MI 3: DIALOG
Research Foci in Phase One

Experiment and Corpus

Input Analysis

- Takes interleaved natural language and mathematical user input of varying degree of informality
- Transforms it to domain reasoner format via deep syntactic and semantic analysis
- Manages a variety of referential, structural, lexical, and domain-related ambiguities arising on the way

\[ B \text{ contains } x \in A \]

\[ \text{math parsing} \]
\[ \text{math expression substitution} \]
\[ \text{sentence parsing} \]

Proof Management

**Direct Support for Assertion-level Reasoning**

- The assertion application module constructs and represents proofs at assertion-level: “by applying the DeMorgan rule, we can prove \( (A \cup B) \cap (C \cup D) = (A \cap C) \cup (B \cap D) \) by showing that \( (A \cup B) \cup (C \cup D) = (A \cap C) \cup (B \cap D) \).”
- Large mathematical databases incur expensive search for applicable assertions. Proposed solutions: agent-based architecture.

**Resolution of Underspecified Knowledge**

- Reconstruct user proof at assertion-level and match it with a ‘golden’ proof of the main problem.
- A problem is to adapt the symbols used by the user to those of the system.

**First Approach to Proof Step Evaluation**

- Evaluation of a user proof step along the three dimensions: soundness, relevance and granularity.
- Current approach for granularity and relevance: relate assertion-level user proof to a ‘golden’ proof of the main problem.
- Challenge: recognize user’s intention (reasoning direction, strategy, etc.).

Tutoring

Flexible natural language dialog allows the realization of different tutoring strategies. In particular, we looked into

**Didactic method** where the tutor provides (didactic) explanations and asks questions directing the student towards already explained information.

**Socratic method** is characterized by eliciting information from the student through a directed line of reasoning, thus encouraging active learning.

**Algorithm Simulating Socratic Tutoring Strategy**

- Allows students to build their own schemas, and to reflect on the tutoring feedback.
- Employs as input the current proof step, proof status, task related dialogue status, and characterization of the student input.
- Hinting session status specifies pedagogically relevant information (domain dependent and independent).
- Content specification of hint categories is based on enriched mathematical ontology and dialogue purposes.

**Multi-dimensional Hint Taxonomy**

- Proof step information: domain relation/objects, inference rule, substitution
- Performable step vs. meta-reasoning: info in proof step vs. its explanation
- Active vs. passive: into elicited vs. info given away
- Conceptual vs. pragmatic: different ways of referring to same info

Hint categories constitute different combinations of the dimensions.