Information Retrieval and Situation Theory

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"In the beginning there was information. The word came later." Fred I. Dretske

1 Introduction

The explosive growth of information has made it a matter of survival for companies to have at their disposal good information retrieval tools. Information storage is becoming cheaper, and because of this more voluminous. Due to this fact a growing amount of (expensive) information disappears unused (or unread) simply because there are no possibilities to retrieve this information effectively. The problem, however, has been studied for years, as what has become known as "the information retrieval problem" and can be described as follows:

> "In which way relevant information can be distinguished from irrelevant information corresponding a certain information need".

Systems trying to solve this problem automatically are called information retrieval (IR) systems. These systems which are developed from a defined model try to furnish a solution for the problem. There are various models of IR systems; the most publicized ones are the Boolean, the Vector Space [1], and the Probabilistic models [2, 3]. More recently, van Rijsbergen [4] suggested a model of an IR system based on logic because the use of an adequate logic provides all the necessary concepts to embody the different functions of an IR system.

We have advocated in earlier work that a logical approach should be based on a theory of information, *Situation Theory*, which provides a powerful arsenal of concepts, which is useful in modelling documents and queries for the purpose of IR ([5], [6],[7]).

Moreover, it was showed that Situation Theory provides a framework to different types of IR models, thus allowing speculation on their properties and their characterisation language ([8], [9],[10]).

This paper is an essay to convince the reader that Situation Theory presents many characteristics that are both adequate and appropriate for the study of IR. Here we concentrate on the ones we have experience with:

- A situation theoretical IR model
- A situation theoretical framework for studying IR models

The organisation of the paper is as follows. In section 2, the reasons for using Situation Theory as the theory to model an IR model are given. Section 3 focuses on the aspects of Situation Theory as a meta-theory for IR. In the last section some conclusions and some guidelines for further research are presented.

2 A Situation Theory Information Retrieval Model

Information can be stored and relayed in different forms including texts, images, audio and video. In this paper, these forms are referred to as documents. In most cases an IR system does not, or cannot, incorporate the entire information content of a document due to factors of efficiency and complexity. Hence, an IR system handles a manipulable representation of the document information content. This internal representation aims to give as faithfully as possible the document's information content. In conventional text-based IR systems, the creation of internal representation is often referred to as indexing.

A user in need of information submits a query to the IR system that expresses the information need. The query is then evaluated by the system and transformed into an internal representation that is manageable by the system. The transformation of a query involves a process often similar to that used to represent a document's information content. The system compares the query representation with all the document representations and determines by some matched-based computational techniques the document representations which may satisfy the user request. These then become the retrieved documents. Both the comparison and the representation processes of documents and queries sometimes use additional semantic knowledge generally stored in a thesaurus. An example is that of synonymous relationships; a document indexed by an item is also indexed, eventually implicitly, by all the synonyms of that item that are stored in the thesaurus.

Depending on how efficient and adequate the system is, the retrieved documents correspond variably to the relevant documents that satisfy the original information need. The positive correspondence between retrieved and relevant documents is the main objective of an IR system: a good IR system should retrieve as many relevant documents as possible, but only the relevant documents.

In a logical IR model, it is supposed there is a way to represent the information content of a document by a sentence d and the information need as phrased in the query by a sentence q. The "truth" of $d \rightarrow q$ would mean that the query sentence can be inferred from the document sentence. To put it another way, the information captured by d is sufficient to infer the information represented by q. In the IR world, this could be viewed as the document satisfying (or being relevant[1] to) the query.

The use of logic seems to be a more accurate model of information and its flow, which are principal concerns of IR. Indeed, in the Oxford English Dictionary, logic is defined as:

> "The branch of philosophy that treats of the form of thinking in general, and more especially of inference and scientific method."

That is, logic is a formalization of the way we use information in our everyday life to think, infer, conclude, acquire knowledge, make decisions and so forth. In this sense, logic undertakes to model information and its flow. In [7], we discussed the preponderance of the flow of information in IR. For example, in textual IR systems, the flow allows us to read (recognition of letters, words, and sentences); the flow allows us to understand what we are reading (semantics); and the flow allows us, with respect to our knowledge of the subject, to derive additional information from what we have read (pragmatics).

The use of logic for modelling IR has been perused by authors such as [11, 12, 13] all of whom proposed interesting frameworks, although these authors have all adopted a truth-based logic, which corresponds to the second view of logic in the Oxford English Dictionary:

> "Also since the work of Frege (1848–1925), [logic is] a formal system using symbolic techniques and mathematical methods to establish truth-values in the physical sciences, in language, and in philosophical argument."

In many domains that relate to information, such as artificial intelligence, databases, linguistics and even philosophy, information is represented by some structure or calculus that is built on the concept of truth. We, on the other hand, following the line of [14, 15, 16, 17, 18, 19], and so forth, advance a logic-based model of IR using a logic of information and its flow. For this reason, we have chosen to use a theory, namely Situation Theory, that is primarily concerned with the representation of information and its flow.

In this section, we show the appropriateness of Situation Theory to model IR. We base our discussion on the work of Dretske [14] who provides a comprehensive dissertation about the role of information and its flow. Indeed, the philosophy behind the development of Situation Theory conforms to many of the points expressed by Dretske. Those relevant to IR are discussed in this section, and their representations within Situation Theory[2] ontology are emphasized.

[1] In this paper, the term "relevance" is used in both contexts, with respect to the user (which is the correct use in the IR world) and with respect to the system (indicating good satisfaction).

[2] The main concepts in Situation Theory are summarized here:

2.1 Signal

Dretske [14] explains that information is knowledge about a source; it is communicated by a signal to a receiver. In IR, the source is the document and the receiver is anybody observing the document (reading a text, listening to an audiotape or observing an image). Signals are whatever means by which the information about a source is delivered to the receiver. For example, if the document is a text, the signal is a mixture of the reader's vision capability, his/her understanding of the information read, and his/her general knowledge about its subject. A signal can also be the indexing process which delivers a representation of the information content of the document.

Dretske [14] defines a source as any structure with an information content; situation is of primary concern here. Let d be a situation and φ be an information item. If the signal carries the information that d contains φ (or, as expressed by Drestke, d is φ), this is written in Situation Theory $d \models \varphi$. A signal which carries $d \models \varphi$ often carries additional information about the situation d or other situations owing to the exact fact that d supports φ. This information is said to be nested into the fact that d supports φ.

Dretske notes that information can be encoded in two forms: a signal carries the information $d \models \varphi$ in digital form if, and only if, this information is not nested in any other information carried by that signal; otherwise, the signal carries this information in analog form.

2.2 Perception

The amount of information contained in documents is usually very large. One could compare a (physical) document's information content to a sensory experience, which often embodies a great variety of details. According to Dretske [14], the perception of a sensory experience is the process by which information is delivered to a cognitive agent for its selective use. It is identified with a signal that carries information about a source which is coded in analog form. Until information has been extracted from this signal, nothing corresponding to recognition, classification or identification has occurred. It is the successful conversion of information into the appropriate digital form that constitutes the essence of a cognitive activity. In Situation Theory, situations are the objects of perception. They provide the information that signals carry in analog form.

A perception process often embodies information about a variety of details that, if carried over in total to the cognitive agent, would require immense storage and retrieval capabilities. Moreover, there is more information than can be extracted and/or exploited by the cognitive agent. Only some of the information the perception process carries in analog form is retained. The same holds true with most (if not all) IR systems. The indexing of a document does not give an exhaustive description of the information content of that document. There would be too much information to store, and sometimes it is not even possible to exhaustively determine the information content.

A perception process is determined not by what information is carried, but by the way it is carried. Seeing, hearing or reading are not different processes because of the information they carry (the information might be the same), but because of the vehicle by which this information is delivered. Two different concepts are involved here: how the information is delivered and what the information represents. Situation Theory is concerned with the latter, for a situation can be a text, an image or a speech. Therefore, a model based on Situation Theory could eventually incorporate multimedia oriented IR systems.

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1. **Infon:** Information has the general form *a property P holds / does not hold for the set of objects* $a_1, \ldots, a_n$. These two items of information are modelled by the two *infons* $\langle\langle P, a_1, \ldots, a_n; 1\rangle\rangle$ and $\langle\langle P, a_1, \ldots, a_n; 0\rangle\rangle$.
2. **Situations:** They are parts of the world from which information is extracted. Let ϕ be an infon representing a item of information. If a situation s makes this information true, this is denoted $s \models \phi$.
3. **Types:** They represent the uniformities that cut across infons. For example, the three following infons $\langle\langle \textit{Weather}, \text{Glasgow}, \text{sunny}; 1\rangle\rangle$, $\langle\langle \textit{Weather}, \text{Utrecht}, \text{sunny}; 1\rangle\rangle$ and $\langle\langle \textit{Weather}, \text{Algiers}, \text{sunny}; 1\rangle\rangle$ have the common information that it is sunny. What differs in this representation is the city. The type abstracting among these infons can be defined as $\varphi = [\dot{s} \mid \dot{s} \models \langle\langle \textit{Weather}, \dot{c}, \text{sunny}; 1\rangle\rangle$ which is the type of any situation about a city (represented in the type by the parameter $\dot{c}$) where the sun is shining. If s is one of them, this is written $s \models \varphi$.

2.3 Cognition

Dretske [14] describes cognition as the conversion of the information a cognitive agent receives in analog form into digital form. The result is usually qualified as a knowledge with respect to the cognitive agent. The conversion, referred to by Dretske as digitalization, involves a loss of information because it turns a structure of greater information content to one of lesser information content. What is gained by this loss is some sort of classification of the information provided. The indexing process in IR can be compared to a digitalization process. The IR system is the cognitive agent. The document is a situation that contains information in analog form. The information which is (successfully) digitalized constitutes the document representation. The goal is to minimize the loss of information involved in the conversion while at the same time obtaining a small enough document representation for both storage capacity and retrieval speed. The outcome of the cognition process is often a partial representation of the information carried about a source, which is a document in IR.

Some researchers [15, 16] refer to a situation as a partial object, which can contain a vast amount of information, though only part of it is digitalized. Moreover, whether an item of information is to be digitalized or not depends on two properties attached to the cognitive agent:

- its capability of perception. For example, a human being and a robot do not perceive information at the same level. A robot can identify entities that a human being cannot, and vice versa.
- its focus of attention, because cognitive agents are often constructed to fulfill a task. For example, the color of a wall may be of no interest to a moving device whose purpose is to avoid the wall.

The essence of Situation Theory is to capture these facts, which is often not the case with many others frameworks such as those based on truth (e.g., Classical Logic, Default Theory [20], Modal Logic [21]). In these, every representation of an information item is assessed to either belong or not to belong to the document (the assessment is often a truth value). This is unreasonable because many information items have no connection whatsoever with the information content of the document.

A document can be identified as a situation since a document contains the information written in its text, or contained in its images. In text documents, the digital information is the information that is made explicit by the indexing process. This information is strongly dependent of the properties of the indexer (the cognitive agent).

2.4 Information vs. meaning

Dretske [14] claims that information and meaning are two different concepts. Indeed, there is no reason to assume that the information a signal carries is identical to its meaning. Often, the information contained in a signal exceeds its meaning. For example, the statement "Keith is at home" means that Keith is indeed at home. It does not mean that "Keith is at home and not at work", though Keith being at home implies that Keith is at home and not at work. A signal that carries "Keith is at home" also carries "Keith is at home and not at work". This information follows from the flow of information that springs from the meaning attached to the statement. This difference between information and meaning is highlighted in the quote ([14]):

> "... information is that commodity of yielding knowledge, and what information a signal carries is what we can learn from it".

In IR, understanding the meaning attached to the sentences of a document is important, but is insufficient for determining the information content of the document. A more thorough representation of a document's information content needs the appropriate capturing of the flow of information. This is why frameworks such as Montague Semantics [22] are not appropriate, since they are theories of meaning, whereas Situation Theory is a theory of information.

2.5 Flow of information

During the indexing process in IR, the information that is digitalized constitutes the document's initial representation, which is not an exhaustive description of the information content of that document. This representation customarily depicts the explicit information content of the document, which is determined at most from the meaning of the sentences of the document. Additional information can often be identified as part of the document information content. This additional information constitutes the implicit information content of the document. This information is carried in analog form and remain so until extracted (or digitalized) by a the indexing process. Then, it becomes carried in digital form, that is, as part of the (known) information content of the document. The existence of this information is due to the flow of information that arises from the explicit information content of the document.

It may help in understanding this notion of flow of information to consider some examples. A situation showing smoke contains information that there is a fire because of the constraint that smoke usually means fire. Squareness for an object contains the information that the object is a rectangle relative to an analytic constraint. A document about Pascal contains information about programming languages.

We can see that the flow of information characterizes information containment and can generally be defined as the information an object contains or carries about itself or another object. The purpose of an IR system is to provide information about a query and that a query is a representation of an information need that an IR system attempts to satisfy. Hence, determining relevance consists of computing the information contained in one object (e.g., a document) about another (e.g., a query). This problem is the identification of a flow of information between the document object and the query object.

Information containment is usually described by (informative) relationships between items of information and the object affected by this information containment. Let it be a relationship between the two information items p and p' (e.g., synonymity). The flow of information based on this relationship indicates that an object which contains the information item p, contains or carries the information that, itself or a second object which contains the information item p'.

In Situation Theory, constraints model relationships which are defined between types. Let ϕ and φ be two types that constitute the constraint $\phi \rightarrow \varphi$. The application of this constraint to a situation s_1 is possible if first $s_1 \models \phi$ and then informs of the existence of a situation s_2 such that $s_2 \models \varphi$: the fact $s_1 \models \phi$ carries the information that $s_2 \models \varphi$. A *flow of information* circulates between the situations s_1 and s_2, and the nature of the flow is defined by the constraint $\phi \rightarrow \varphi$.

If s_1 is the document object and s_2 is the query object, then the existence of the flow that circulates between s_1 and s_2 means that the document is relevant to the query. The nature of the flow is determined by the constraints, which in IR, can model any thesaural, semantic relationships (e.g., "Holland" and "The Netherlands" are synonymous) or pragmatic relationships (e.g., the systematic relationship that most people attach to "wine" and "France"), or more complex relationships like those handled by artificial intelligence.

2.6 Uncertain flow of information

The flow of information can be uncertain. For example, consider the synonymous relationship between the two terms t and t' as the basis of a flow. Often, two synonymous terms have different meanings in certain contexts. If it is not known which sense the term t refers to in a given context, then the flow that relates this term to t' is uncertain. The relationship between t and t' might not be appropriate with respect to that context.

In Situation Theory, uncertain flows come from the fact that constraints do not always hold. The constraints that do not always hold are called conditional. A conditional constraint is written $\phi \rightarrow \varphi \mid B$, which highlights the fact that the constraint $\phi \rightarrow \varphi$ holds for a given situation if the background conditions captured within B are satisfied by that situation:

- if the situation satisfies the background conditions, the use of the constraint is certain as well as the resulting flow.
- if the background conditions are not satisfied, the constraint cannot be used.
- if it is not known whether the background conditions are satisfied by the situation, the use of the constraint is uncertain, and the resulting flow is uncertain.

The use of background conditions in an IR model acknowledges the important fact that information is seen to be dependent on a context. For example, background conditions can represent context with respect to polysemic words. Consider the word "bank" in a document dealing with finance. Inference with respect to that word should relate to the "money bank" context, and not "river bank".

The background conditions can be particularly complex to identify. In every day reasoning, people often use background conditions, though they are not aware of them. People often, if asked, cannot express them. This should not imply the non-existence of the background conditions. As Devlin points out [17], background conditions become a concern only when a constraint fails.

Similar problems arise in IR. Take the example of a synonym-based constraint. If the term referred to in this constraint is polysemic, disambiguation is necessary to ensure that the constraint can be used. In IR, disambiguation unfortunately is not always successful or even possible [23, 24]. This implies that the use of such a constraint will often be uncertain, thus leading to an uncertain flow. The more uncertain the flow, the less relevant the document.

In IR, it is usually insufficient to say that a document is relevant to a query; knowing the extent of relevance is mandatory[3]. In [25], we use the uncertainty engendered by uncertain flow as the basis of a numerical formulation of relevance. We achieved this by mapping a theory of uncertainty on top of Situation Theory. However, by using Situation Theory to model IR, the uncertain nature of the flow of information is already qualitatively captured, and can then be initially studied on its own.

2.7 Natural Language Processing

The use of Situation Theory provides an additional benefit because it has been used to develop a framework for natural language processing. This framework is called Situation Semantics [26, 27]. It models the utterance of a sentence with three entities: the type that represents the information content of the sentence, the situation that the sentence describes, and the situation in which the sentence is uttered. All the components of a sentence are defined in terms of these three types of entities, which are combined to form the three entities of the sentence. A model based on Situation Theory can use Situation Semantics as the natural language process to identify the types that are supported by the situation modelling the document.

3 A Theory for Information Retrieval based on Situation Theory

In this section we will suggest that Situation Theory presents enough expressiveness to be a suitable candidate as a "meta-theory" for studying IR. As mentioned in the previous section, IR's main goal, is to retrieve information objects that are *likely to be relevant* given an information need. An IR model can be seen as a proposal for a solution given this problem. Underlying every IR model is a theory that defines the notion of relevance. Such a theory could be implicit or explicit in the model. For instance, in the probabilistic models, the notion of relevance is explicitly defined in terms of probabilistic laws. One probabilistic definitions of relevance could be that a document d is relevant given a information need q, iff it holds that $Pr(d \mid q) > Pr(d)$.

As mentioned in the previous section, van Rijsbergen [4] suggested a model of an IR system based on a logic. A document d is about q if the document logically satisfies the query. A diverse range of IR models has emerged based on the way they define aboutness. A meta-theory should offer the possibility to axiomatise the aboutness relation of every IR model.

It is important to have such a formalism in order to propose optimisation for existing IR models based on some theoretical foundations. Another benefit of such a meta-theory lies in the fact that several authors have indicated that optimisation of certain IR models –mostly of others– is marginal, and significant improvements are not possible anymore: they are often not able to give a formal proof of such theses. A formal framework for IR, or stated differently an IR meta-theory should answer questions like:

- Which model is preferred over an other model?
- Why is it not possible to significantly improve certain models?
- Which theories are behind the retrieval mechanism?

[3] In most IR systems, the comparison of a document and a query representation results in a numerical value, often referred to as degree of relevance, that expresses to what extent the information content of that document satisfies the information need as specified in the query. The retrieved documents are ordered according to a degree of relevance, and the ordering displays to the user which documents, according to the system, satisfy his or her query, the best.

- What are the assumptions to express preferences of models?

Related to these problems is the fact that IR is based on certain underlying assumptions, which up to now have not been formally expressed.

Up to now IR systems are in compared in effectiveness through their recall and precision values[4]. These are statistic values which indicate the accuracy of a given IR system. We admit the great usefulness of these statistics, however, to be able to make more strict statements concerning qualities of one model over an other model, we should nevertheless have at our disposal more formal means of comparison. Also, to prove the statements about the behaviour of IR systems, statistics are not conclusive; there seems to be a need for a more logical characterisation of these systems.

3.1 Which theory?

In the context of this paper, it should not surprise the reader that we propose Situation Theory as being a good candidate as a theory to analyse properties of IR models.

As mentioned in the previous section, IR models are developed around the concept of information. Consequently, for a study of IR models we have to go beyond the rather trivial approaches of internal representations of the documents[5]. For instance if the theory cannot express relations between information items, IR models with such a relational language (e.g. Farradane's relation indexing [28, 29]) are excluded.

Let us first explain how we see an IR model in a situation ontology. We have to state first what the domain of the aboutness relation is. Is it between models and formulas? Is the relation an association between a set of sentences and a sentence? What we need is an IR theoretic study of aboutness.

We already proposed that the aboutness relation can be seen as flow of information between two situations. Different IR models proposing different kind of flows, let us first inspect the basic aspects governed by all IR models.

First, there is a characterisation language that *digitalise* the information in a document. The keyword languages play a pivotal role in the majority of characterisation languages. Items of informations are keywords extract from the document. A set of items is termed *an index*. Following Devlin [17], we see this item of information as *an infon*. Using Dretske's terminology, we can see an infon as a *digitalized* piece of information.

Secondly, there is a matching function that determines whether a set of information items is about another set of information items. In order to create a platform for a discussion about aboutness decisions, we have to make some explicit assumptions of aboutness. The first of these is that aboutness can be derived with some sort of *logic*.

Formally, we represent the aboutness-relation with the symbol $S \,\Box\!\!\rightsquigarrow T$: intuitively this means that situation S is about situation T, and $S \,\Box\!\!\not\rightsquigarrow T$ means that S is not about T. In conformity with reality it is often not immediately clear if a situation S is about another situation T. We suggest that aboutness can be viewed as some sort of logical derivation. These logical derivations play an important role both in IR as well as in Situation Theory [18]. For instance, consider the extension of situation by union of another situation; can we decide that $S \cup T \,\Box\!\!\rightsquigarrow T$ for any arbitral situation S and T? Making this aboutness derivation explicit is the underlying idea of our work.

This kind of derivations are used to model derivation of IR models. In most cases an aboutness-relation can be described by an effectively calculated set of axioms and rules. This is for instance the case for derivation in classical proposition logic, but also for derivation in several modal logics [21].

The definition of the derivation system is the following:

Definition 3.1 (Derivation System) Given a language $\mathcal{L}$, a derivation system $\mathcal{A}$ is a pair of the form $(Ax, Rule)$, with Ax a set of axioms and $Rule$ a set of rules of the form $R(T_1, \ldots, T_k, T_{k+1})$. Here, T_1,. . .,T_k are the premises of the rule and T_{k+1} is the conclusion, with $T_i \in \mathcal{L}$.

[4]Given an information need N formulated as a query q, $Rel(N)$ is a set of relevant documents w.r.t. the information need, and $res(q)$ is a set of retrieved documents given the query, the recall and precisions values are defined as follows: $Recall(N,q) = \frac{|Rel(N) \cap res(q)|}{|Rel(N)|}$ and $Precision(N,q) = \frac{|Rel(N) \cap res(q)|}{|res(q)|}$.

[5]For example in typical IR systems a document is represented by a set of keywords.

Note that we do not make any statement about how the derivation relation is being determined by the derivation system. It is for example possible that this happens analogously to the classical logical derivation: an aboutness decision is derivable from another one if there is a range of 'intermediate' decisions, which are either an axiom or arise from previous decisions by application of a rule. However, one can also think about another derivation relation. It is for instance possible to consider a default theory (cf. [20]) as a derivation system. In that case the derivation relation is being defined by being an element of an extension; this derivation relation is in general not expressible in the way of the classical logical derivation relation. Generally, this is the case for non-monotonic derivation relations. This derivation system results in a sufficiently abstract framework in which the (plausible) inference mechanism of an arbitrary retrieval mechanism can be captured, and maps it to inference between aboutness relation of situations.

So in our meta-theory *aboutness* is treated as a relation between situations. Therefore aboutness is treated as a primitive notion with regard to information. This differs from other approaches like the Boolean model, in which aboutness can be expressed in terms of so called information containment.

We can propose postulates which are not universally valid but only hold within the context of a particular IR system. This offers the possibility to compare IR systems according to which axioms and rules they satisfy.

For instance, the Situation Theory model as proposed in section 2, is based on the reflexivity axiom, that is, every situation is about itself. One important postulate governed by many logical approaches and not by so-called overlap models[6], is the transitivity rule, also known as the Xerox-principle. Given that $S \Box\!\!\rightsquigarrow T$ and $T \Box\!\!\rightsquigarrow U$ we can conclude that S is about U. This rule is valid if the aboutness derivation is founded on boolean logic. However stating that there is an overlap of information items between set S and T and there is an overlap between T and U does not imply at all that there is an overlap between S and U. Therefore we can conclude that overlap aboutness decisions are not transitive [8].

The comparison process as follows: consider strict coordinate level matching, where d is about q if $q \subseteq \chi(d)$, and the boolean retrieval model, where d is about q if $\chi(d) \vdash q$ in a classical derivation system extended with the closed world assumption. We can state that the postulates of the derivation system modelling the strict coordinate level matching are a subset of the postulates of the derivation system of the boolean retrieval model. On the basis of this knowledge we can prove that the recall of a boolean retrieval system is always higher than or equal to that of a strict coordinate level matching system [8, 30].

After formulating the set of postulates given an IR model, we can distinguish some basic properties of sets of postulates. One important property, governed by some models and rejected by some other is non-monotonicity.

In the Artificial Intelligence field, the *non-monotonic* behaviour of rules (in their terminology, known as *non-monotonic reasoning*) plays an important role. A rather informal definition proposed by Łukaszewicz [31] clearly presents the idea of this sort of rules.

Definition 3.2 (Non-monotonic reasoning (Łukaszewicz '90)) By *non-monotonic reasoning* we understand the drawing of conclusions which may be invalidated in the light of new information. A logical system is called non-monotonic iff its provability relation violates the property of monotonicity.

In terms of IR, assume there is a document representation d which is about a request q. Now, if there is additional information about d (for instance by using a thesaurus), the question arises whether in this model d is still about q? Some authors argued that IR models should cover this non-monotonic character, as *natural* aboutness has a non-monotonic property [32, 33, 30].

4 Conclusions and Further Research

From Dretske's account of the role of a theory of information [14], Situation Theory seems the right framework for the qualitative modelling of the IR system. Situations and types show similarities with documents and their information content. Supported information corresponds to the explicit information content (digitalized) of the document, whereas carried information corresponds to its implicit information content. Constraints are the perfect tool to represent thesaural, or any semantic or pragmatic relationships.

[6] Where d is about q if $(q \cap \chi(d)) \neq \emptyset$, with χ denotes the representation function, in this case a set of information items.

We have also presented a guideline for a framework for IR based on Situation Theory. Within this framework, formal representatives of documents and their representation have to been outlined. By proposing a set of postulates, implicit assumptions governing an IR mechanism can be brought to light. The effectiveness of a retrieval mechanism can be examined, not only by running experiments, but inspecting the postulates of the model, and the properties and consequences of the postulates.

The use of Situation Theory to model an IR system or to develop a meta-model of an IR system led us to a better understanding of the nature of information in IR. This nature is multiple and can be studied in different perspectives. For example, in future research, we will look at the nature of information for user modelling. Indeed, a correct representation of the user (mental) intention certainly generates better retrieval. The attainment of such a representation enters the area of Cognitive Science, some aspects of which can be formally expressed with Situation Theory [17].

It also is interesting to note the use of a meta-model for studying uncertainty aspects in IR. Applying the method as proposed in [34] in our framework, it is possible to model relevance degrees at the deduction level of the underlying logic, in order to have them explicitly rest on preferential ground. This is based on the claim that user preferences on documents rest on preferences among aboutness properties: while making his choice the user takes for granted certain assumptions on aboutness, and certain preferences on these assumptions.

Another study that we will investigate is the representation of contexts, which recently has reached higher prominence in IR. For example, with networked IR (or any distributed database), which are increasingly pervasive, it is necessary to represent that retrieval is with respect to a site (a context). Moreover, two sites (contexts) may be involved in a retrieval process and the information retrieved from them must be aggregated. Situation Theory captures this notion of context with situations and background conditions.

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