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EXTENSION OF FUNCTION MODELING TO NON-TECHNICAL SYSTEMS

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Abstract

TRIZ-based Function Analysis is one of the most widely used TRIZ techniques which provides modeling technical systems in terms of physical interactions and defining functions of the system's components based on these interactions. While the technique has proven to be successful during numerous cases, when applied to modeling social (business) or knowledge and information-based systems its use appears to be less successful due to some mistakes and confusions which result from mismatch of physical and non-physical components. The paper presents several suggestions regarding extension of Function Modeling which is a part of TRIZ-based Function Analysis to better model non-technical components.

Keywords: *Function Analysis, Function Modeling, TRIZ for non-technical applications*.

1 TRIZ-based Function Analysis

To make a difference between technical and non-technical systems, one can say that non-technical systems focus on processing knowledge and information rather than material or energy. Nevertheless, in modern days it is difficult to find a business that would not involve technology means even for completely non-technical business, for example, insurance or banking services. More and more companies use digitalization to support their processes as well as to increase both efficiency and productivity.

TRIZ-based Function Analysis (often mentioned as "*Value Engineering Analysis*") was developed in the 1980s [1], [2] and has been applied as one of core TRIZ tools in most of TRIZ projects since.

The original version of TRIZ-Based Function Analysis demonstrated long-term success and became a "standard de facto" analytical tool in TRIZ. For example, its version developed by company GEN TRIZ is a part of MATRIZ training curricula [3] which must be learned in order to become certified in TRIZ. From time to time, further improvements of its original version are suggested [4]. Function Modeling is a core of TRIZ-based Function Analysis.

A key concept which differentiates TRIZ-based Function Analysis from other ways of function modeling is a way in which an elementary function is modeled and presented. According to [3], a function is a result of physical interaction between two components which depicts change or maintenance of a certain parameter of one of the components (a "target" component) by another component ("function carrier").

Modern TRIZ-based Function Analysis is a universal tool which is used in following type of projects but not limited to:

- Function-Cost optimization of a product or a process (also known as "Function-Ideal Modeling" and 'Trimming").
- Clarification of functionality within a problem zone.
- Problems discovery and ranking.
- Anticipatory failures forecast.
- Patent circumvention.
- Function-Oriented Search.
- Disruptive innovation opportunities discovery.

While majority of applications of TRIZ-based Function Analysis have been done in engineering and technology areas dealing with processing material ot energy, it is obvious that the tasks mentioned above are important for systems from other ares as well: business, social and so forth.

Below we will introduce our suggestions on updating the original TRIZ-based Function Modeling to better model non-technical components and functional interactions. Note that this paper only focuses on the aspects of function *modeling* and does not cover changes in other stages of TRIZ-based Function Analysis which remain the same as in its original version.

2 Original Function Modeling: Shortcomings

First, one must note that the shortcomings presented below have low relevance during "classical" use of Function Modeling: when it is used to model technical (engineering) systems. Most of problems emerge during business or IT applications of Function Modeling.

During recent years, there were many attempts to apply TRIZ approach to model functions in non-technical systems. Unfortunately, most of the attempts that we can find in the publications, although produced rather acceptable function models, contained the following typical mistakes:

- Incorrect definition of functions (e.g. using parameters as function targets).
- Joining several critical functions to a single function.
- Misidentifying a critical component but using it as a part of a function instead.
- Incompleteness of a component model: critical supersystem components might be missing.
- Missing critical functions.
- Messing up goals and functions.

In turn, confusion during function modeling process can often be caused the by following typical reasons:

- Too abstract descriptors of functions (e.g. "transport" vs. "move").
- Uncertainty what to do with information flows (e.g. during control, measurement, or

detection).

- Uncertainty how to deal with functions in digital devices (storage and processing of information).
- Uncertainty how to deal with different kinds of functions in hybrid systems (e.g. IoT).
- Uncertainty how to deal with function modeling of business, management, and organizational systems which include non-material components.

3 Proposed Extensions of Function Modeling

3.1 Tangible and Intangible Components

The suggestions below in this paper propose to extend function modeling with intangible objects as well as introduce several extra categories of tangible and intangible objects.

The Manual [3] identifies that the components of a function model must be material components: "*The components of an Engineering System are always material objects. A material object could be a substance, a field, or a combination of both. Substances, such as water, an automobile, and a toothbrush, have resting mass. On the other hand, fields, such as an electric field, magnetic field, and thermal field, do not have resting mass. Fields enable interactions between two substances*."

Such definition is perfectly valid for physical system dealing with processing of material and energy. However, in non-technical systems intangible objects can participate in interactions and deliver functions as well. These can be such components as "price", "advice", "opinion", etc. since they can affect parameters of other system's components. Table 1 shows some types and examples of components in the extended version of Function Analysis.

Table 1

Types, Classes and Examples of components during Extended Function Analysis.

TYPE	CLASSES	EXAMPLES
Tangible system and supersystem Components	People, tools, elements of infrastructure, material documents, etc.	Postman, operator, car, scanner, receipt, planning system, warehouse, client, package, address label, cash, database, …
Intangible system and Supersystem Components	Data, information, knowledge, decision, reaction, emotion, etc.	Price, opinion, data, data flow, specific order, (verbal) report, …

In the original Function Modeling, we distinguish between two types of components: all components (system and supersystem) and Target component of main function. It is proposed to extend with three more types of components: 1) Intangible component, 2) Module for storing or processing data/information/knowledge, 3) Human component. Table 2 shows examples of such components and shapes proposed for better visualization of function models presented in graphics format.

Table 2

All types of components during Extended Function Analysis.

TYPE	EXAMPLE
Module for storing/processing Information/knowledge/data	Database
Immaterial component (data, information, opinion, advice, etc.)	Advice
System tangible component (from original FA)	Scanner
Super-system tangible/intangible component	Client
Target Component of Main Function (tangible/intangible)	Parcel
Human	Operator

Figure 1 shows an example how a function model can be made more detailed and expose more functions when an intangible component is introduced.

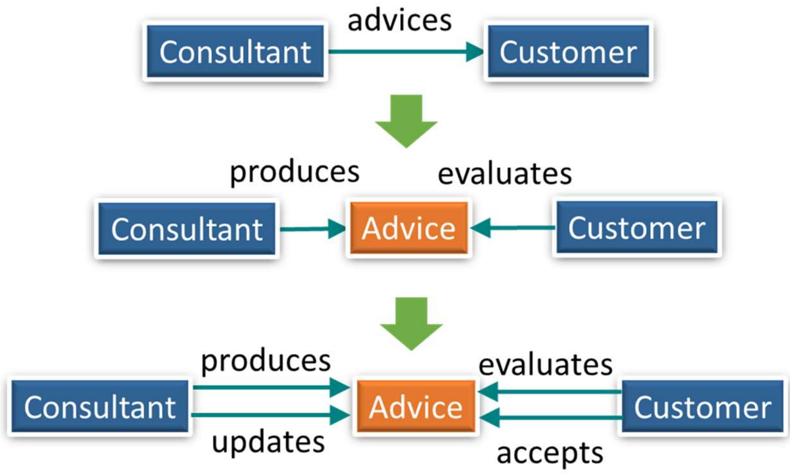

Fig. 1. Obtaining more functions due to introduction of intangible component.

3.2 Monitoring Functions

In turn, a function in [3] is defined as "*an action performed by one material object to change or maintain a parameter of another material object*".

It is very strict limitation, which makes it impossible to define delivery of a function by a component if there is no change or maintenance of some parameter (or state) of the other component. For example, the function "*thermal sensor measures temperature*" is double invalid in the original Function Modeling: 1) It is not allowed to use parameter as function target, 2) thermal sensor neither changes nor maintains temperature. A valid function will be, for example, "*air activates thermal sensor*".

Nevertheless, in non-technical systems, specifically involving humans, a certain action produced by a human operator neither changes nor maintains any parameter of another object but changes the operator's own parameter or state as, for example, a result of observation of certain process. Why is it important to pay attention to observation and consider it as function? In non-human systems time taken before a component changes its own state does not play important role in defining costs of operation, but in case of human operator, time spent for observation can become quite costly. In addition, there can be all sorts of problems related to the process of obtaining information which might be missed out if one does not include this function to the model, and a critical problem may be ignored at the stage of Problems Discovery of Function Analysis process. Therefore, it is proposed to add another category of functions: “passive” functions that either change or maintain a parameter (state) of a component which is a function carrier rather than function target. In that case, there are always be two inversely directed functions present between a component which initially acts as function carrier (e.g. provides observation or monitoring) and a function target which becomes a function carrier (Fig. 2)

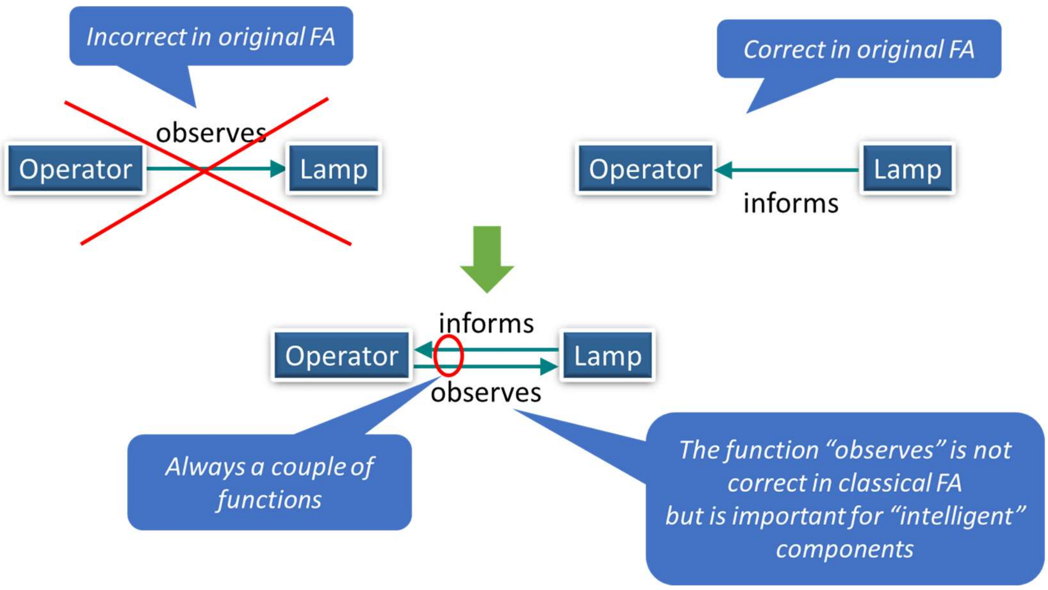

Fig. 2. Inverse active and passive functions

4 Modeling a system supporting business process

Analysis of functions in business is usually perfromed on the basis of modeling business processes to identify specific tasks and then decomposing these tasks to functions and sub-functions that have to be performed to deliver the tasks [5]. While there are a number of business process modeling frameworks, there are no formal rules how to present these functions. We argue that introducing a formal system-based approach can help to improve function modeling in business systems and business services. To do it, a part of a business process model is selected, and then TRIZ-based Function Analysis of a system providing and supporting this part of the business process is performed. An example of such approach is shown in Fig 3 and 4. Fig. 3 shows a part of a business process modeled wih one of the most poular tools in business - BPMN (Business Process Modeling and Notation [6])

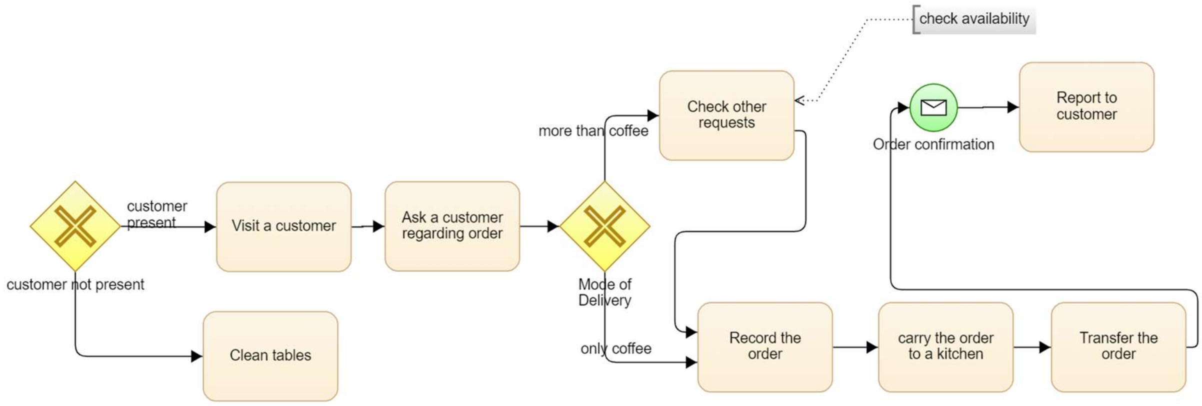

Fig. 3. A process of taking an order by a waiter in cafe modeled with BPMN

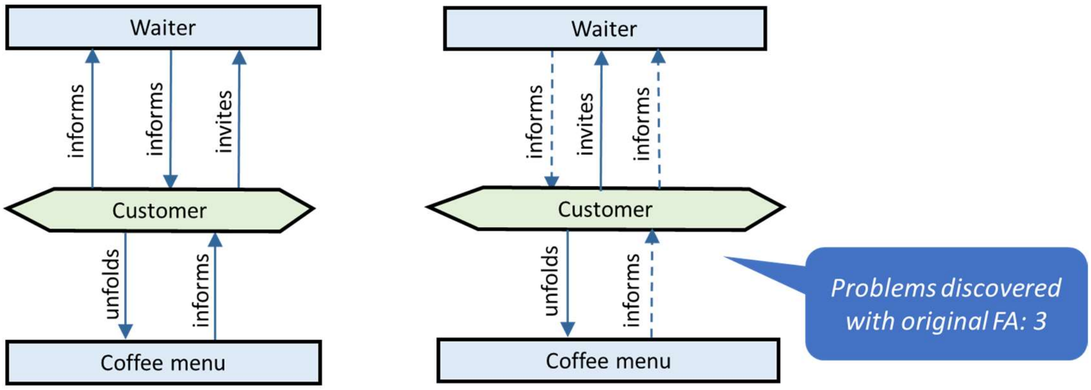

Fig. 4. Function model of taking order from a customer with original function modeling: left – model without discovered problems, right – a model with discovered problems

Once we apply extended function modeling as described above, the resulting function model includes more details which help to extract more problems (Fig. 5)

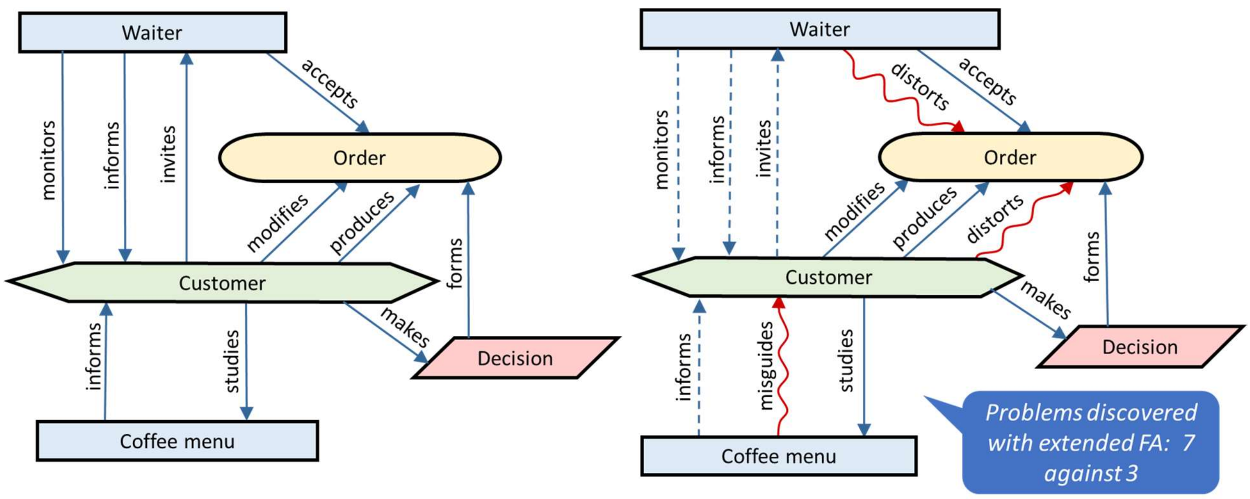

Fig. 5. Function model of taking order from a customer with extended function modeling: left – model without discovered problems, right – a model with discovered problems

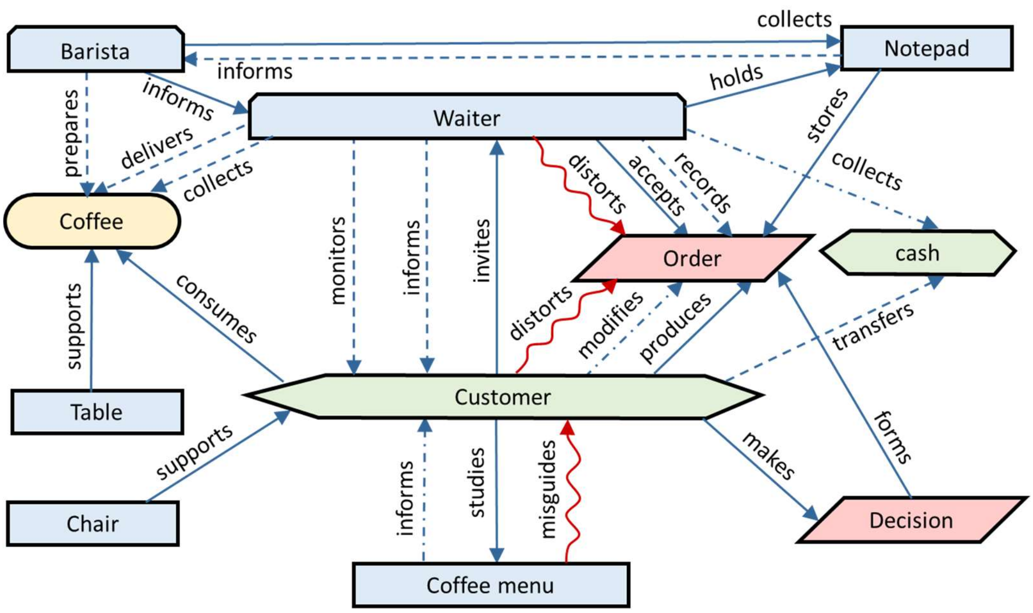

Fig. 6. Function model of taking an order and delivering the order with discovered problems.

To illustrate an Extended Function Modeling for hybrid systems, for example including information processing, a system for scanning shop's vistors and intellgent recognition of their features was taken. The results of scanning and recognition are analysed and an analyst produces advice on the basis of report generated by the system. The function model of the system is shown in Fig. 7.

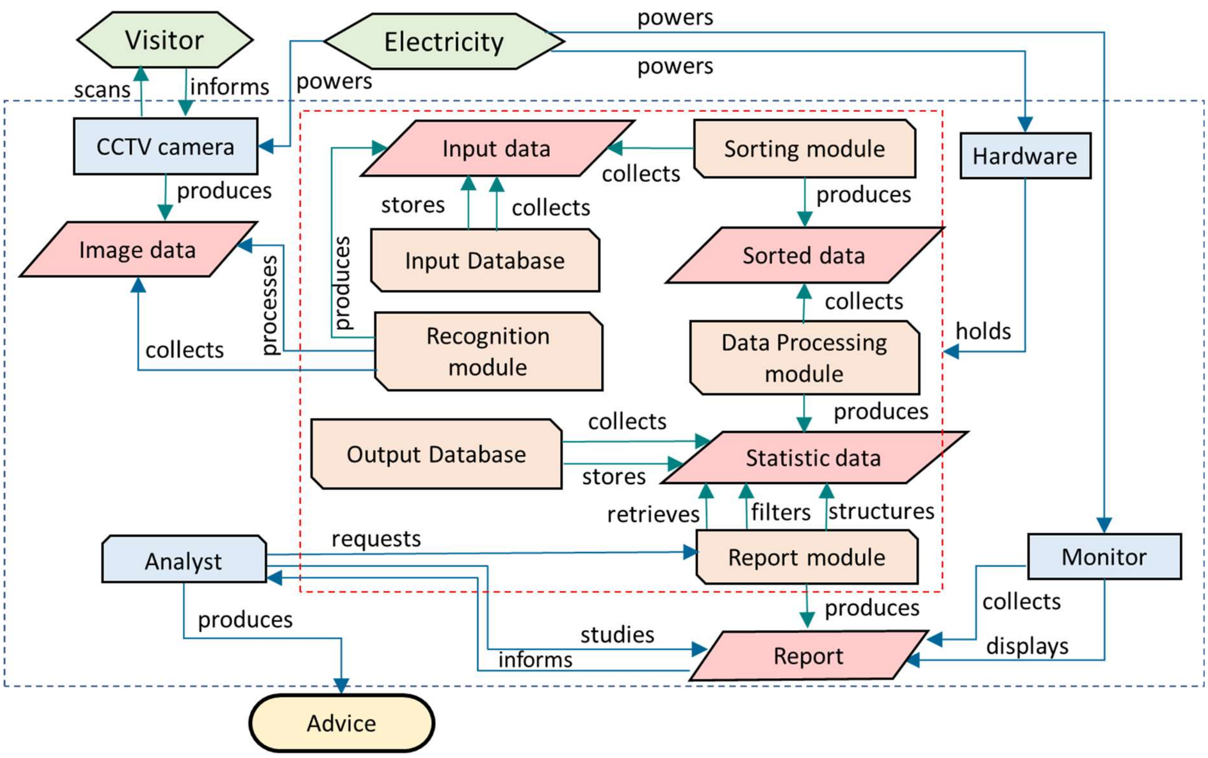

Fig. 7. Function model of a system for scanning and intelligent recognition of features of a shop's visitors.

5 Conclusions

We believe that the additions presented above will help to improve TRIZ-based Function Analysis for non-technical and certain classes of technical systems.

Although the paper is limited to presenting the function modeling part only, the following advantages were observed during applications of the tool:

- Function/Cost model becomes more complete and accurate for knowledge and information-driven, intelligent and hybrid systems.
- New types of components expand a range of components to be included and modeled.
- Function definition for "intelligent" components is redefined.
- More complete and accurate extraction of problems.
- Extended function ranking with respect to supersystem.
- New types of costs were added to avoid missing costs.
- Better visualization of components of a Function Model.

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Communication

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