' is hereby greatly challenged through this checklist of property changes (much more than 40, example 'temperature'), elaborated in Directed Variation.

TRIZ relation – Conflicts and contradictions

Thinking in conflicts and contradictions has been a great contribution of Altshuller's theory and constitutes an axiom of TRIZ. Be it through the contradiction matrix, matrix 2003 (4) or thinking in physical contradictions, the process indicates conflicting requirements can be solved using a set of inventive principles. Referring to both paragraphs above, a conflict can be expressed in 'conflicting properties'(5). The resolution of conflicting properties is reduced to changing a property, which is linked to Su-fields below. E.g., strength conflicting with weight can be resolved changing fragmentation, homogeneity or porosity.

TRIZ relation – Function database

As accessible through a free web resource (6), knowledge can be classified by function (rather than alphabet). This classification opens a wide range of solutions for a challenge function. The classical example: *In how many ways can one empty a glass of water without touching the glass?* A brainstorm brings use a straw or heat the environment, or just wait. The function database answers with 48 ways to move a liquid (6). In order to achieve this function, a property needs changing. Directed Variation® indicates that 10 properties can be changed to achieve this function. I.e. porosity (+ concentration) includes solutions like osmosis and absorption or temperature (+ pressure) includes boiling and evaporation. All 48 solutions can be classified within these 10 property changes.

TRIZ relation – S- Fields

S-fields analysis suggests changes in a substance i.e. changing a property of a substance, adding a new substance i.e. adding a substance exhibiting different properties to the whole system or adding a field (state change). The completeness here of a working system relates to completing the necessary properties for the required function. Again this is part of the Directed Variation theory as it comes down to changing properties and thus functions.

3. Directed Variation®: the basic process

Through Directed Variation® CREAX aims to reduce most tools of the TRIZ methodology to a straightforward procedure (7). In itself, this is more of enrichment than reduction as the tool can now be expanded to any domain, and brings a much more accessible framework for the inventive engineer. This, as any domain is defined by its specific properties and functions.

As clarified above, most of the functional tools of TRIZ can now be summarized in a negotiation of properties of a system, for new or improved function. Rather than describing 'changing property paths' or the TRZ trends of evolution, Directed Variation® identifies pure property spectra. A property spectrum depicts the variety, range or scale in which a property is variable. Take the property spectrum 'state', this includes properties *solid – liquid – gas – field*. A summary of the method (8) is given in Fig 2. below:

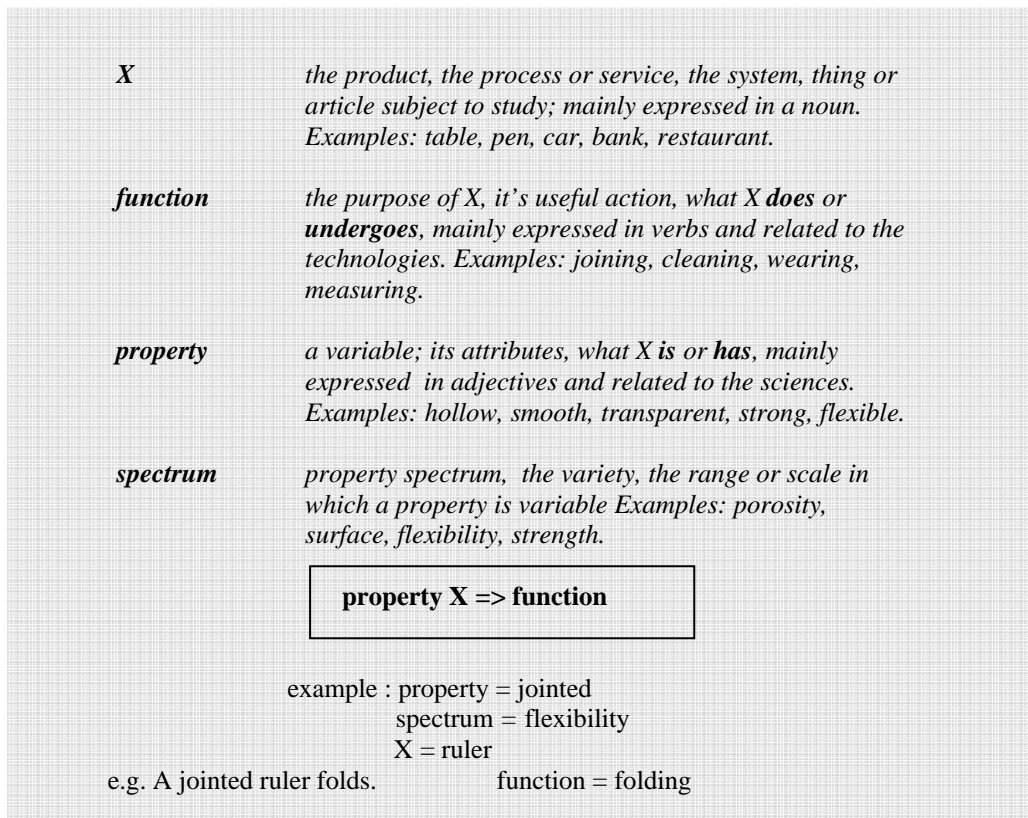


Fig 2. Basics of Directed Variation

The beauty of the system is that whilst the relation between a property and a function is solid, it is independent of products. This abstraction gives the ground for connecting products, systems and/or technologies (3). Any transparent system connects the function ‘to look through’, any jointed system connects ‘folding’, any protruded system connects more surface or grip. This allows the construction of idea generating matrix texts in which the variations are connected to any product, to be interpreted by the reading engineer (3). An example formulation is given below in Fig. 3.

*Your porous **PRODUCT** is easier to transport as it reduces the weight.
Your hollow **PRODUCT** can contain a related substance. Making your
PRODUCT flexible or jointed allows you to fold or direct your **PRODUCT**
to be more precise or compact. A protruded surface on your **PRODUCT**
gives more surface area which can provide better heat transfer of grip.*

Fig. 3. Extract of idea generation matrix text; fill in any product (3)

4. Product DNA® – graphical representation

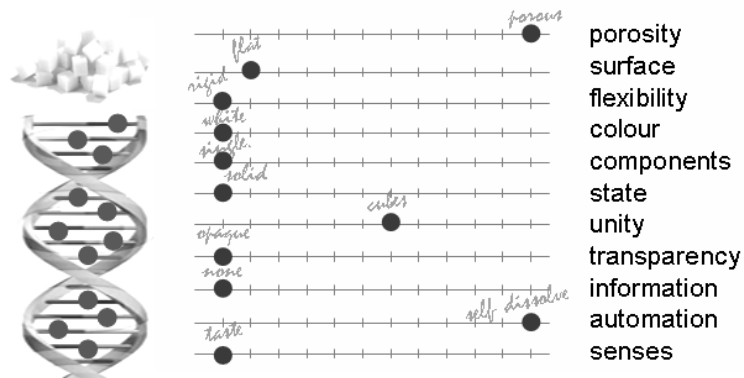
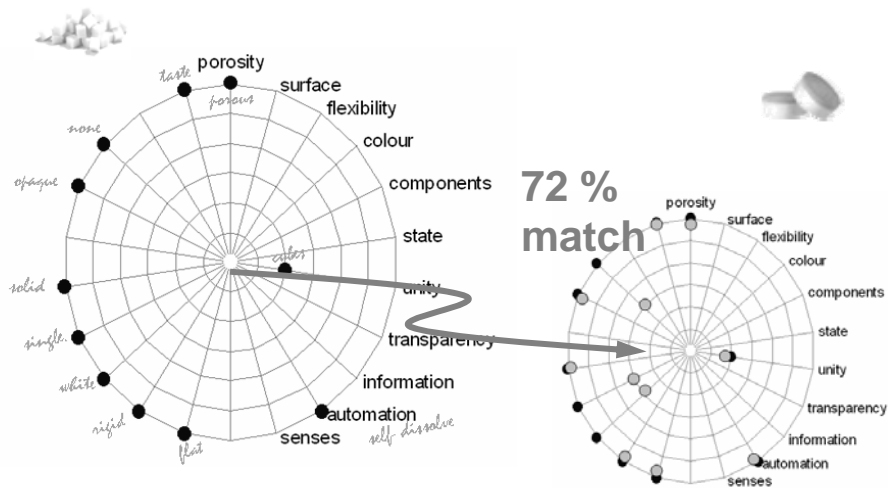


Fig 4. Product DNA real and stretched out

As an example, consider sugar cubes. If property spectra porosity, surface, flexibility, and some more as shown on Fig 4 above are stretched out; one can indicate (dots) the specific properties of our product ‘sugar cubes’. Again, looking at the Product DNA above, combined with its main function, sugar can be identified as a riddle. Below (Fig. 5) is a top view of Figure 4, whilst every spectrum is twisted 16 degrees. The map can be used as a base for connection. Through a Product DNA search in patents, medical products, chocolate pellets, ice cubes, effervescent tablets and dish wash tablets appear as connected.

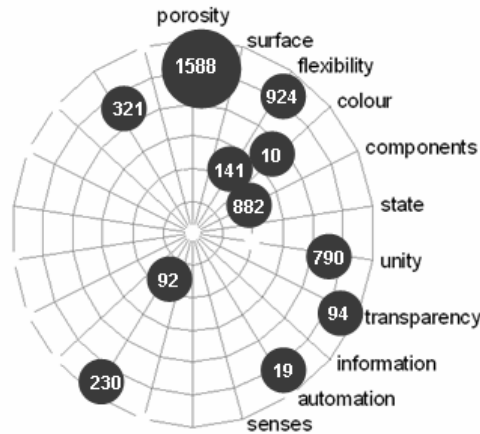


**Fig 5. Product DNA sugar; view from above.
Right: Product DNA of a close match, dish washing pallet**

Figure 5 (right) shows a 72% (8 of 11) matching connection: dish wash pellets. The 28% mismatch of dish wash pellets is inspiration for the sugar cube, for example, add a second layer with milk powder,(components), indicate the difference with colour (colour and information). By evaluating the range of dish washing products, their variations may inspire liquid sugar pads or liquid/spray dispensers. Since these new variations have solved problems in their area, they can solve similar problems in sugar, as for example liquid sugar dissolving faster. Other domains above bring effervescent sugar cubes or sugar ice cubes for ice coffee as further examples. These examples show that the property or function connections, that are schematically depicted in Fig. 1, form ideal connections for comparative innovation. Since these related domains can be identified by computer algorithms, the searches are unbiased by human knowledge and thereby often create many unexpected solutions.

5. Computer aided Creativity, data mining through directed variation (patent pending)

A small but important finding, whilst remembering Bloomberg's quote on top of this paper, a good structure for automated data mining was uncovered. Since properties are not really listed in patents, language structure brings distinction. A property is what a product is or has, i.e. a transparent window, a hollow window, a brittle window or a double window. Each property here is expressed as an adjective, a property-adjective. Some exceptions are verbal adjectives, breakable glass or cleanable glass, mainly ending with -able. Nevertheless, by searching adjectives, one can distill all related properties of a system. An example case was described in reference (8). An adjective is moreover defined as a word that expresses an attribute of something (1) Adjectives, properties are related to the science of the system. The functions of a system are, for example, holding, cutting, cleaning or draining; they are described through verbs. Verbs are defined as a content word that denotes an action or a state (1). By charting all verbs connected to a system, one can structure all related functions. In order to research property-function connections, adjective-verb relations are investigated.



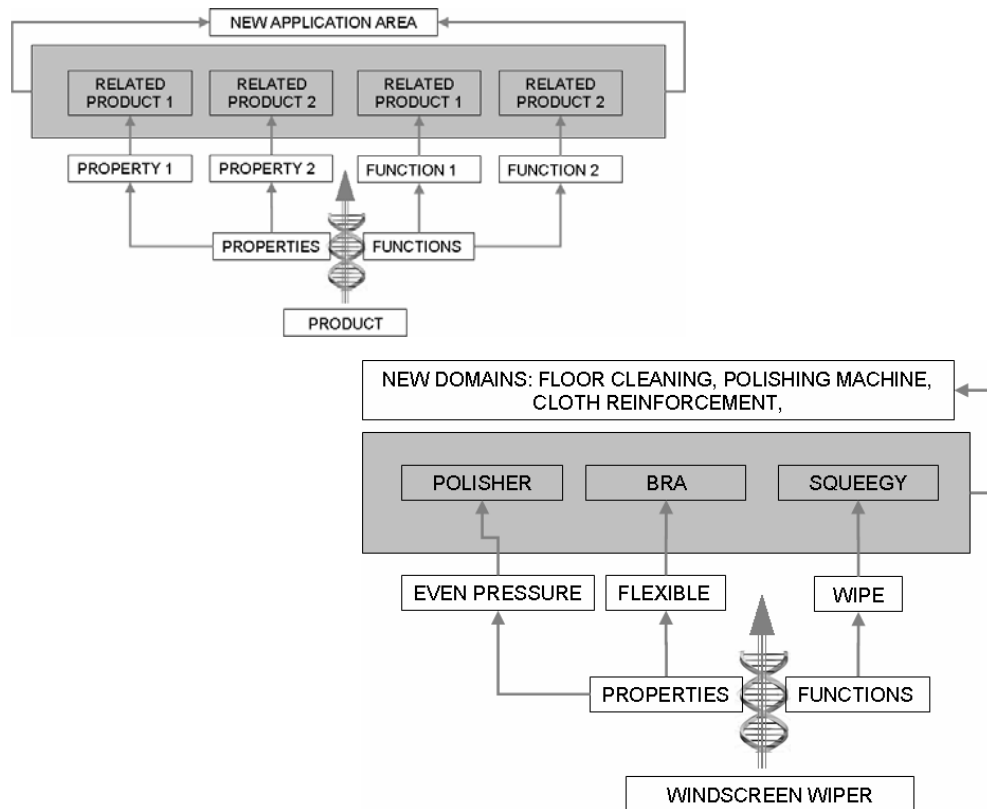
**Fig. 6. DIVA generated property plot of propeller patents (limited patent pool)
Numbers depict amount of patents, position show the variation.**

Figure 6 illustrates an automated search (9) identifying the patents that describe propellers with distinct properties. The survey indicates 94 transparent propeller patents, 94 fully flexible propeller patents, 230 smooth propeller patents and 92 surfaced ones. The main patented area appears as porous propellers. If this search is segmented over time, one can evaluate the evolution of the propeller design, similarly discussed in reference (8) on piston rings.

An important input is related to the 'not patented' properties, for example no patents were identified on scented propellers, where one could imagine its use in air conditioning systems.

6. Solution Marketing: systematic identification of new markets for existing products

Starting from Product DNA, one can identify by every property and their connected functions, which other domain requires the product. The sugar example property self dissolving in water has been used in road construction. The sugar being mixed in the concrete, dissolves with rainfall, giving the necessary porosity to drain the water. Also in concrete the emulsifying property of soy peal is used to create a more homogeneous concrete. Referring to the paragraph above, this process can largely be automated and has successfully been applied in raw material industry. General process in Fig. 7.



**Fig. 7. Solution Marketing process based on product DNA
Example from windscreen wiper to floor cleaning**

7. Conclusion and application of Directed variation®

In order to connect two items, they have to have similarities, as defined above. Properties and functions form a string of product DNA. As shown below.

Property to function (first 2)		Function to property (first 2)
Porosity: 1. contain 2. cool		Transport: 1. porosity 2. unity
Surface: 1. hold 2. cool		Hold: 1. surface 2. shape
Flexibility: 1. fold 2. hold		Store: 1. flexibility 2. unity
Transparency: 1. view 2. inspect		View: 1. color 2. transparency
Shape: 1. assemble 2. fit		Assemble: 1. unity 2. porosity
State: 1. dissolve 2. flow		Dissolve: 1. state 2. unity

Fig. 8. Linked property – function relationships in Directed Variation

The first column illustrates a process starting from each property and changing that property, to gain new or improved function. For example, hollow sugar can contain something (10). The right column is the opposite process. Knowing the desired function, what properties should I change; i.e. if I want the sugar to dissolve, change property state to liquid sugar, or unity to finer powder sugar.

Related to the TRIZ methodology, Directed Variation® brings a measurable, rigorous approach to innovation. The proposed methodology transforms the functionality of TRIZ tools into basic property-function relationships.

Through the use of language technology, Directed Variation® allows automation in property-function searches. This enables to identify related products and technology domains that can act as inspiration for product or system innovation.

Through properties and functions of an existing system (Product DNA®), new markets can be identified that require those properties and functions. The research can be largely automated.

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