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Fundamental Properties of Aboutness

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1. INTRODUCTION

Information retrieval (IR) is a reasoning process which is assumed to be driven by determining aboutness (|=) between two information carriers (i.e., document and query). Thus, the study of aboutness will be very helpful to set up the foundational theories of IR. Aboutness is modeled as a binary relation over the information carriers (IC). Early studies viewed aboutness as a form of entailment. We regard aboutness as a broader notion.

Recent attempts have been made to formalize properties of information carriers (IC). Early studies viewed aboutness as a reasonable (hopefully sound) properties of aboutness which is amenable to formal treatment. Thus, the purpose of this article is to consider aboutness from a fundamental, commonsense perspective, to shed light on the nature of aboutness by formalizing properties describing it, and to define a set of reasonable (hopefully sound) properties of aboutness, which is independent of any given IR model.

2. PRELIMINARY FRAMEWORK

Our framework is defined as {IC, →, ⊥,}, with the following properties:

(1) Reflexivity: A→A
(2) Transitivity: A→B, B→C ⇒ A→C
(3) Asymmetry: A→B doesn’t imply B→A
(4) Containment-Composition (CC): A@B→A; A@B→B
(5) Absorption: A→B ⇒ A@B=A
(6) Non-conflict containment (NCC): A→B ⇒ A⊥B
(7) Containment-Preclusion (CP): A→B, B⊥C ⇒ A⊥C

Where A, B, C ∈ IC; information containment (A→B) models the information is explicitly and implicitly nested; information composition (A@B) models A and B can be composed to more complex information carrier; information preclusion (A⊥B) means A clashes, or contradicts, with B.

3. “AXIOMATIZING” ABOUTNESS

The following are argued as commonsense aboutness properties:

(R) Reflexivity
(AS) Asymmetry
(AC) Aboutness Consistency:
A|= B
A⊥B

(C) Containment:
A→x→B
A|= B

where X is the maximal steps of transitivity of information containment to keep aboutness relation. Brooks found that it is approximately two-step [1].

(CT) Cut:
A @ B |= C A|= B
A|= C

(M) Mix: A|= C, B|= C
A@B|= C

(A) AND:
A |= B A|= C
A |= B⊕C

(QLM) Qualified Left Compositional Monotonicity:
A|= B B⊥C C⇒ A
A@C|= B

(QRM) Qualified Right Compositional Monotonicity:
A|= B A⊥C B→C
A|= B⊕C

(E) Equivalence:
A|= B B|= A A|= C
B|= C
4. NON-ABOUTNESS
Several authors have investigated this notion [2, 3, 5, 6]. Information filtering is an example of a situation where reasoning about the non-aboutness of incoming documents with respect to the user profile may be easier than reasoning about their aboutness. We drop the closed world assumption regarding |= and determine non-aboutness (⊥) via constructive means. In the following we describe commonsense properties of non-aboutness:

\[(P)\] Preclusion: \(\frac{A \in B}{A \not\models B}\)

\[(N-C)\] Containment Non-aboutness: \(\frac{A \rightarrow B}{A \not\models B}\)

\[(P-NA)\] Preclusion Non-aboutness: \(\frac{A \models B \land C}{A \not\models C}\)

\[(S-NA)\] Symmetry Non-aboutness

Proposition 1 P-NA and S-NA are derivable properties.

5. INTERACTION BETWEEN ABOUTNESS AND NON-ABOUTNESS
The following properties are normative rules depending on whether an optimistic or pessimistic stance is adopted. It is assumed that one is either an optimist or a pessimist.

\[(OL)\] Optimistic left: \(\frac{A \models B \land C \models B \quad A \rightarrow C}{A 
\oplus \models B \land C \models B \quad A \rightarrow C}\)

\[(OR)\] Optimistic right: \(\frac{A \models B \quad A \models C \quad B \rightarrow C}{A \not\models B \oplus C}\)

\[(PL)\] Pessimistic left: \(\frac{A \not\models B \quad A \not\models C \not\models B}{A \not\models B \land C \not\models B}\)

\[(PR)\] Pessimistic right: \(\frac{A \not\models B}{A \not\models B \land C}\)

6. COMPLETENESS, CONSISTENCY AND SOUNDNESS
The completeness of an aboutness reasoning system means for any two arbitrary information carriers A and B, the system must be able to conclude either \(A \models B\) or \(A \not\models B\).

Proposition 2 The aboutness and non-aboutness system \(\{R, C, QLM, QRM, E, P, N-C\}\) is complete.

It would be undesirable for an aboutness inference system to be inconsistent, i.e., \(A \models B\) and \(A \not\models B\) cannot be true at the same time.

Hypothesis The commonsense aboutness and non-aboutness systems together with a pessimistic stance \(PL, PR\) are consistent.

Verifying soundness cannot be approached as is traditionally done in logic: Aboutness is a fuzzier notion than truth. Moreover, unsoundness may be tolerated in order to promote recall of an IR system (i.e., via optimism). The degree of unsoundness may turn out to be a more pertinent question than whether an aboutness system is sound or not.

7. INTENDED APPLICATIONS
Aboutness is an important area in theoretical study of IR. Our belief is that a better understanding of aboutness will lead to significant breakthrough in IR theory and more effective IR systems. Moreover, it could be applied to the following fields:

- **IR functional benchmarking.** The traditional empirical methods (performance benchmarking) are good at evaluating the performance of a system, they are unable to assess its underlying functionality. This can be overcome by aboutness based functional benchmarking.

- **Query expansion.** This is also a reasoning process for query-query aboutness decision. The desirable properties of aboutness can serve as a guide to improve the effectiveness of the inference rules within the query expansion process.

- **Intelligent agents.** They can use aboutness, non-aboutness theorems and the interaction between them to help make relevance and non-relevance decision, e.g., in information filtering, the non-relevant documents are first excluded according to the work of non-aboutness agent.

8. FUTURE WORK
IR models often employ various weighting factors. For simplicity we have not considered them. In the future we plan to incorporate them by ordering the initial aboutness relationships and the inferences produced. Among other things, this will allow a more fine-grained analysis of aboutness and non-aboutness. In addition, we will consider "similarity" relation, which can model the document (or term) clustering, and its interaction with aboutness.

9. REFERENCES

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1 We use "hypotheses" here because at the moment this question is still being worked on.