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Taking the Teacher's Perspective for User Modeling in Complex Domains

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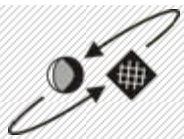

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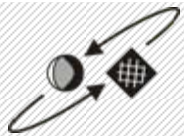
Serious games

- Games might be a good training environment (Aldrich, 2005; Gee, 2003, Michael and Chen, 2005)
- Serious games: games that focus on more than fun, by training specific content or skill.
- Mentioned advantages of serious games: (Gee, 2003)
  - It's a natural medium to use for young people
  - Fun might encourage longer learning
  - Learning by doing instead of learning theory outside of context



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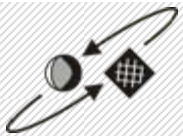
Serious games

- Question: how can the training be focused most on the challenges of the player at hand?
  - Develop a user model with estimated capacities of student
  - Adapt training using this user model
- This has similarities with the domain of intelligent tutoring systems
- In this presentation a new method for user modeling in complex domains will be presented



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Intelligent Tutoring Systems

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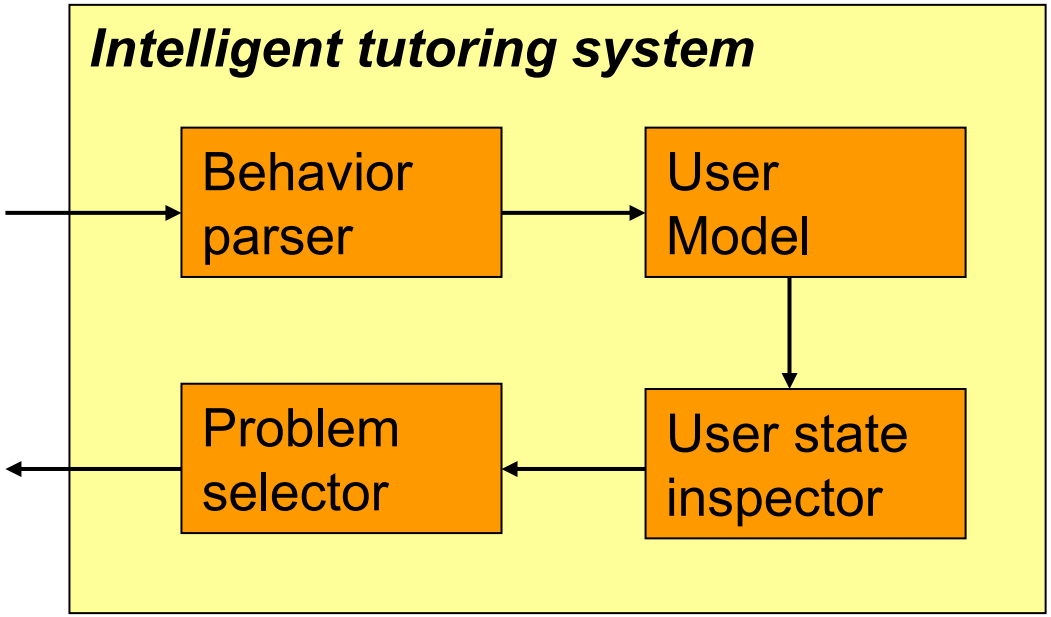

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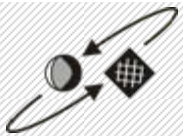
Intelligent Tutoring Systems

- Normal approaches are often only applicable in hierarchical & well-studied domains
- For example: model tracing (Anderson & Gluck, 2001)
  - Tries to develop a model of the (in)correct knowledge of a student
  - These systems map a user's actions to specific mental processes



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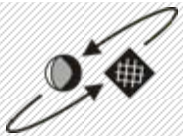
Hierarchies & serious games

- Games are often rich environments with a lot of interaction possibilities
  - It is difficult to map each specific action to a specific mental process
- Problem: incorrect mapping might lead to an *incorrect user model*, and therefore to incorrect training adaptation
- Possible solution: restrict the set of interactions
  - Serious gaming: no! Multiple routes (Gee, 2003)
  - Intelligent tutoring: no! Be *flexible*, *adapt* to the individual (Ohlsson, 1986)



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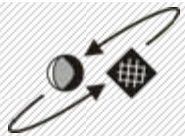
Teacher Modeling

- Possible solution for domains that lack theories of hierarchy: Teacher Modeling
- Main idea: as it is difficult to model the thoughts of a *student/player*, try to model aspects of the thoughts of the *teacher*



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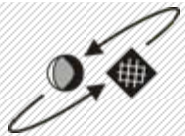
Teacher Modeling

- Assess the capacities of the student
  - Assessments play a critical role in normal (classroom) learning settings (Shepard, 2000)
- Act like a teacher who:
  - Does not always know *what* a student is thinking
  - Does know *when* a student is making a mistake
  - Can make an *assessment over time* that states what skills are performed correct and incorrect
  - Needs *observations* to *prevent forgetting* the assessment



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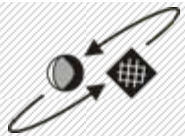
Teacher Modeling

- Teacher modeling requires:
  - Set of training objectives: training dimensions
    - Will often be very broad, as fine-grained (model tracing) approaches are difficult to apply
  - Set of training exercises
    - With multiple outcomes
    - And an indication of the student's behavior for each outcome and each dimension



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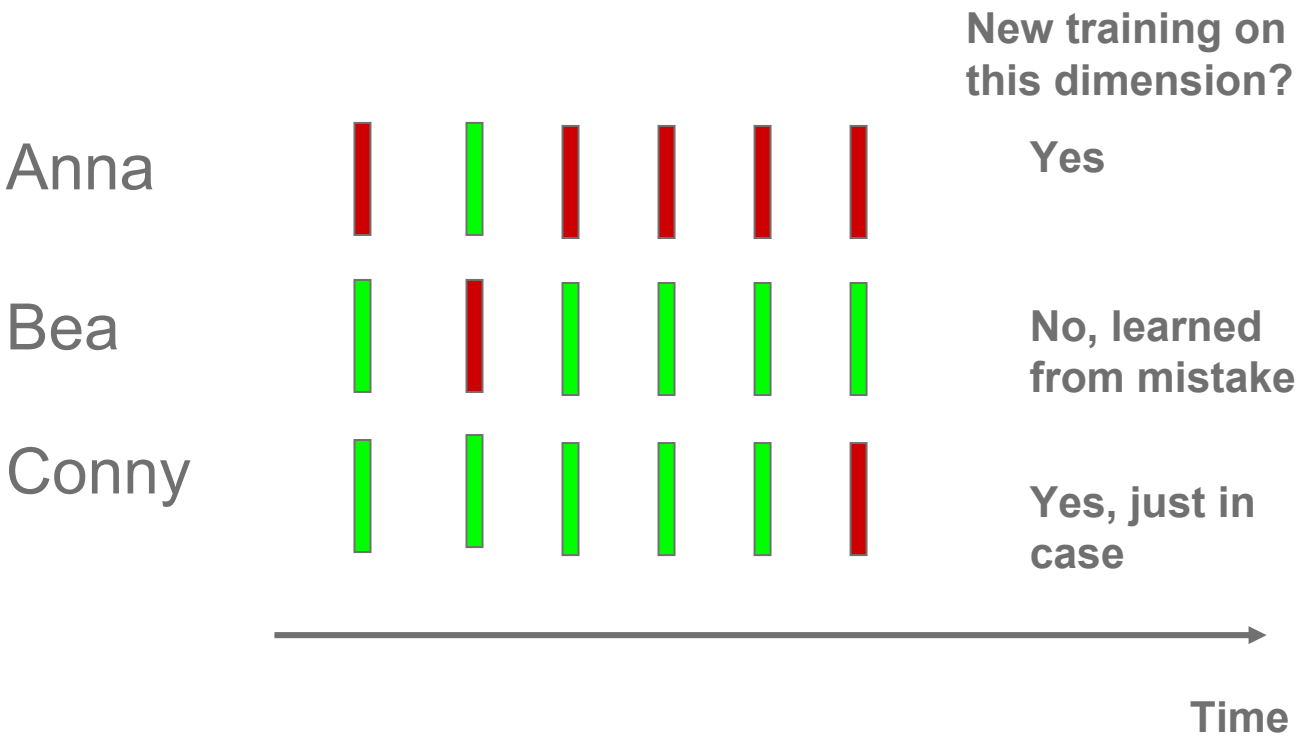
Teacher Modeling

› What would a teacher think of the following students?



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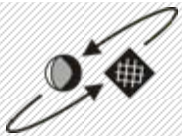
Teacher Modeling

- Important to keep track of:
  - Positive and negative occurrences
  - Frequency of occurrence
  - Recency of occurrence
- Formal theories of declarative memory can take this into account (Anderson & Schooler, 1991)
  - Information containing unit: Chunk
- Chunks have an activation level
  - Represents usefulness of chunk in the past (Anderson *et al.*, 2004; Anderson and Lebiere, 1998)
    - In case of our model: “how representative is this behavior for the current student?”



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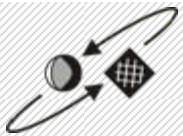
Teacher Modeling

- Keep track of a student's skills using three chunks for each dimension:
  - Amount of *positive completed* exercises
  - Amount of *negative completed* exercises
  - Overall *amount of training*



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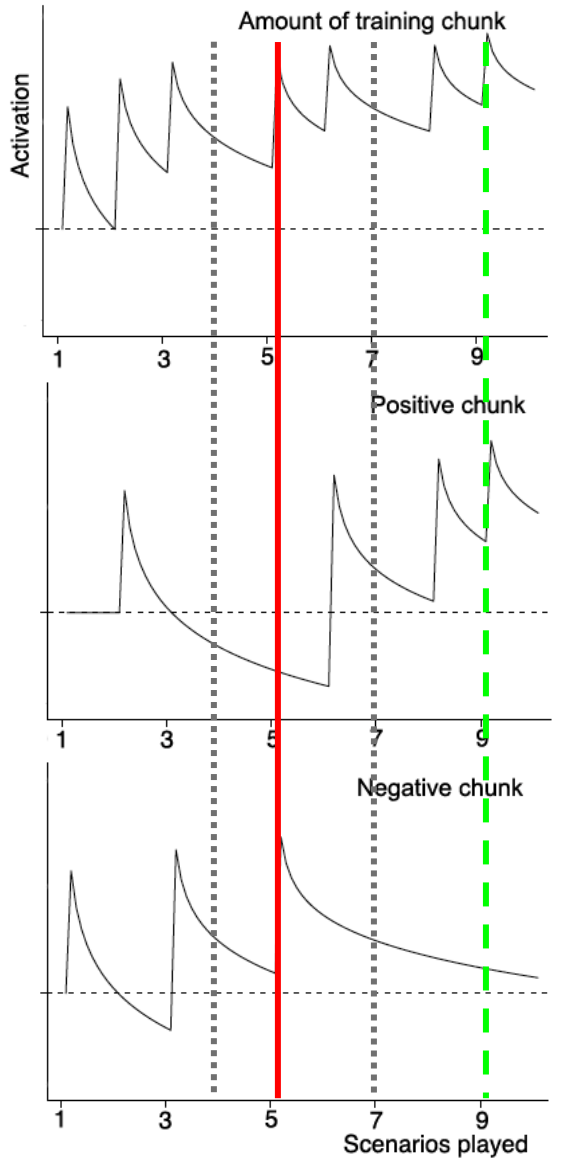
Example

- Base-level learning equation:

$$A_i = \ln\left(\sum_{j=1}^{n} t_j^{-d}\right)$$



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Formal decision rules

1. Transform activation score into probabilistic score
   (Anderson *et al.*, 2004; Anderson and Lebiere, 1998)

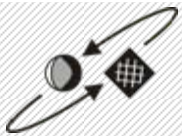
$$P_i = \frac{1}{1 + e^{-(A_i - \tau)/s}}$$

"How certain am I that the student performs the behavior in this manner?"

2. Overall measure of dimension performance:

$$Total_j = P_{positive(j)} + \left(1 - P_{negative(j)}\right) + P_{training(j)}$$

3. Train dimension with lowest total score



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Does it work?

- *"Does the model correctly adapt to the characteristics of individual students?"*
  - By focusing training mostly on the most challenging dimensions

- Tested in simulations

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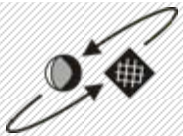
Simulations

- Train 4 dimensions during two hundred training exercises
  - Each exercise “trains” one dimension and has two possible outcomes: positive or negative
- Time between trainings was constant
- Always keep training varied:
  - Dimension with highest score on amount of training chunk was excluded from selection



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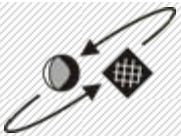
Simulations

› 4 types of students were simulated

	% of questions correct , per dimension			
	A	B	C	D
Novice	0%	0%	0%	0%
Intermediate	50%	50%	50%	50%
Partial expert	25%	25%	75%	100%
Expert	75%	100%	100%	100%

› Simulations had a consistent character
  - no “learning”



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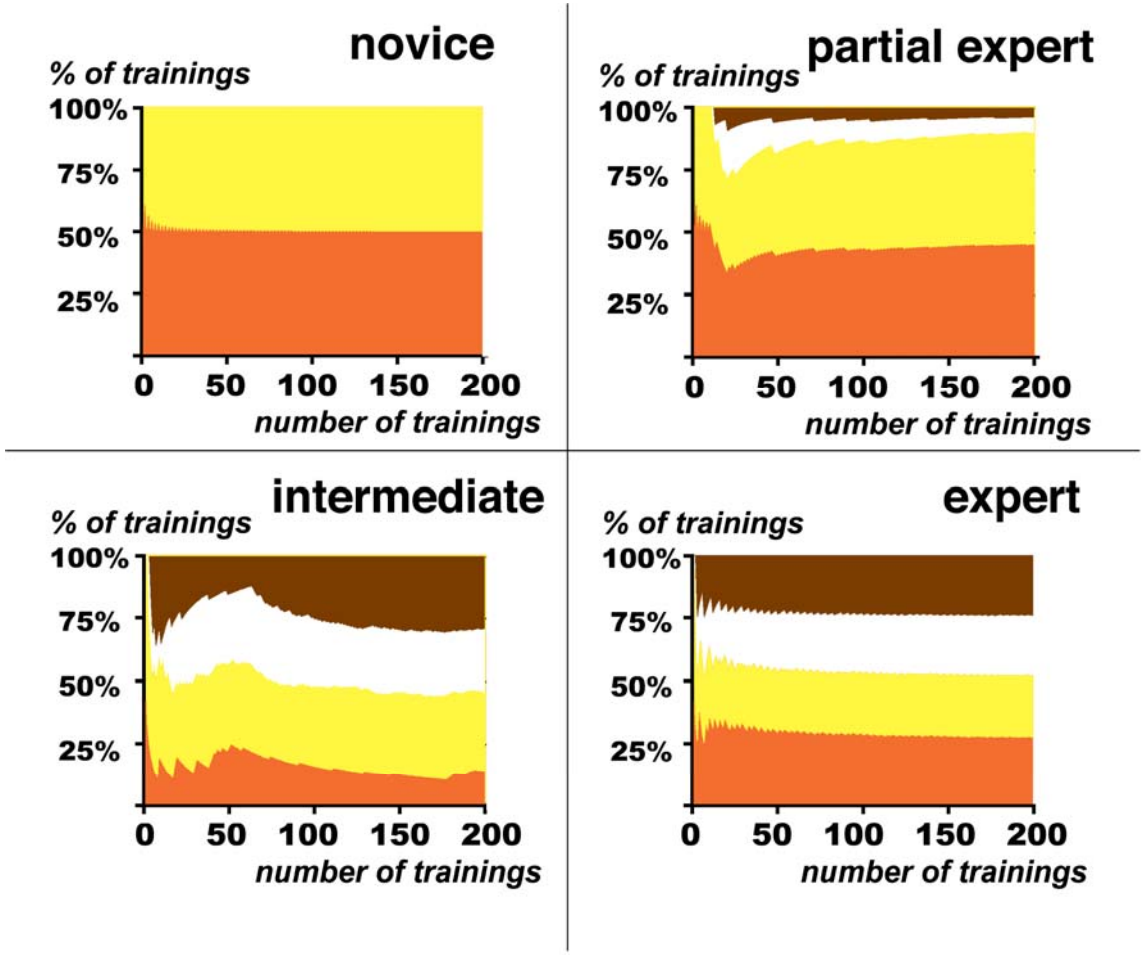
Simulation 1



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Simulation 2

"What if students learn during the training, and change their behavior?"

- Characters became 1% more likely to complete an exercise correctly, each time they trained the dimension

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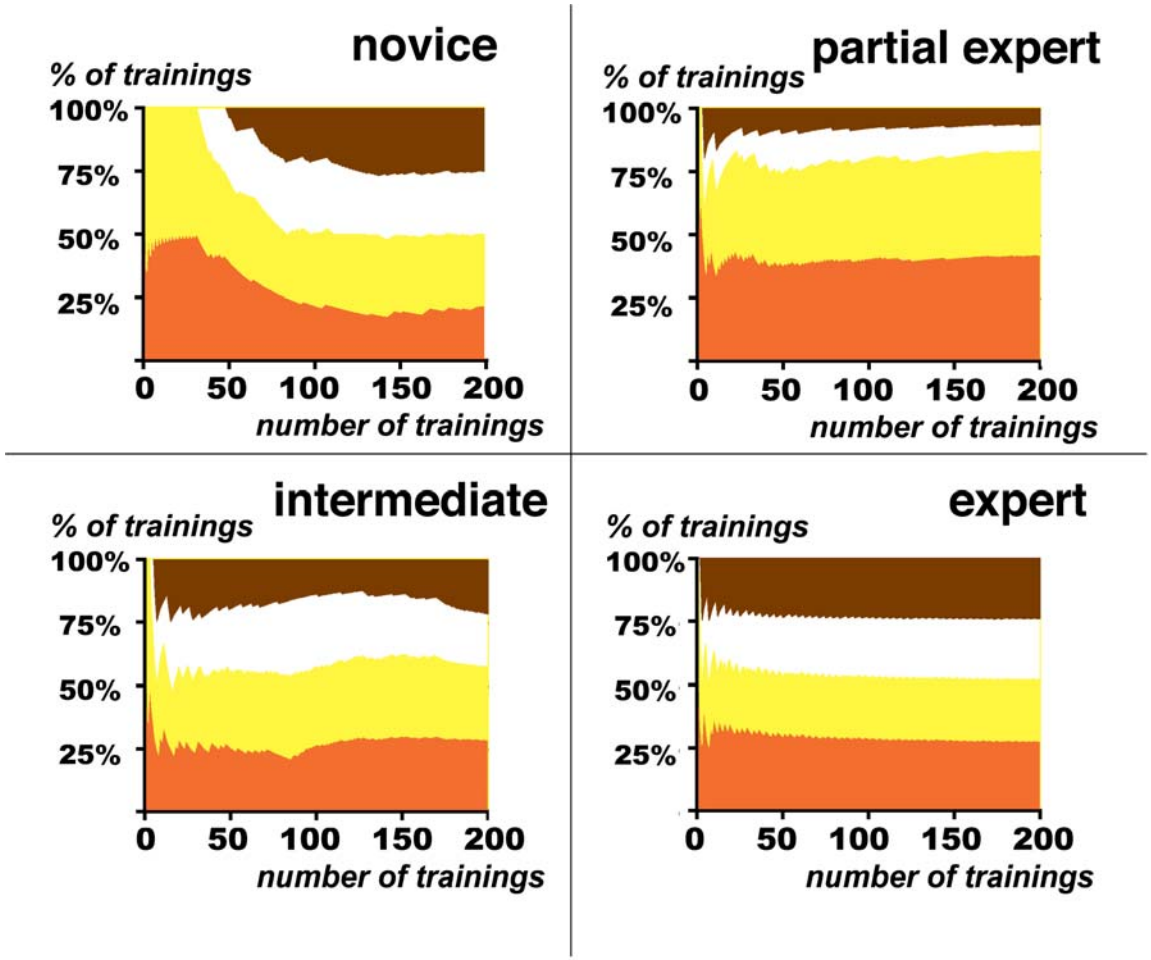
Simulation 2



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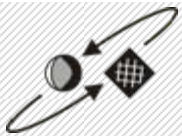
Conclusion

- Research on serious games might benefit from techniques for intelligent tutoring
  - Hierarchical domain -> traditional methods such as model tracing
  - No (complete) theory of hierarchy -> teacher modeling
- Mechanism of teacher modeling:
  - Identify set of training dimensions
  - Use 3 chunks per dimension: amount of training, positive encounters and negative encounters
  - Combine chunks in a total dimension score and train dimensions with a low dimension score



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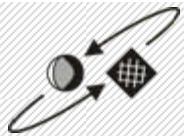
Conclusion

- Teacher modeling
  - Takes frequency and recency of training (observations) into account
  - Uses continuous assessments to get insight in student performance
- The method has been tested in a simulation
  - It adapts training selection to the individual & adapts to (changing) behavior
- Each specific domain will require user studies to test the learning gain
- We are currently developing a serious game in which the user model is tested (Janssen *et al.*, 2007)
- Method might also be useful for other recommender systems, if they have to categorize broad interests



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Thank you for your attention
Questions?

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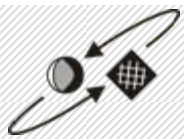

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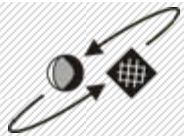

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