An Approach to Generating Human-computer Interfaces from Task Models

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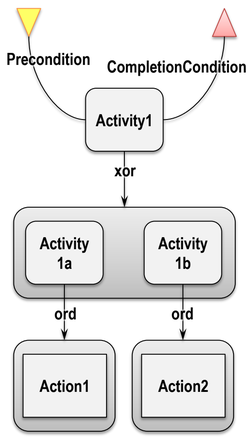
Introduction

- Human-computer interaction (HCI) can occur in situations unanticipated by designers and thus not always be usable or support operator tasks
- The proposed method uses existing work, which shows that formal methods and L* machine learning can be used to analyze and design robust HCI, to automatically generate interface designs from task models guaranteed to usably support operator task goals

Task Model

- Human task behavior is represented using the Enhanced Operator Function Model (EOFM)
- Human behavior is captured as a hierarchy of goal-directed activities and actions
- Strategic knowledge describes when activities are relevant
- Decomposition operators define the ordinal relationships between activities and actions

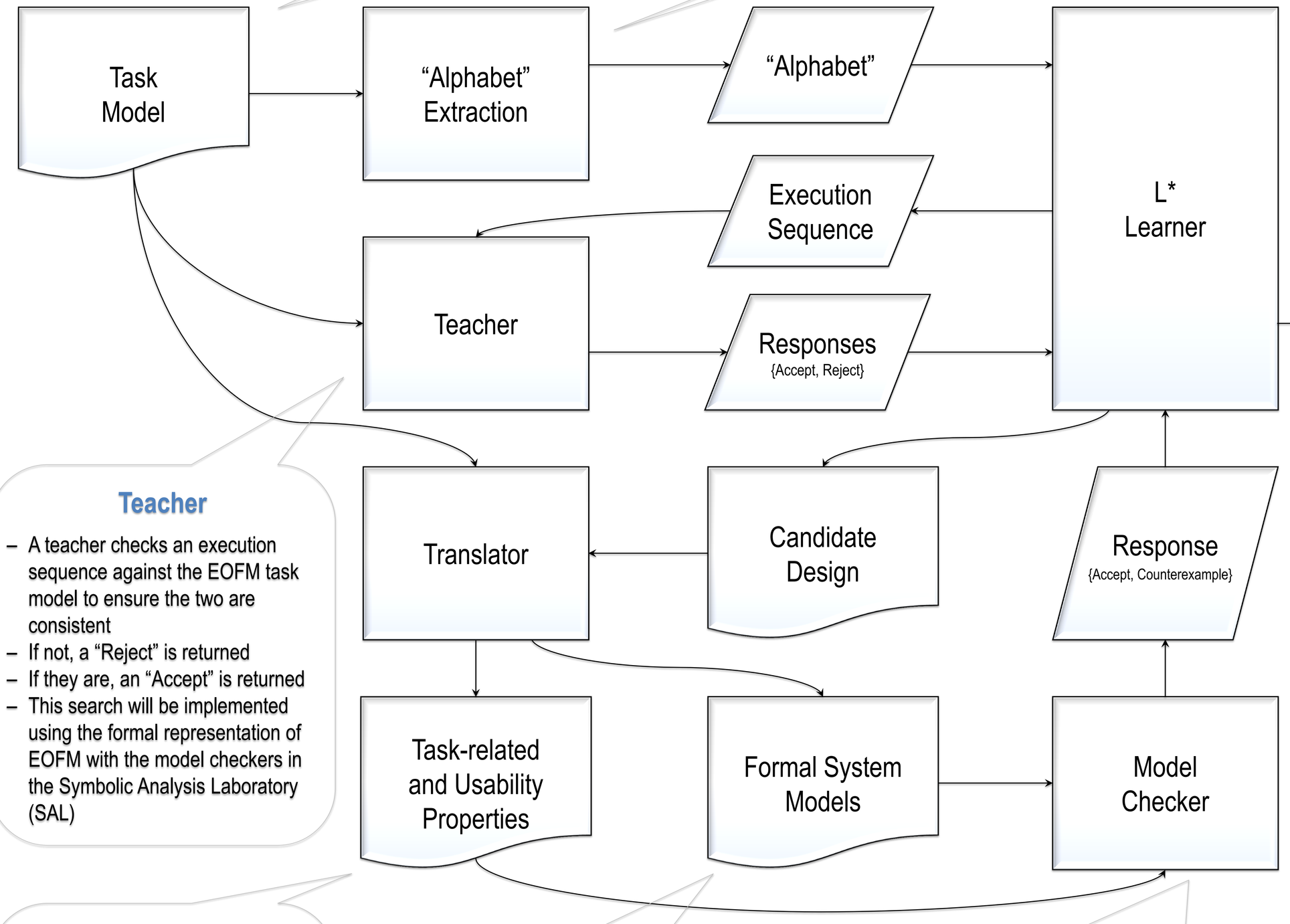


"Alphabet" Extraction

- Task models are parsed to find the events that trigger changes in the human-computer interface:
  - Human actions
  - System conditions from task strategic knowledge
- These are treated as characters in the alphabet accepted by a finite state machine representing the interface design

L* Learner

- An L* algorithm iteratively learns a finite state automata representation of an interface design by issuing queries and producing candidate designs that are examined by other processes in the approach
- Queries represent execution sequences ("strings" of "alphabet" characters)
- The L* Learner receives inputs indicating if a produced execution sequence is valid or not
- Candidate interface designs represent learned interfaces consistent with previous inputs
- The L* Learner receives inputs indicating if the candidate is valid or not and, if not, an illustrative unacceptable execution sequence (a counterexample)



Teacher

- A teacher checks an execution sequence against the EOFM task model to ensure the two are consistent
- If not, a "Reject" is returned
- If they are, an "Accept" is returned
- This search will be implemented using the formal representation of EOFM with the model checkers in the Symbolic Analysis Laboratory (SAL)

Interface Design

- The produced finite state machine will represent a human-computer interface design guaranteed to always support the human behavior in the task model and adhere to the checked usability properties
- The formal model can then be used in the design, implementation, and testing of the actual human-computer interface

Task-related and Usability Properties

- A translator uses the design and task model to generate LTL specification properties for checking the candidate design
- Task-related specification properties that assert desirable properties of task execution are generated from the EOFM task models
- Usability property patterns and the candidate design are used to create usability specifications

Formal System Models

- Two formal system models are created
- Model 1 represents the human operator interacting with the candidate design with the behavior in the task model
- Model 2 represents the candidate interface design's behavior independently of the human behavior in the task model

Model Checker

- A model checker (SAL) is used to evaluate the acceptability of the candidate design
- It does this by checking the two formal system models against the generated specification properties
- Model 1 is checked against the task-related properties
- Model 2 is checked against all other usability properties
- If a verification fails, the counterexample illustrating why the interface is unacceptable is returned
- If all of the specifications are verified, "Accept" is returned

Conclusions and Future Work

- The implementation of this approach is currently underway
- If successful, the approach has the potential to improve the usability of human-computer interfaces and encourage user-centered design
- The implemented approach will be tested and validated using artificial examples as well as a PCA pump application

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