FUNCTION MODELING FOR THE REST OF US

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Abstract:

To quickly move from problem to inventive solution, a clear understanding of the problem at hand is necessary. The process of identifying the right problem statement is embedded at the core of both TRIZ and ARIZ. Among the many tools available to TRIZ practitioners, function modeling is extremely helpful to achieve a deeper understanding of the system being examined and to arrive at a clear definition of the problem. Unfortunately, function modeling can be very difficult for the novice practitioner--thinking functionally is unfamiliar.

Recent advances in computational linguistics now make it possible for the TRIZ novice to approach the practice of function modeling with confidence. By tapping into a broad “informational fund”, practitioners can leverage knowledge beyond their own personal experience and gain insights into the mereological and functional relationships that are required to accurately abstract their system for function modeling. Expert TRIZ practitioners can also benefit by having a virtual subject matter expert supplement their creative insights.

Using a simple example, a model for applying state-of-the-art semantic concept extraction and retrieval to the task of system functional modeling is explored. The benefit to TRIZ practice is shown through the modeling, trimming, and extension of a system which is the subject of a current US patent application.

Introduction

> The greatest challenge to any thinker is stating the problem in a way that will allow a solution.
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> -- Bertrand Russell (1872 - 1970)

The notion of solving a problem is fundamental TRIZ. So much so, that it is embedded in the very name of the discipline. However, to solve a problem effectively, one needs to first understand the problem. This means understanding that the problem being examined is the correct one, defining the goal of the desired solution, and expressing the problem statement in a way that allows the solver to map the problem situation to the solution goals naturally.

One of the great powers of TRIZ is that the tools for this methodology provide a framework and a language for describing and understanding problems. Furthermore, TRIZ also provides motivation for the goal of problem-solving. The basic concept of Ideality is an expression of such a goal. The ideal system will possess certain characteristics. While the ideal system is not itself a goal, it provides a useful way of planning the goals that will drive the evolution of the solution to a problem [1].

In practice, system functional modeling has become a very widely used tool to help implement TRIZ and to gain better insights into how to leverage the Ideality concept. Ideality considers the ratio of useful functions and harmful functions of a system. Specifically, Ideality is often expressed with the formulae of a form similar to *Ideality = Useful functions / (Harmful functions + Cost)* [2, 3]. It is this relationship of useful and harmful functions that makes system functional modeling a tool that is so well suited for TRIZ. In the functional model, the practitioner explicitly identifies the useful and harmful functions in the system, thus providing an excellent vehicle for understanding how to move the system in the direction of the Ideal Final Result.

Unfortunately, this tool is not used by all TRIZ practitioners. Why? Because the collective experience with system functional modeling suggests that it is not easy for the novice practitioner. In a quick survey of TRIZ practitioners, experts seemed to find little difficulty with functional modeling. Nonexpert practitioners, on the other hand, reported difficulty with both system component definition and function specification. The expert practitioners also reported observing this issue when working to assist nonexperts.[1]

What is behind this gap in the experience with system functional modeling? The answer seems to lie in the availability of actionable local knowledge. Expert practitioners have developed a lexicon of functions and parameters that are readily applicable to broad situations. The nonexpert, lacking this personal resource, struggles to find the way to

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[1] Informal survey conducted by author during period from June 2006 through February 2007. Expert classification is applied to specialized TRIZ consultants or engineers who devote more that 50% of their time to TRIZ-related analysis. Nonexperts comprise novice TRIZ practitioners and experienced, but occasional, TRIZ practitioners.

express their understanding of the system. If knowledge is the problem, can we look to the TRIZ Informational Fund for the solution?

The TRIZ Information Fund

Altshuller teaches us that the problem-solver needs to have a wealth of actionable knowledge available to be most effective [4]. This is the basis of the TRIZ Information Fund. The fund comprises the full scope of literature that is produced and available through a variety of sources: published collections of scientific effects and their applications, patent literature, captured industrial experience, to name a few [5]. The fund is as rich as it is deep. Unfortunately, the strength of the fund is also its weakness.

Let us consider the single resource of patent literature. It is estimated that over 80% of the world's technical knowledge is captured in existing patent literature.[2] The body of patent literatures comprises many millions of documents. How can any one practitioner study this body effectively and have access to precisely the right information at precisely the time when that information is needed?

Until recently, there was no good answer to this question. The patent literature was a poorly utilized source of knowledge and solution ideas. However, recent advances in computation linguistics have changed this situation. Modern computers can process and organize these millions of documents with great speed. Semantic indexing technology provides the mechanism to instantly locate specific facts and information that are directly relevant to a technical question. These technologies not only make the dream of a useful TRIZ Information Fund a reality, they also create the opportunity to transform the information fund from a static repository of information to an active knowledge source that is integrated with the objective of a problem-solver's activities.

Semantic Analysis to Prepare a Specialized Information Fund

In looking at the question of how to best apply the TRIZ Information Fund to the task of system function modeling, it is important to understand what is needed by the practitioner. When we create a system functional model, there are two basic types of information that are required. The functional model itself can be described as an entity-relation-entity (ERE) model. The entities which make up this model are components, or parts, of a whole system. The relations which connect the entities represent the functional interactions between components of the system. So the specific knowledge that is required to construct a functional model is knowledge of the taxonomy of the system being modeled, and knowledge of the potential functional interactions that are evidenced in the system.

The first area of knowledge is the subject of mereology, the science of cataloging whole-part relationships. These whole-part taxonomies capture our knowledge of how the world and the things in it are put together. Similarly, functional relationships capture our

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[2] Source: European Patent Office

understanding of how systems function. Having this understanding, the practitioner is well prepared to identify the component parts of the system that is being examined.

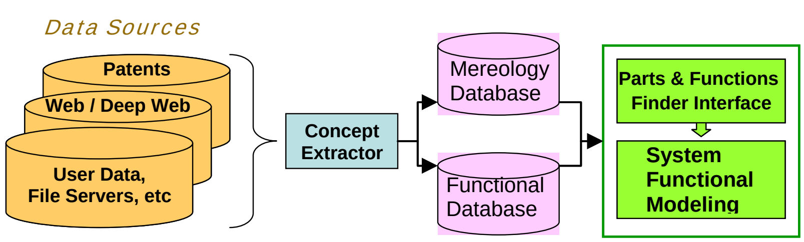
It is now possible to extract this knowledge from natural language text documents and to create a specialized system functional modeling information fund. Techniques for such extraction are now a part of the information fund itself. By way of a simple example, let us consider the sentence: “The car is equipped with the engine.” In this example, we can see that the noun phrase “the car” is related to the noun phrase “the engine” by the verb “equipped”. It is further the case that the semantics of the verb & prepositional phrase structure confers upon the verb “equipped” a language sense that denotes a whole-part relationship. This it is concluded that “car” and “engine” participate in a whole-part relationship, where “car” is the whole and “engine” is the part [6].

Similar techniques of semantic analysis allow for the recognition of functional interactions between entities through the identification of the *perform* verb sense. Thus the relevant knowledge can be extracted from literature to create a task-specific information fund to enable more effective system functional modeling.

Knowledge-Enabled Functional Modeling

To better understand how such an information fund can be applied to system functional modeling for TRIZ practice, it is best to consider an example. In the example that follows, we will consider the modeling of a simple system. We will also look at how the system can be simplified and extended with the assistance of targeted knowledge delivery from the information fund. The architecture of the underlying software system to enable this is shown in figure 1.

Figure 1 - Architecture of Knowledge-Enabled Function Modeling Software System



In this example, the case of a pet lead with adjustable handle (US 2007/0006821 A1) is considered as a sample system for examination. The exercise will cover four distinct operations in the application of system functional modeling:

1) Identifying components
2) Finding component interactions
3) Simplifying the system through trimming (reducing harmful functions)
4) Extending the system (increasing useful functions)

We begin the process of system functional analysis by naming the device model that we want to create, as shown in Figure 2. By selecting a name which reflects the class of system that we want to model, the software system is informed of what types of systems should be included in subsequent knowledge searches. In this way, when the user requests assistance in identifying components, only relevant mereological relationships will be included. Figure 3 shows the results of such a requested component search.

Figure 2 – Naming functional model to specify system class

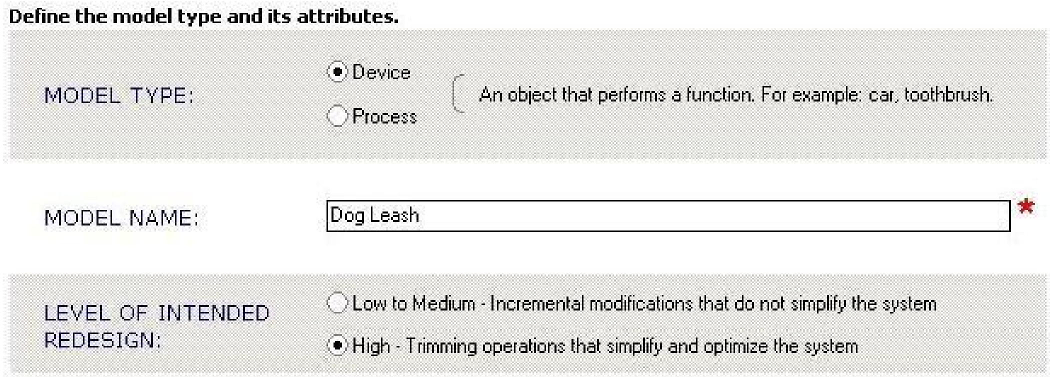
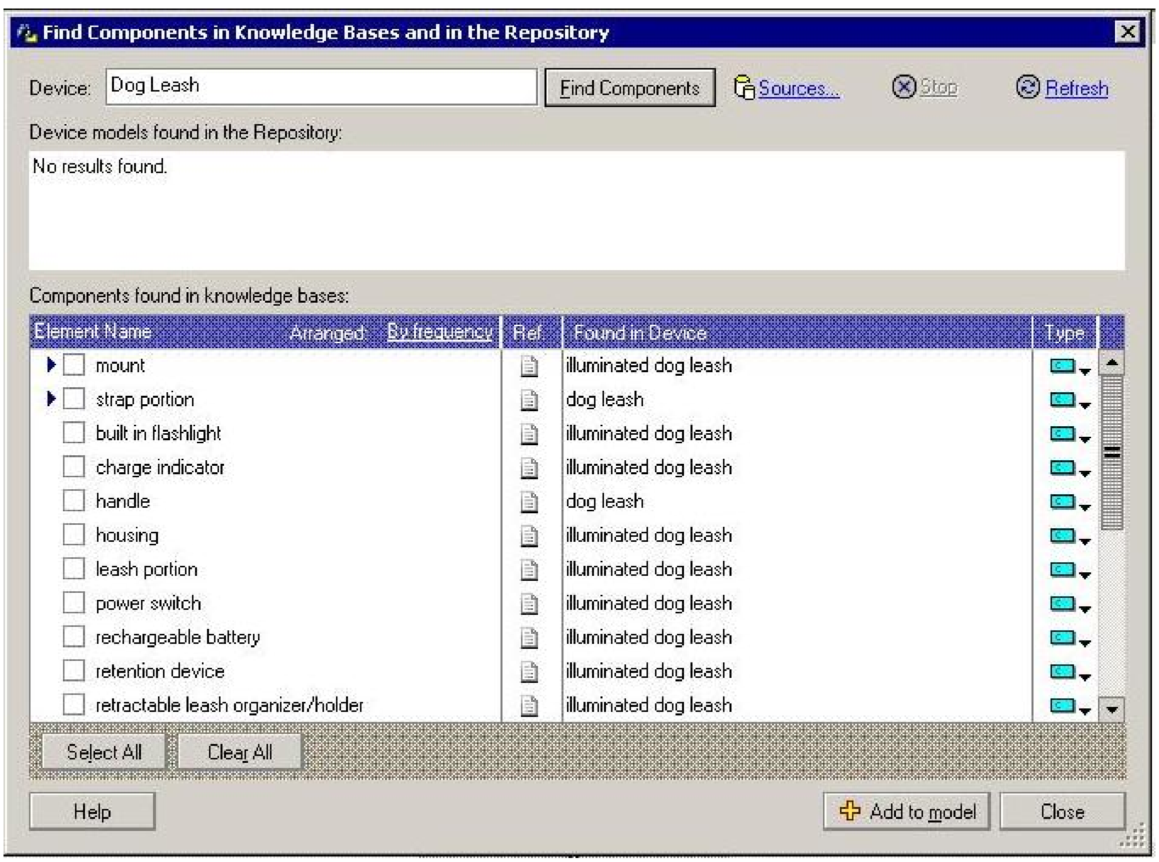


Figure 3 - Results of mereological component search for system "Dog Leash"



The listed search results comprise a list of all components that are mentioned in the semantically indexed reference materials in a context which suggests that the components are part of a leash system. Results are ordered by the frequency with which they are mentioned in the literature, as the relative frequency of occurrence is a measure of relevance. Components that may have subclassifications are indicated with a pointer icon that, when clicked by the user, reveals the possible subclasses of components for selection. The specific type of device in which the component was identified is noted. A document icon is also present to allow the practitioner to gain a better understanding of the relevance of the suggested component. When the associated icon is clicked, the reference that suggests the mereological relationship is presented to the practitioner (Figure 4).

Figure 4 - Reference to component "lead" as part of the whole system "leash"

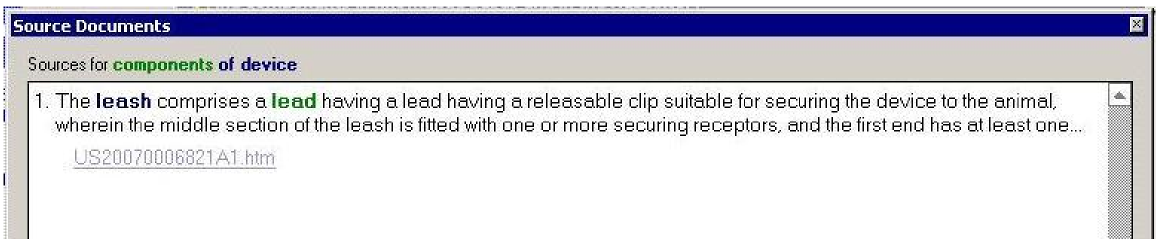
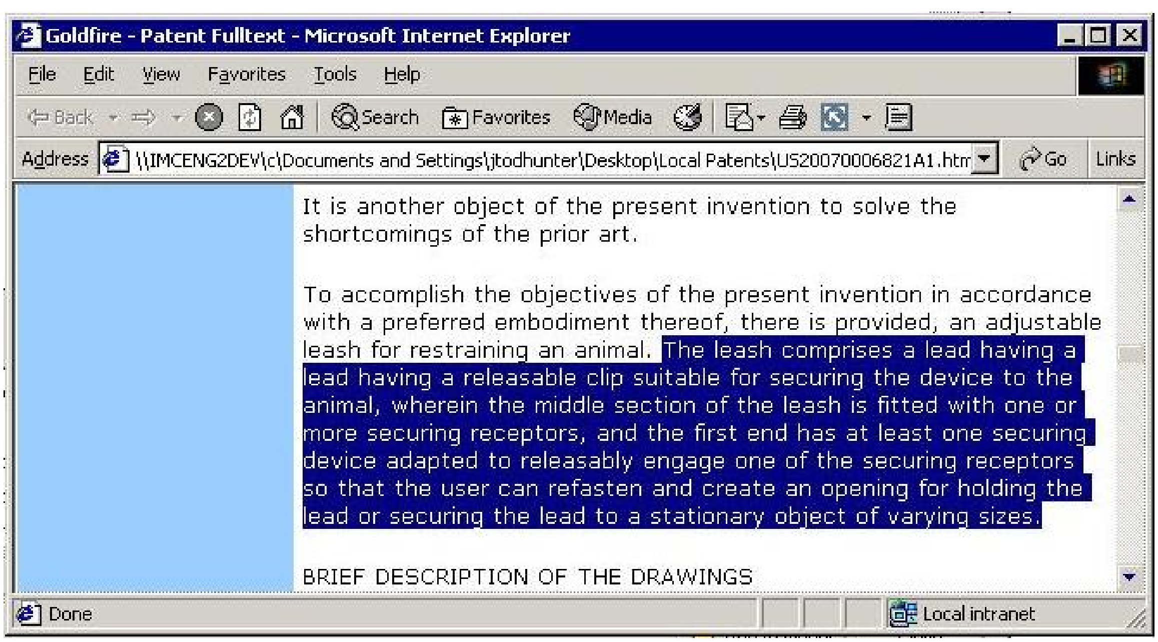
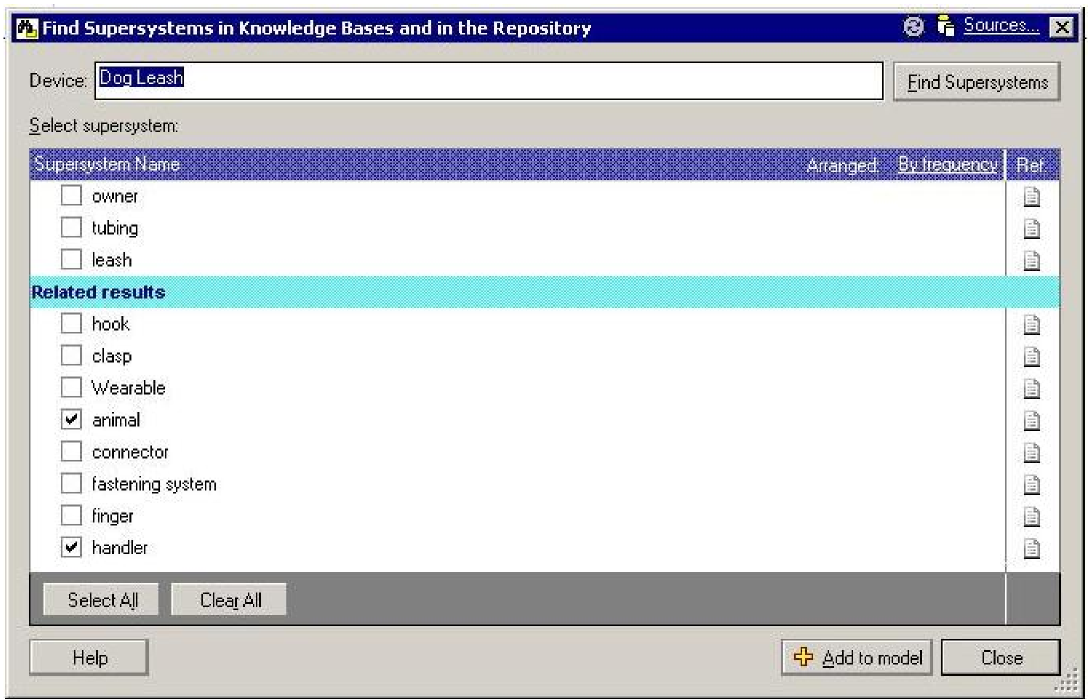


Figure 5 - Full text of referenced document



If still deeper insight into the nature of the relationship of the suggested component to the system is needed, a hypertext link retrieves the full text of the source document. This ability to view not only the consolidated results of the mereological search but also the available supporting content from the information fund provides the practitioner with both the key information and the confidence to quickly identify the components of the system to be modeled. Simply selecting components from the result set populates the model canvas.

Figure 6 - Results of supersystem search request

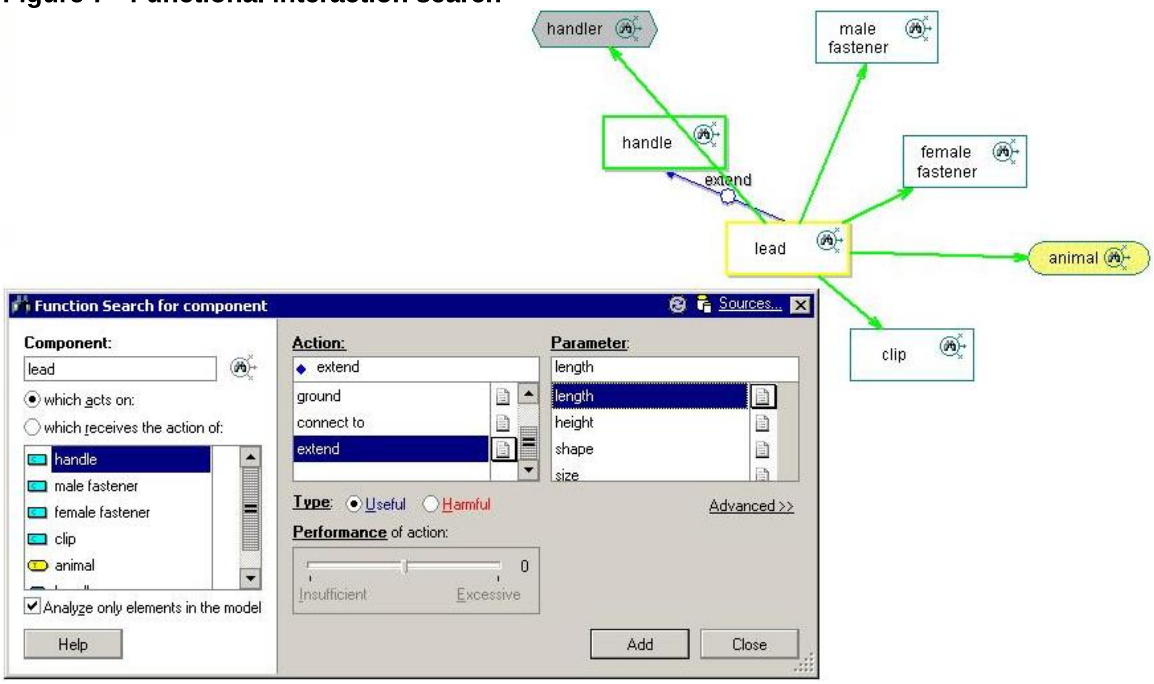


The identification of potential supersystem elements is similarly enabled. Figure 6 shows the results of a search for supersystem elements. As before, visibility to the underlying documents is provided.

Once components have been identified, the task of identifying the functional interactions among the components takes center stage. This is often the most problematic aspect of system functional modeling because nonexpert practitioners are simply not conditioned to think about system in the required way. They often have difficulty expressing the functions that are involved in the system, and they have even greater difficulty with defining the affected parameters. Here again, the TRIZ Information Fund provides the needed relief.

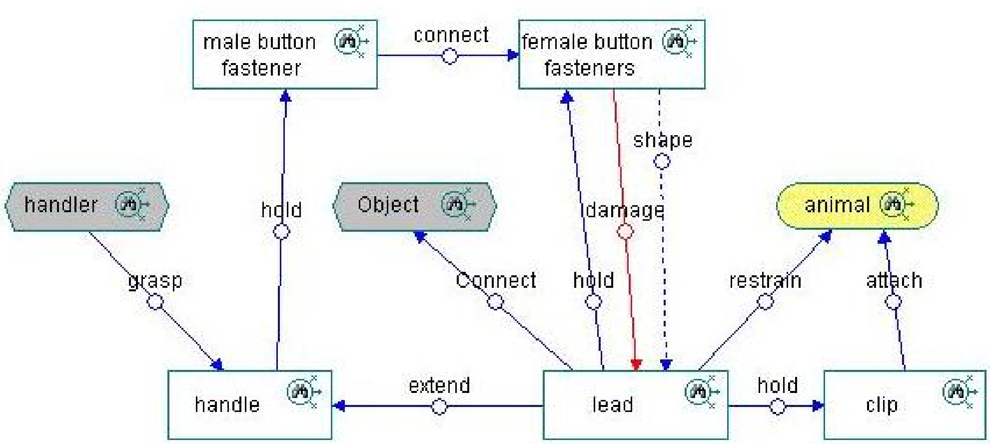
On demand, a functional interaction search of the functional relationship database retrieves specific knowledge about the types of interactions that can exist between model components. Figure 7 shows the results of such a search. In this example, the icon in the model element that is labeled "lead", was activated to launch the search. The results in the leftmost scrollable list within the Function Search dialog box indicate other components of the system for which the search has identified known interactions. The components that are identified are also highlighted in the model by the addition of temporary connector lines. By selecting a component from the list ("handle" in the example shown), a selection of known interactions is presented in the Action list. The practitioner can use the familiar document icon to drill down into the information fund. Selecting an action from the suggestion list or entering an action manually presents a possible list of parameters for investigation. Chosen functions are added to the model, as is shown below for the function "extend".

Figure 7 - Functional interaction search



By enabling the practitioner to complement personal knowledge with the power of the TRIZ information fund, the process of functional interaction identification is made simple. Following the steps outlined above, a nonexpert user can build a creditable system functional model with ease. Figure 8 depicts a complete model for example system constructed exclusively from the knowledge that is contained in the information fund.

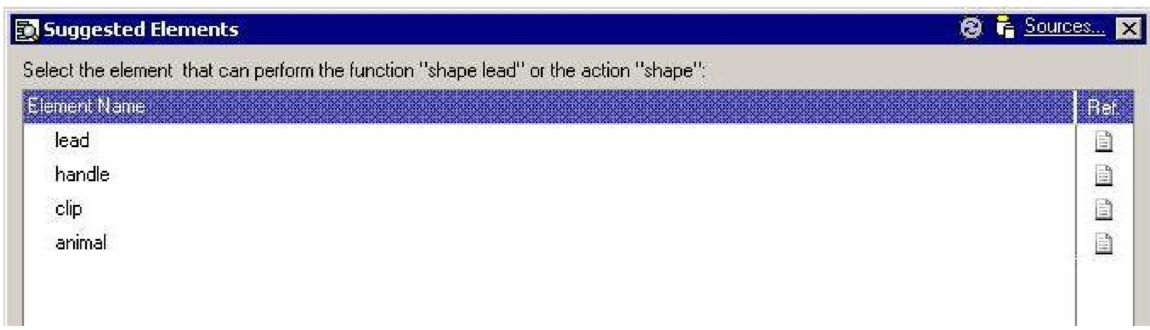
Figure 8 - System functional model built from TRIZ Information Fund



Of course, the facile creation of the model is not the goal of system functional modeling. It is what happens with the model that is of interest. In the example system, we see that the female button fasteners damage the lead. This is because the fastener perforates the lead when it is attached. Also, the primary function of the female fastener is to modify the shape of the lead when the male and female button fasteners are engaged. This function is inadequately performed because the fixed position of the fasteners does not allow adequate flexibility in the size of the resulting lead loop which is formed.

To improve the system, we shall consider improving the ideality of the system by eliminating the harmful functions. This will be pursued for illustrative purposed using a software trimming wizard. As we go through the process of trimming the female button fasteners, we must decide what to do about the beneficial function of altering the shape of the lead. Since this is a key design benefit of the system that we want to preserve, we choose to transfer the function to another component. But which component should be chosen?

Figure 9 - Suggested candidate components to accept transferred beneficial function



Once again, the TRIZ Information Fund comes to our aid. Figure 9 shows the result of asking the trimming wizard to suggest possible recipients of the transferred function. The examination of the knowledge that is served up from the information fund stimulates creative thinking and helps the practitioner make a knowledgeable choice. In this case, the choice is made to reassign the function to the handle.[3]

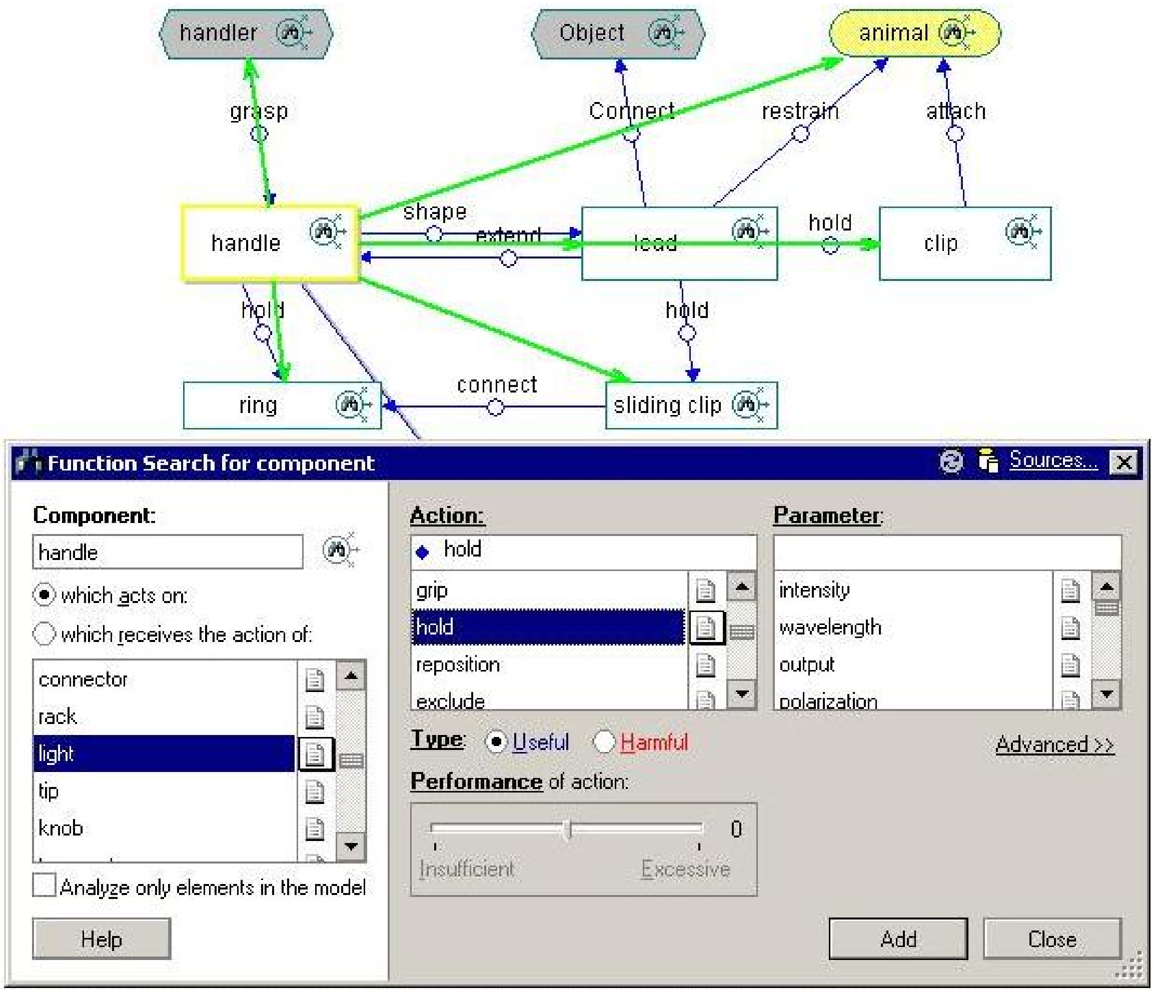
This simple illustration shows how the specialized mereological extract of the TRIZ information fund can be helpful in a trimming exercise. However, it also possible to improve ideality by increasing the beneficial function content of the system. Somehow, this seems a much harder task since we are no longer manipulating components and functions that exist within the system. How can we find functions which represent possible new features to add to our system?

Fortunately, this too can be addressed with the aid of the TRIZ information fund. Since the mereological and functional relationship databases are constructed from the broadly

[3] This is noted without substantive explanation, but, for the record, the appearance of the suggestion handle in the list of suggested components surface some pre-existing personal domain knowledge that made this seem a very natural choice.

based content of the information fund, it is possible to analyze relationship concepts beyond the narrow confines our existing system.

Figure 10 - Tapping the TRIZ Information Fund for ideas to expand a system's functionality



In Figure 10, we see how, by asking for a broader search (accomplished by unchecking the box labeled "Analyze only elements of the model"), new ideas can be sourced from the available literature. Browsing the identified components in the Function Search dialog box reveals many new ideas that can be considered as possible functional extensions of the system. For example, we see that in some systems a handle has been designed to hold a light. This could represent a great way to add useful function to our system, and thus advance our system to maximal ideality.

Conclusion

Altshuller identified the need to study advances in the theory and practice of inventive problem-solving. The evolution of technology has helped to add new elements to the practice. High speed computers and advanced computational linguistic technique make possible the realization of the TRIZ Information Fund in a way that was unattainable only a few short years ago.

The advances in deep semantic analysis not only enable the extraction of simple semantic elements, but now higher level concepts such as whole-part relations can be teased out of the body of literature. The availability of such high level conceptual data makes possible a new class of tools to assist the TRIZ practitioner. By matching the level of conceptual analysis that is performed by the practitioner to the level of concepts that are derived from the information fund, new levels of creative insight and effectiveness are possible as man leverages machine.

Specifically, the application of whole-part and functional concept extraction to prepare a system function modeling database of captured experience transforms the modeling experience for the nonexpert practitioner. The most daunting aspects of functional modeling are made easier with the aid of software that participates as a virtual subject-matter expert.

References

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