

# Statistical Student Modeling

Rahul Yedida  
Ankush Kumar  
Srihari Joshi  
Vima Rai

Ms. Kundhavai K R  
Batch No. - 48

October 5, 2018

# Overview

- 1 Introduction
- 2 Literature Survey
  - Algorithm
  - Extensions
  - Alternatives
- 3 Requirements
  - Hardware
  - Software
- 4 Timeline
  - Back End
  - Front End

- **Domain:** Educational data mining, statistical learning

# Problem Statement / Definition

- **Domain:** Educational data mining, statistical learning
- **What:** An Intelligent Tutoring System (ITS)

# Problem Statement / Definition

- **Domain:** Educational data mining, statistical learning
- **What:** An Intelligent Tutoring System (ITS)
- **How:** Several algorithms proposed in literature, based on BKT

# Problem Statement / Definition

- **Domain:** Educational data mining, statistical learning
- **What:** An Intelligent Tutoring System (ITS)
- **How:** Several algorithms proposed in literature, based on BKT
- **Data:** 2009-10 Skill-builder ASSISTments data

# Problem Statement / Definition

- **Domain:** Educational data mining, statistical learning
- **What:** An Intelligent Tutoring System (ITS)
- **How:** Several algorithms proposed in literature, based on BKT
- **Data:** 2009-10 Skill-builder ASSISTments data
- **Metrics:** RMSE, MAE

- Adaptive teaching systems for elucidating concepts



- Adaptive teaching systems for elucidating concepts
- Primarily based on Hidden Markov Models (HMMs)

# Intelligent Tutoring Systems

- Adaptive teaching systems for elucidating concepts
- Primarily based on Hidden Markov Models (HMMs)
- Generated interest after Corbett & Anderson, 1994.

- Model students learning state

# Motivation

- Model students learning state
- Use non-traditional cues, e.g. affect

- Model students learning state
- Use non-traditional cues, e.g. affect
- Can modeling help improve education?

# So what are we doing?

- Implement a web-based ITS solution

# So what are we doing?

- Implement a web-based ITS solution
- Individual models for each user

# So what are we doing?

- Implement a web-based ITS solution
- Individual models for each user
- Idea: start with simple models (single concept, basic BKT), go increasingly complex, hopefully implement KAT.



# Overview

- 1 Introduction
- 2 Literature Survey
  - Algorithm
  - Extensions
  - Alternatives
- 3 Requirements
  - Hardware
  - Software
- 4 Timeline
  - Back End
  - Front End

# Bayesian Knowledge Tracing (BKT)

- Proposed by Corbett & Anderson, 1994.

# Bayesian Knowledge Tracing (BKT)

- Proposed by Corbett & Anderson, 1994.
- Fundamentally, a two-state HMM—*learned* and *unlearned*.

# Bayesian Knowledge Tracing (BKT)

- Proposed by Corbett & Anderson, 1994.
- Fundamentally, a two-state HMM—*learned* and *unlearned*.
- Viterbi algorithm can be used to solve for the hidden state sequence.

# Overview

- 1 Introduction
- 2 Literature Survey
  - Algorithm
  - Extensions
  - Alternatives
- 3 Requirements
  - Hardware
  - Software
- 4 Timeline
  - Back End
  - Front End

- Pardos and Heffernan, 2011. Incorporated problem difficulty.
- Yudelson et al., 2013. Incorporated student learning speed.
- Schultz and Arroyo, 2014. Combined BKT with HMM-IRT, called Knowledge and Affect Tracing (KAT) model.
- Lin and Chi, 2016. Added student response time directly into the model, creating the Intervention-BKT (I-BKT).
- Spaulding, Gordon, Brezeal, 2016. Used commercial affect-analysis tool called Affdex.

# Overview

- 1 Introduction
- 2 Literature Survey
  - Algorithm
  - Extensions
  - **Alternatives**
- 3 Requirements
  - Hardware
  - Software
- 4 Timeline
  - Back End
  - Front End

# Why not Deep Neural Networks?

- RNNs, LSTMs successfully applied (Piech et al., 2015; Lin and Chi, 2017)



# Why not Deep Neural Networks?

- RNNs, LSTMs successfully applied (Piech et al., 2015; Lin and Chi, 2017)
- Difficult to interpret!

# Why not Deep Neural Networks?

- RNNs, LSTMs successfully applied (Piech et al., 2015; Lin and Chi, 2017)
- Difficult to interpret!
- With HMMs, can identify "most likely" hidden state sequence, and can also find HMM parameters (EM algorithm)

# Overview

- 1 Introduction
- 2 Literature Survey
  - Algorithm
  - Extensions
  - Alternatives
- 3 Requirements**
  - Hardware
  - Software
- 4 Timeline
  - Back End
  - Front End

- Working router
- Computer

- 2 GB RAM
- Optional: GPU, if using affect-aware models

- 1 Introduction
- 2 Literature Survey
  - Algorithm
  - Extensions
  - Alternatives
- 3 Requirements**
  - Hardware
  - Software**
- 4 Timeline
  - Back End
  - Front End

Recent web browser

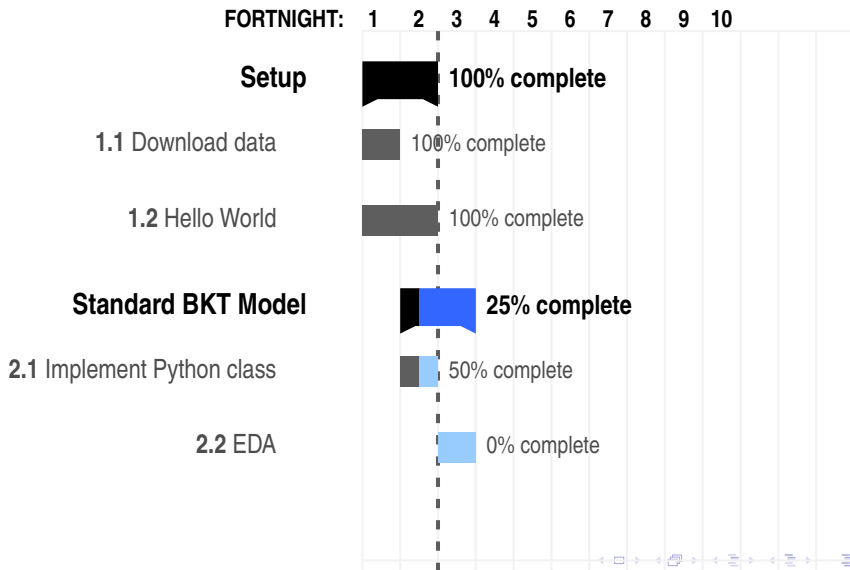
- Python, Flask
- Node.js, npm
- pycodestyle
- GNU/Linux



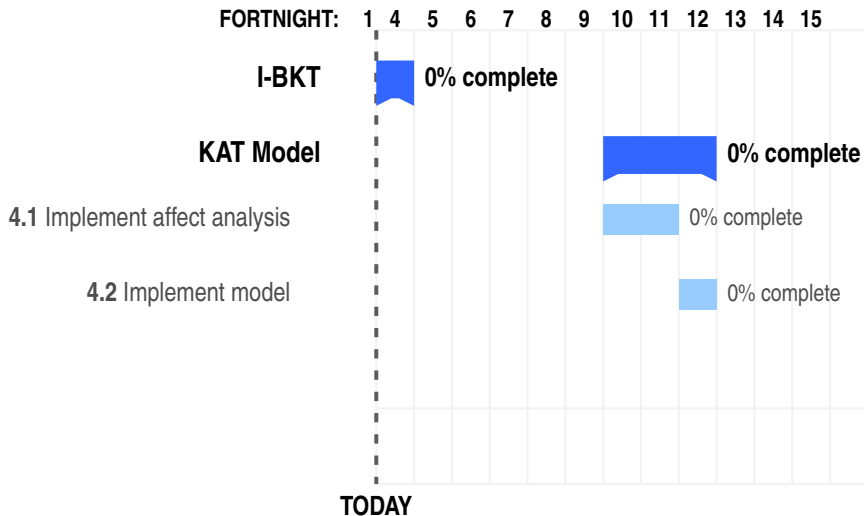
# Overview

- 1 Introduction
- 2 Literature Survey
  - Algorithm
  - Extensions
  - Alternatives
- 3 Requirements
  - Hardware
  - Software
- 4 **Timeline**
  - **Back End**
  - Front End

# Timeline from Sep 12 (first commit) to Oct 24 (F3)



# Timeline from Oct 24, 2018 (F4) to April 10, 2019 (F15)



# Timeline from [expand]

# References



A. T. Corbett and J. R. Anderson (1994)

Knowledge tracing: Modeling the acquisition of procedural knowledge

*User modeling and user-adapted interaction*, 4(4), 253 – 278.



R. S. d Baker, A. T. Corbett, and V. Aleven (2008)

More accurate student modeling through contextual estimation of slip and guess probabilities in bayesian knowledge tracing

*Intelligent Tutoring Systems*, 253 – 278, Springer.



C. Lin and M. Chi (2016)

Intervention-bkt: incorporating instructional interventions into bayesian knowledge tracing

*International Conference on Intelligent Tutoring Systems*, 208 – 218, Springer.



S. Chiappa and S. Bengio (2003)

Hmm and iohmm modeling of eeg rhythms for asynchronous bci systems

*Tech. rep.*, IDIAP.

# References

-  S. Spaulding, G. Gordon, and C. Breazeal (2016)

Affect-aware student models for robot tutors

*Proceedings of the 2016 International Conference on Autonomous Agents & Multiagent Systems*, 864 – 872, International Foundation for Autonomous Agents and Multiagent Systems.

-  S. Schultz and I. Arroyo (2014)

Tracing knowledge and engagement in parallel in an intelligent tutoring system

*Educational Data Mining*.

-  Z. A. Pardos and N. T. Heffernan (2011)

Kt-idem: introducing item difficulty to the knowledge tracing model

*International Conference on User Modeling, Adaptation, and Personalization*, 243 – 254, Springer.

-  M. V. Yudelson, K. R. Koedinger, and G. J. Gordon (2013)

Individualized bayesian knowledge tracing models

*International Conference on Artificial Intelligence in Education*, 171 – 180, Springer



# References



C. Piech, J. Bassen, J. Huang, S. Ganguli, M. Sahami, L. J. Guibas, and J. Sohl-Dickstein, (2015)

Deep knowledge tracing

*Advances in Neural Information Processing Systems*, 505 – 513.



C. Lin and M. Chi (2017)

A comparisons of bkt, rnn and lstm for learning gain prediction

*International Conference on Artificial Intelligence in Education*, 536 – 539, Springer.



Z. C. Lipton, D. C. Kale, C. Elkan, and R. Wetzel (2015)

Learning to diagnose with lstm recurrent neural networks

*arXiv preprint*, arXiv:1511.03677.



J. Johns and B. Woolf (2006)

A dynamic mixture model to detect student motivation and proficiency

*Proceedings of the National Conference on Artificial Intelligence*, 21(1), 163, AAAI Press; MIT Press.

# The End