SFB 378
Ressourcenadaptive
Kognitive Prozesse

MI3 DIALOG
Future Research

Project MI 3 — DIALOG — Pinkal, Siekmann, Benzmüller, Kruijff-Korbayová

WP1: Interpretation of Informal Mathematical Input

Robust Sentence-Level Analysis

- Processing “ill-formed” input (syntactic errors, incompleteness, out-of-grammar) through combination of deep and shallow methods:

  In diesem Fall: z.B. $K(A)$ = dem Begriff $K(A \cup B)$

- Extension from written-only to simultaneous written and spoken input, accompanied with simple pointing/selection on screen

Discourse Representation of Informal Mathematical Input

Und wenn $B \subseteq K(A)$ sein soll, muss es auch Element von $K(A)$ sein.

- Coreference of symbolic identifiers
- Anaphoric reference to parts of mathematical expressions
- Discourse structure as reflex of proof structure

Ontology-Based Domain-Specific Interpretation

- Informal and/or imprecise naming of domain concepts and relations:

  A muss in B sein
  . . . B vollstaendig ausserhalb von A liegen muss . . .
  . . . dann sind A und B vollkommen verschieden

- Semantically complex operators:

  Wenn alle A in $K(B)$ enthalten sind und dies auch umgekehrt gilt, . . .

WP2: Proof Management and Proof Step Evaluation (PSE)

Abstract-level Proof Representation

- Required for PSE:
  cognitive oriented proof representation

PSE example scenario

Assertions already introduced
(A1) $A \wedge B$.
(A2) $A \Rightarrow C$.
(A3) $C \Rightarrow D$.
(A4) $F \Rightarrow B$.
(G) $D \vee E$.

Alternative proof step directives.
(a) From the context follows D.
(b) B holds.
(c) It is sufficient to show D.
(d) We show E.

PSE: Novel Theorem Proving Application

Criterion	*Task (first approach)*	*Requirements for theorem prover*
Soundness	$E \vdash^?_C D \vee E$	'Yes' or 'No' answer; any theorem prover resp. calculus C
Granularity	proof-steps($E \vdash^?_C D \vee E$)	adequate abstract-level theorem prover resp. calculus C; measure ‘shortest’ proof; take tutorial constraints into account; proof planning or assertion level reasoning?
Relevance	$A \wedge B$, $A \Rightarrow C$, $C \Rightarrow D$, $F \Rightarrow B$ $\vdash^?_C E$	recognize detours; compare with other ‘shorter’ proofs; take tutorial constraints into account; forward case more challenging

WP3: Domain Reasoning for Ambiguity Resolution

An example

Discourse:
(1) From previous observations we know that A or B.
(2) The former implies D by Lemma X.
(3) Similarly, from the latter follows C.

Alternative user utterances with underspecification:
(a) From this follows C since C implies D by Lemma Y.
— *this may refer to (1)+(2)+(3), to (3), or even (2) with wrong justification*
(b) It holds D since C implies D by Lemma Y.
— *no underspecified anaphoric reference but ambiguity at domain reasoning level*

- Ambiguities may arise at linguistic and domain reasoning level.
- Ambiguities are resolved by a combination of linguistic processing and proof step evaluation.
- Remaining ambiguous readings are explicitly represented and ranked.
- The use of underspecification techniques (CHORUS) will be explored.

Further ambiguity examples

Example	*Where does ambiguity arise?*	*Ambiguity resolution means*
(1) $x \in B$ und somit $x \subseteq K(B)$ und $x \subseteq K(A)$ wegen Vorraussetzung (2) A enthaelt B	linguistic meaning level; attachment, coordination	linguistic means; type checking in (2)
(3) P((A∪C)∩(B∪C))=PC ∪(A∩B) (4) K((A∪C)∩(B∪C))=KC ∪(A∩B)	linguistic meaning level; informal character of discourse	type checking for (3); mathematical domain reasoning for (4)
(5) **T1:** Bitte zeigen Sie: $K((A \cup B) \cap (C \cup D)) = (K(A) \cap K(B)) \cup (K(C) \cap K(D))$! **S1: nach deMorgan-Regel-2 ist** $K((A \cup B) \cap (C \cup D)) = (K(A \cup B) \cup K(C \cup D))$	underspecified proof step	mathematical domain reasoning

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