Evaluating Context-Adaptive User Modeling Techniques For Adaptive Educational Hypermedia Systems

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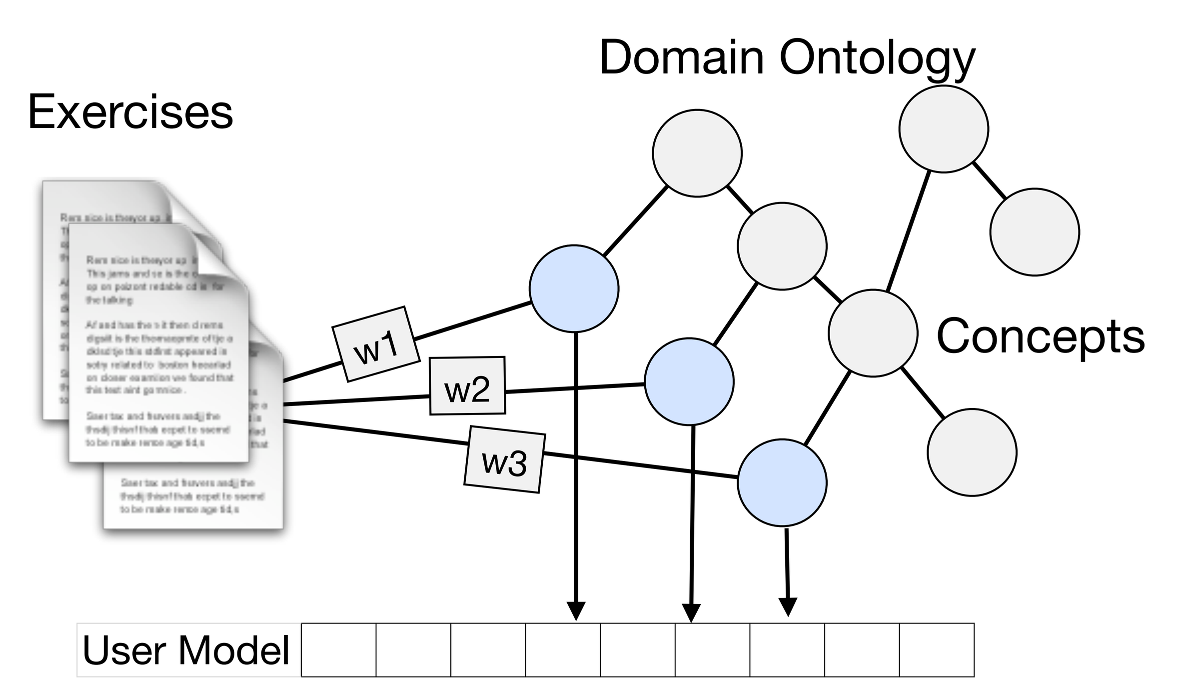
Abstract

User model is a corner-stone of any adaptive system. Without collecting, processing, and managing user-related information an effective user-adapted system simply cannot be built. Since the emergence of the field of user modeling a great number of approaches to modeling users has been proposed. Unfortunately, many of these approaches lack proper evaluation. One of the key aspects of user model evaluation is whether, in fact, the assumptions that it holds about the users are correct.

Another important aspect of the adaptive system's user modeling component is whether user modeling functionality is generic or adapted to the specific context of the user modeling task. After almost two decades of research it has been found that truly generic user modeling systems are quite hard to develop and are rarely practical. Context-adaptable user modeling systems on the contrary are getting more attention.

This work addresses the questions of the accuracy of the context-adaptive user modeling algorithms in the area of adaptive educational hypermedia systems. We have collected several semesters worth of learning logs containing problem solving attempts of students working with an educational system targeted at teaching SQL. A set of user modeling techniques has been evaluated using these logs. The evaluation was targeted at comparative assessing the quality of user modeling techniques as well as exploring the effect their context-adaptability.

Crash Course In Modeling Knowledge (1)



Modeling Knowledge. Legacy CUMULATE (2)

- ★ Overlay model of the domain
- ★ Modeling from positive evidence only
- ★ Weighted impact on concepts
- ★ Penalty for "over-practicing" each exercise
- ★ Non-parameterizeable (one-fits-all)

$$k_0 = 0$$

$$k_{n+1} = k_n + res\cdot(1-k_n)^2\cdot\begin{cases} w/2 & k_n \le .5 \\ w & k_n > .5\end{cases}$$

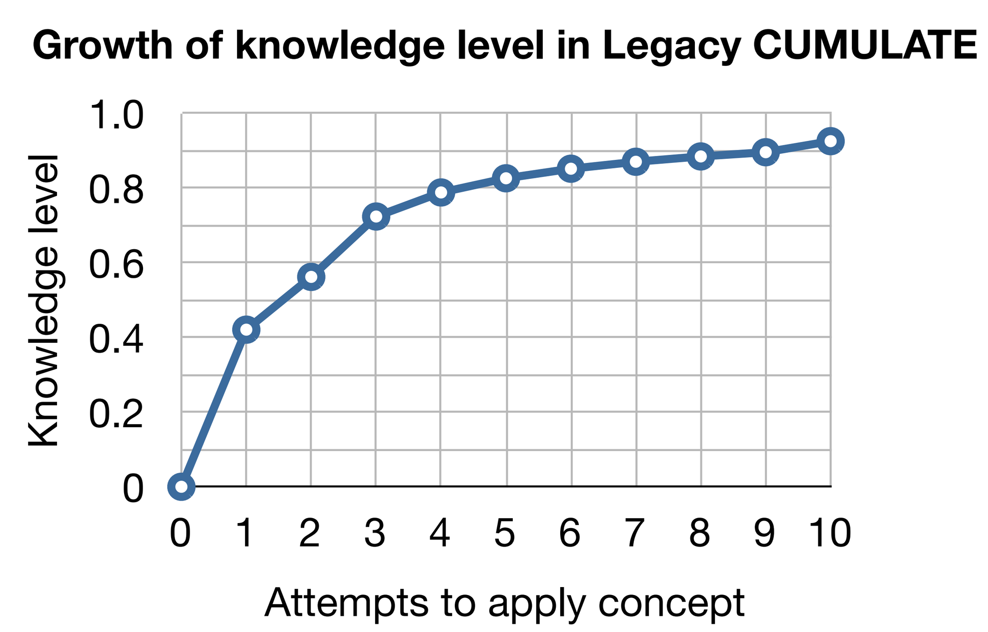
$$w = \sqrt[4]{\frac{w_{c,p}}{\sum_i w_{c_i p}\cdot\left({}_{succ}att_p + 1\right)}}$$

0-error, 1-correct

weight of concept c in problem p

sum of all concept weights in problem p

over-practice penalty (opp): number of prior correct solutions to problem p



Modeling Knowledge. CUMULATE X (3)

- ★ All that Legacy CUMULATE is, plus parameters for ...
- ★ Initial level of concept knowledge (Ko)
- ★ Speed of concept learning (pV)
- ★ "Over-practicing" Penalty (OPP)

$$k_0 = 0$$

$$k_{n+1} = k_n + res\cdot(1-k_n)\cdot pV \times \frac{1}{\left({}_{succ}att_p + 2\right)^{OPP}}\cdot\frac{w_{c,p}}{\sum_i w_{c_i p}}$$

0-error, 1-correct

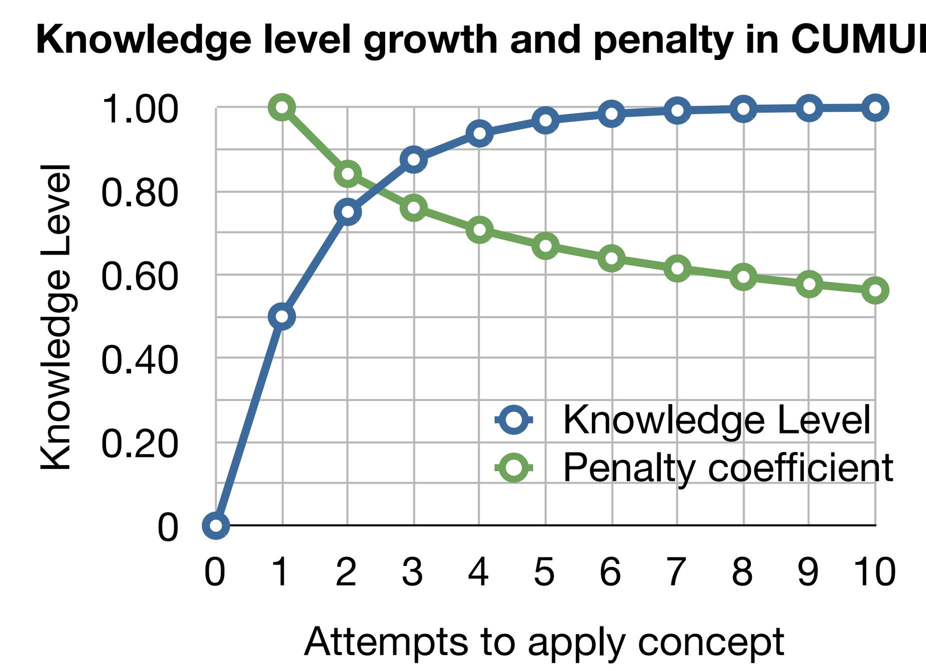
speed of knowledge growth

weight of concept c in problem p

number of prior correct solutions to problem p

over-practice penalty

sum of all concept weights in problem p



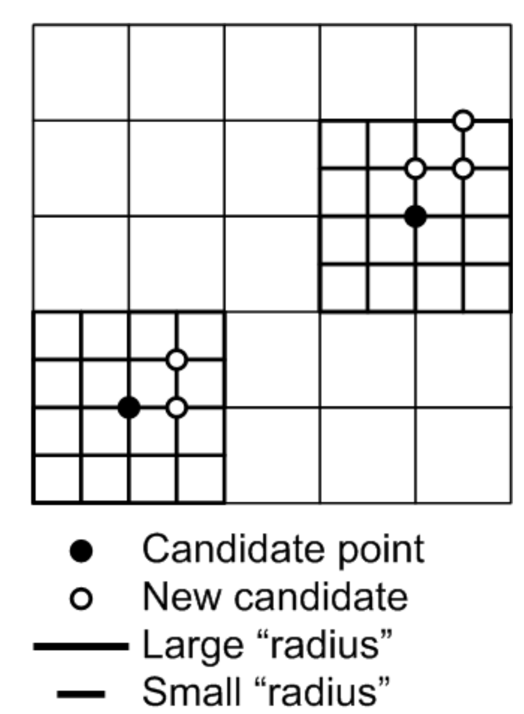
Experiment (4)

School	Sem.	Lvl	Users	Datapts.	µAttempts	µProblems
Pitt	08-1	U	27	4224	156.44	29.96
Pitt	08-1	G	20	1233	61.65	29.95
Pitt	08-2	U	15	458	26.94	16.35
NCI	08-2	U	17	216	12.71	6.59
NCI	08-2	U	18	142	7.89	4.00
DCU	08-2	U	52	4574	81.68	22.82

- ★ Use data from Pitt 08-1 U semester to...
- ★ Fit problem-specific and student-specific parameters
- ★ On global (for-all) and individual (for-each) scale
- ★ Extrapolate fit parameters to the rest of semesters
- ★ Compare results

Parameter Fitting (4.1)

Problem-specific



Optimized "sub-exhaustive" search in the parameter space with sliding search radius and 5th percentile candidate selection.

Student-specific

Wilcoxon's statistic aka Area Under ROC curve - probability of any random response/result being positive.

Combining problem/student-specific parameters

$$c = \frac{p\cdot s}{p\cdot s + (1-p)}$$

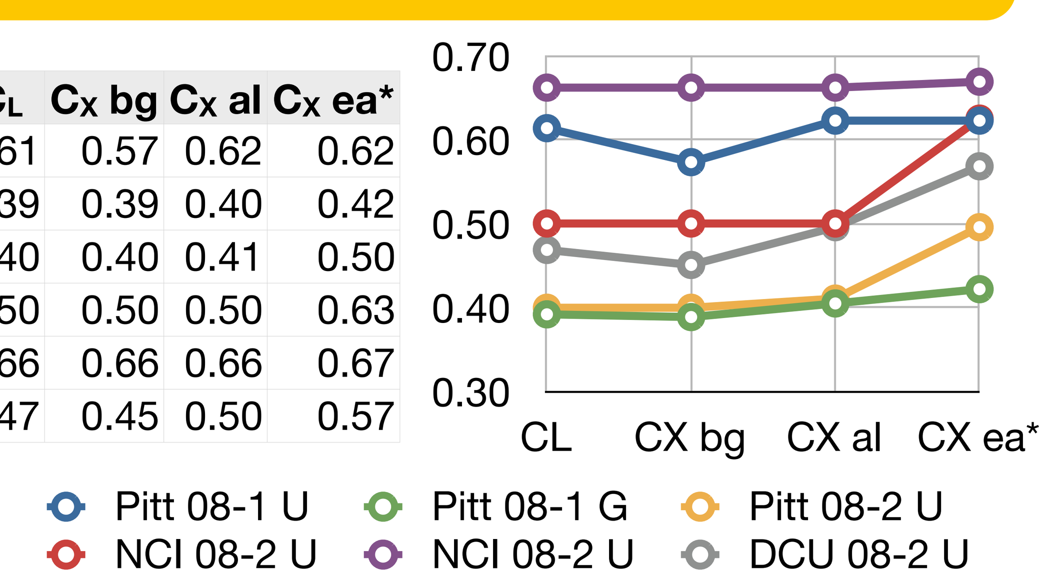
Procedures (4.2)

- ★ Obtain problem- and student- specific parameters on global (for-all) and individual (for-each) scale by fitting Pitt 08-1 U data
- ★ For all semesters, compute modeling accuracy and SSE for:
  - ★ Legacy CUMULATE
  - ★ CUMULATE X best guess global parameters
  - ★ CUMULATE X fit with for-all parameters
  - ★ CUMULATE X fit with for-each parameters*

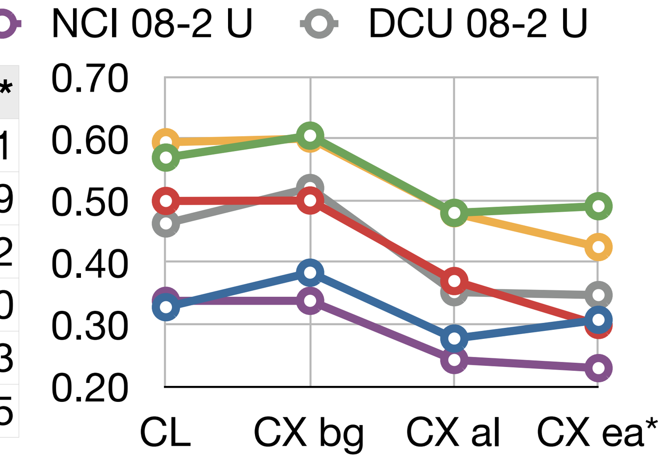
* Use student for-all parameter for semesters other than Pitt 08-1 U, w/o re-fitting individual student parameters

Results (4.3)

Accuracy	C_L	C_X bg	C_X al	C_X ea*
Pitt 08-1 U	0.61	0.57	0.62	0.62
Pitt 08-1 G	0.39	0.39	0.40	0.42
Pitt 08-2 U	0.40	0.40	0.41	0.50
NCI 08-2 U	0.50	0.50	0.50	0.63
NCI 08-2 U	0.66	0.66	0.66	0.67
DCU 08-2 U	0.47	0.45	0.50	0.57



SSE	C_L	C_X bg	C_X al	C_X ea*
Pitt 08-1 U	0.33	0.38	0.28	0.31
Pitt 08-1 G	0.57	0.60	0.48	0.49
Pitt 08-2 U	0.59	0.60	0.48	0.42
NCI 08-2 U	0.50	0.50	0.37	0.30
NCI 08-2 U	0.34	0.34	0.24	0.23
DCU 08-2 U	0.46	0.52	0.35	0.35



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