Constraint-based tutors

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Motivation

- Difficulties with automated student models
  - It is hard to generalize student models that were used in arithmetic and algebra.
  - Representations of the student’s knowledge had to be overly specific.
  - It is impossible to determine what is going in a student’s head.
- An incomplete model can still be very efficient. (Stern, Beck & Woolf, 1996)
- Learn the student’s ability using the errors he makes.
Constraints

State constraint
A state constraint is an ordered pair \( < C_r, C_s > \), where \( C_r \) is the relevance condition and \( C_s \) the satisfaction condition.

Examples
If the code for a Lisp function has \( N \) left parentheses (\( C_r \)), there has to be \( N \) right parentheses as well (\( C_s \)).

If \( (x + y)/d_1 \) is given as the answer to \( x/d_1 + y/d_2 \) (\( C_r \)), then it has to be the case that \( d_1 = d_2 \) (\( C_s \)).
Determining constraint violation is a two-step process

1. Check for each constraint whether the relevance condition is satisfied.

2. Check for each relevant constraint whether the satisfaction condition is satisfied.
Student model

Previous student model
Determine the ability $\theta$ of the student on each concept of a subject and choose items that are in line with the student’s ability.
**Student model**

**Previous student model**
Determine the ability $\theta$ of the student on each concept of a subject and choose items that are in line with the student’s ability.

**Student model with CBT**
Record for each constraint
- how many times it was relevant.
- how many times it was violated.

Determine which constraints are either often violated by the student or that have not been relevant yet.
SQL-tutor
Feedback

- No step-by-step diagnosis. Only give feedback after a submission.
- Feedback on one specific constraint violation
- Different levels of detail for feedback messages: right/wrong, error flag, hint, partial solution and complete solution
Types of constraints

Syntactic

- Constraints on the form of the query
- Relatively easy to write
- Relevant for a large number of problems
- Check for valid attribute names, correct use of keywords like ‘GROUP BY’ and ‘HAVING’

Semantic

- Constraints on the meaning of a query
- Generally more difficult
- Fewer relevant problems, sometimes problem-specific
- Check that a query is sorted in decreasing order.
Example

(p 2
  "The SELECT clause is a mandatory one. Specify the attributes/expressions to retrieve from the database."
  t
  (not (null (select-clause ss)))
  "SELECT")
Evaluation study

- 20 students, two-hour session
- Probability of violating a constraint decreased when the number of occasions the constraint was relevant increased
- Classroom performance: on average 11.5 point out of 100 better
Thank you for your attention!


S. Ohlsson. Constraint-based student modeling.

Adaptation of problem presentation and feedback in an intelligent mathematics tutor.