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. \( K(A) = \text{dem Begriff } K(A \cup B) \)
  - Extension from written-only to simultaneous written and spoken input, accompanied with simple pointing/selection on screen

Discourse Representation of Informal Mathematical Input
- 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 vollständig ausschließlich 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: Novel Theorem Proving Application

<table>
<thead>
<tr>
<th>Criterion</th>
<th>Task (first approach)</th>
<th>Requirements for theorem prover</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soundness</td>
<td>( E \lor C \lor D \lor E )</td>
<td>Yes or ‘No’ answer; any theorem prover resp. calculus C</td>
</tr>
<tr>
<td>Granularity</td>
<td>proof-steps(( E \lor C \lor D \lor E ))</td>
<td>adequate abstract-level theorem prover resp. calculus C; measure ‘shortest’ proof; take tutorial constraints into account; proof planning or assertion level reasoning?</td>
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</tbody>
</table>
| Relevance | \( A \land B \)
\( A \Rightarrow C \)
\( C \Rightarrow D \)
\( F \Rightarrow B \) | 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:
(a) From the context follows \( D \) since \( C \) implies \( D \) by Lemma \( Y \).
(b) It holds \( D \) since \( C \) implies \( D \) by Lemma \( Y \).
(c) From this follows \( D \) since \( C \) implies \( D \) by Lemma \( Y \).
(d) We show \( \neg A \land B \)...

- 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

<table>
<thead>
<tr>
<th>Example</th>
<th>Where does ambiguity arise?</th>
<th>Ambiguity resolution means</th>
</tr>
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<tbody>
<tr>
<td>(1) ( x \in B ) und somit ( x \subseteq K(B) ) und ( x \subseteq K(A) )</td>
<td>linguistic meaning level; attachment, coordination</td>
<td>linguistic means; type checking in (2)</td>
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<tr>
<td>(2) ( A ) enthält ( B )</td>
<td>linguistic meaning level; informal character of discourse</td>
<td>type checking for (3); mathematical domain reasoning for (4)</td>
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<td>(3) ( P(A, C) \lor (B, \neg C) = PC \lor (A \lor B) )</td>
<td>underspecified proof step</td>
<td>mathematical domain reasoning</td>
</tr>
<tr>
<td>(4) ( K(A, C) \lor (B, \neg C) = KC \lor (A \lor B) )</td>
<td></td>
<td></td>
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<tr>
<td>(5) T1: Bitte zeigen Sie: ( K(A \lor B) \cap (C \lor D) )</td>
<td></td>
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<tr>
<td>S1: nach deMorgan-Regel-2 ist ( K(A \lor B) \cap (C \lor D) )</td>
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