Can AI help MOOCs?

Jie Tang
Computer Science
Tsinghua University

Big Data in MOOC

- **149** partners
- 2000+ courses
- **24,000,000** users

coursera
education for everyone

xuetangX.com
学堂在线

- **1,000+** courses
- **8,000,000** users
- **Chinese EDU association**

edX

- **110** partners
- 1,270 courses
- **10,000,000** users
- 10+ MacroMaster

網易公开课

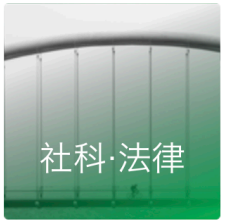
- host >1,000 courses
- millions of users

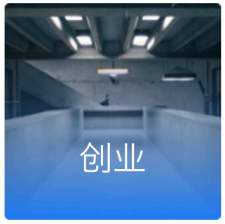
- **~10** partners
- 40+ courses
- **1.6 million** users
- **"nanodegree"**

UDACITY

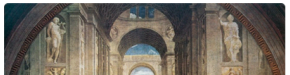
.....

launched in 2013



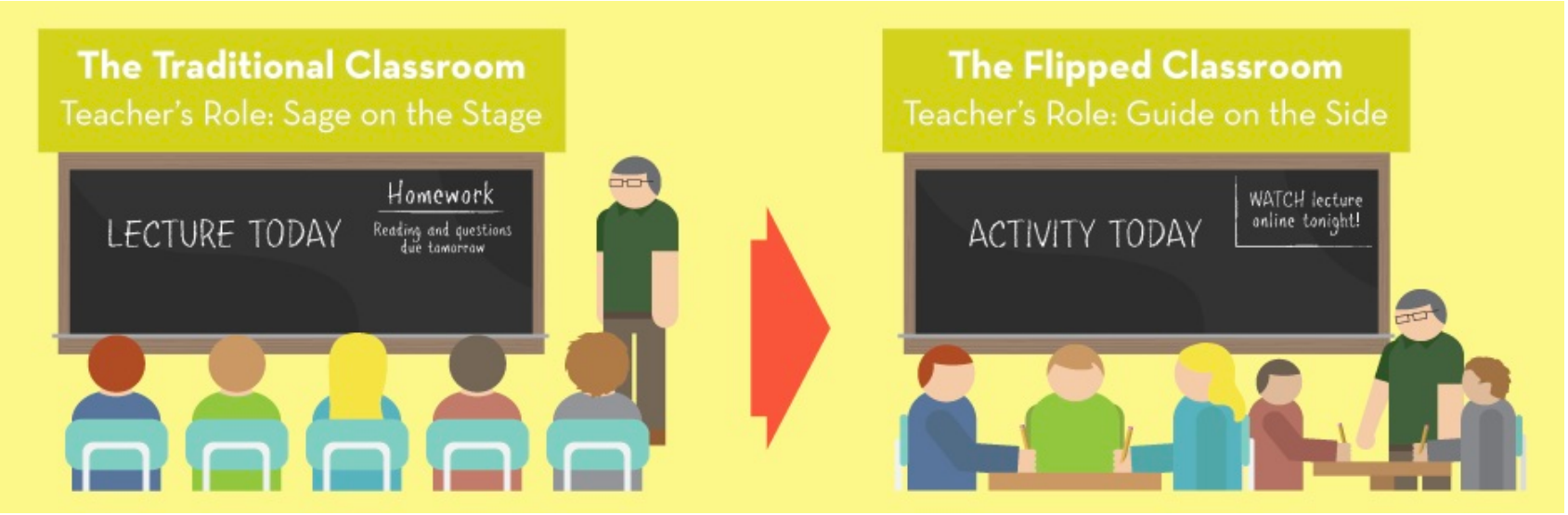


推荐课程 [更多]



Some exciting data…

- Every day, there are 2,200+ new students
- An MOOC course can reach 100,000+ students
- >35% of the XuetangX users are using mobile
- ->Flipped Classroom->online degree



Some exciting data…

- Every day, there are 2,200+ new students
- An MOOC course can reach 100,000+ students
- >35% of the XuetangX users are using mobile
- ->Flipped Classroom->online degree
- "Network + EDU" (O2O)
  - edX launched 10+ MacroMaster degrees
  - Udacity launched nanodegree program
  - GIT+Udacity launched the largest online master
  - **Tsinghua+XuetangX** will launch a MacroMaster soon

Questions

- Are you MOOCer?
- Are you using XuetangX?
- Will you use XuetangX?

However,

- **only ~3% certificate rate**
  - The highest certificate rate is **14.95%**
  - The lowest is only **0.84%**
- Can **AI/DM** help MOOC and how?

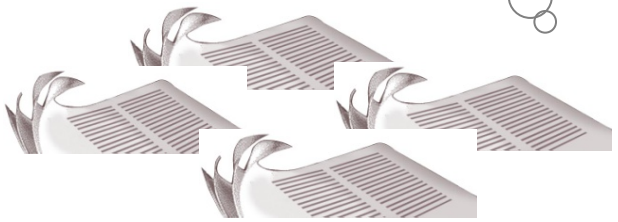
MOOC user = Student?

How to learn more effectively and more efficiently?

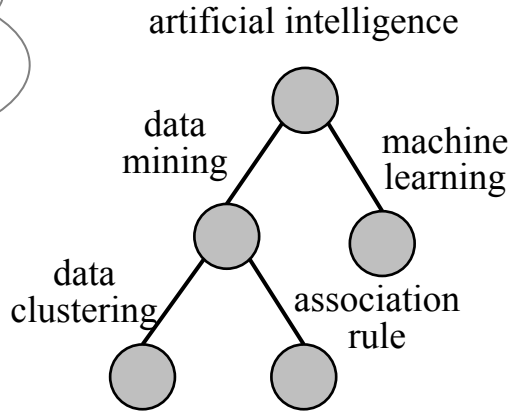
- **Who is who? background, where from?**
- **Why MOOC? motivation? degree?**
- **What is personalization? preference?**

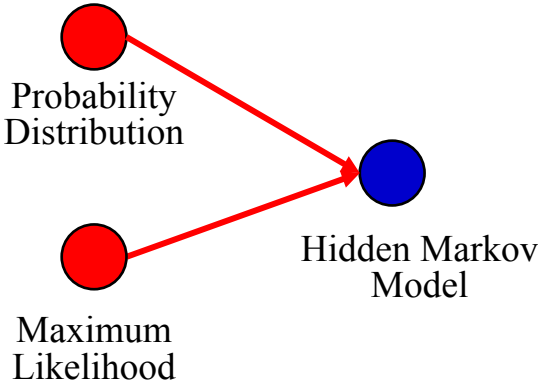
MOOC course = University course?

How to discover the prerequisite relations between concepts and generate the concept graph automatically?



Thousands of Courses





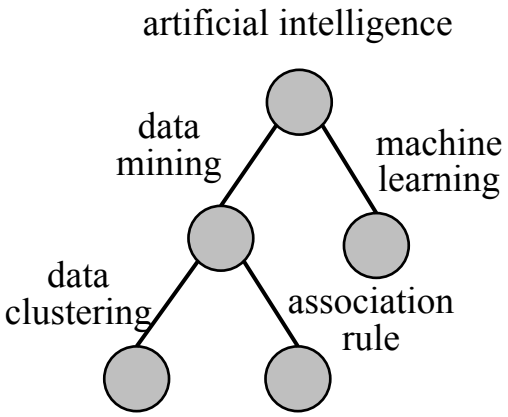
WIKIPEDIA The Free Encyclopedia

Freebase

yago select knowledge

How to leverage the external knowledge?

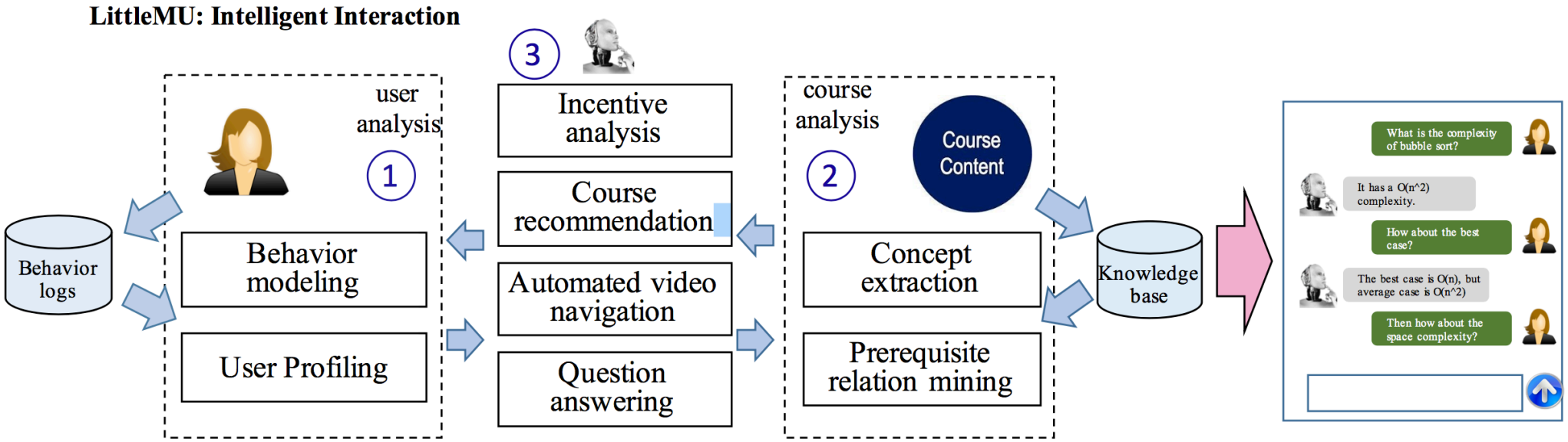
However to improve the engagement?



User

Knowledge

LittleMU (小木)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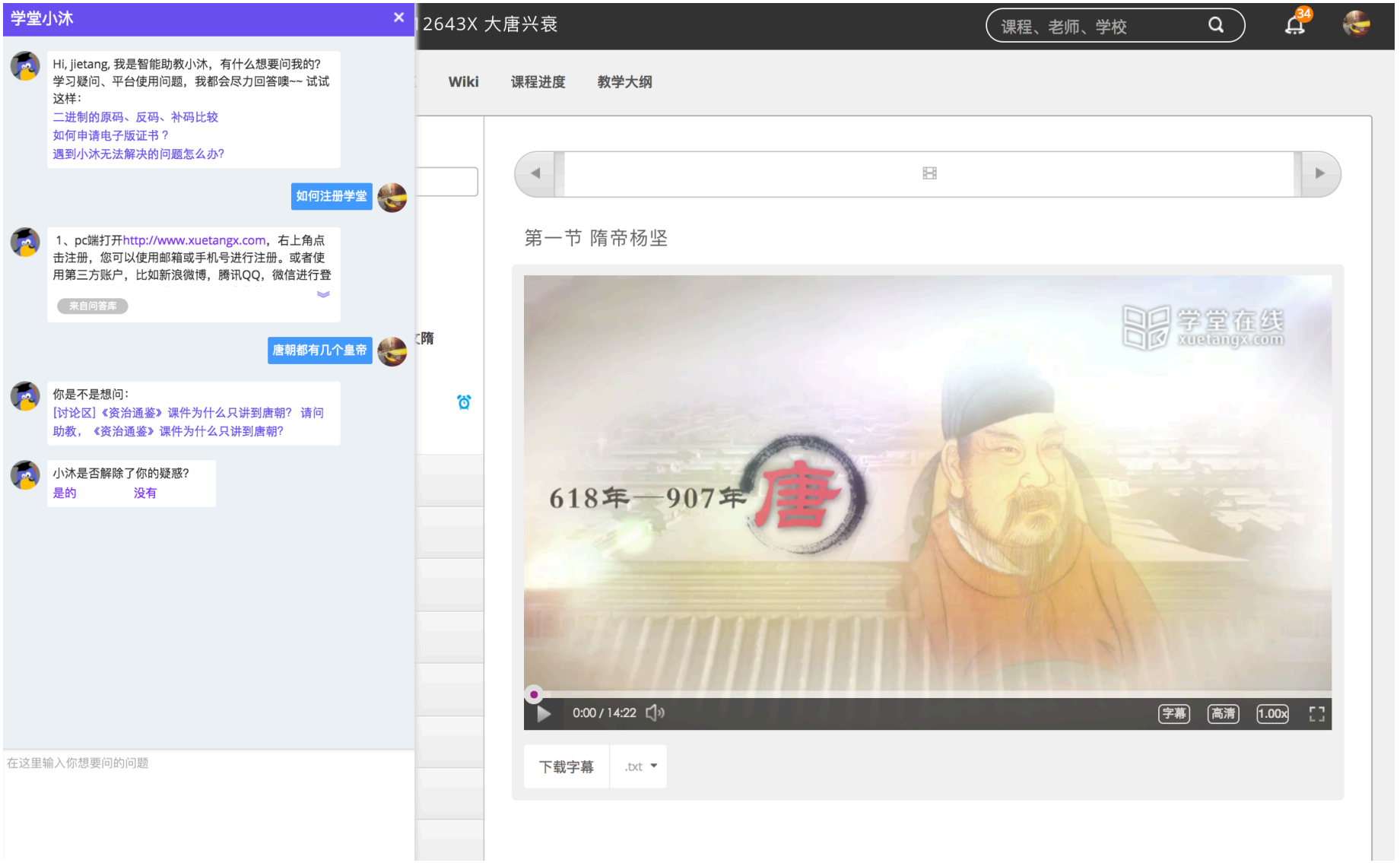
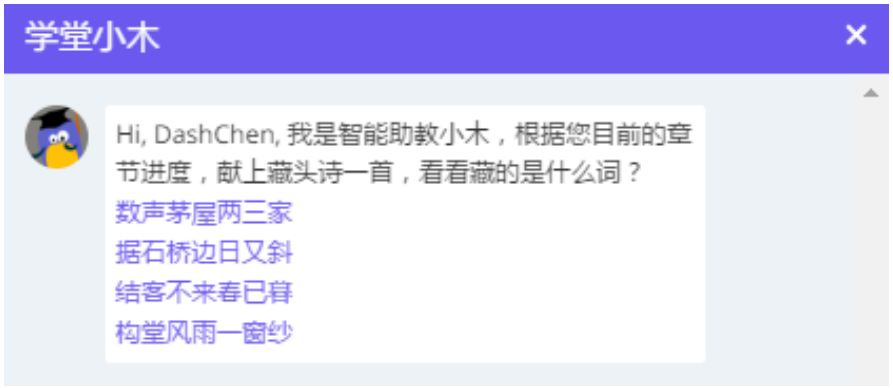
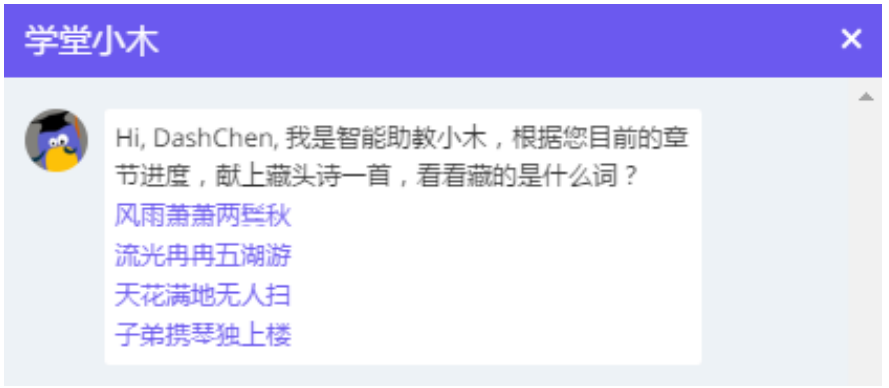
What is the complexity of bubble sort?
It has a O(n^2) complexity.
How about the best case?
The best case is O(n), but average case is O(n^2)
Then how about the space complexity?

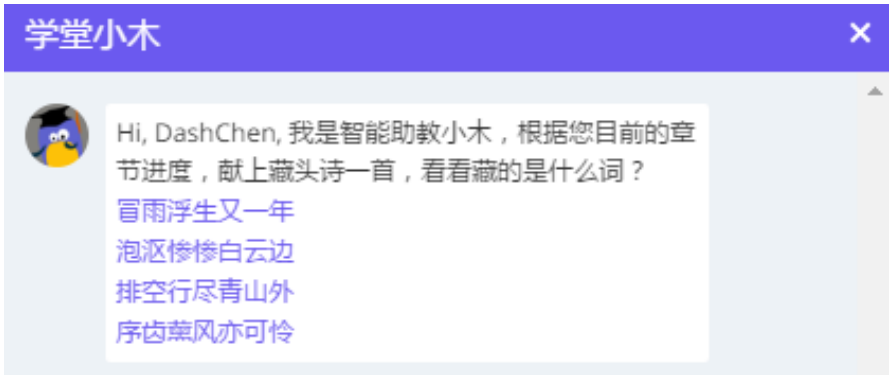
LittleMU (小木)

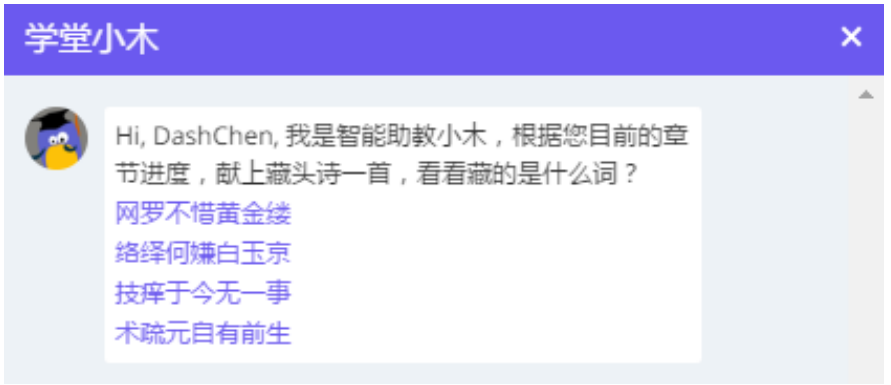

学堂小沐
Hi, jietang, 我是智能助教小沐，有什么想要问我的？学习疑问、平台使用问题，我都会尽力回答噢~~ 试试这样：
二进制的原码、反码、补码比较
如何申请电子版证书？
遇到小沐无法解决的问题怎么办?
如何注册学堂
1、pc端打开http://www.xuetangx.com，右上角点击注册，您可以使用邮箱或手机号进行注册。或者使用第三方账户，比如新浪微博，腾讯QQ，微信进行登
来自问答库
唐朝都有几个皇帝
你是不是想问：
[讨论区]《资治通鉴》课件为什么只讲到唐朝？ 请问助教，《资治通鉴》课件为什么只讲到唐朝?
小沐是否解除了你的疑惑?
是的
没有
在这里输入你想要问的问题
2643X 大唐兴衰
课程、老师、学校
Wiki
课程进度
教学大纲
第一节 隋帝杨坚
学堂在线
xuetangx.com
618年—907年
唐
0:00 / 14:22
字幕
高清
1.00x
下载字幕
.txt

Acrostic Poem: 小木作诗

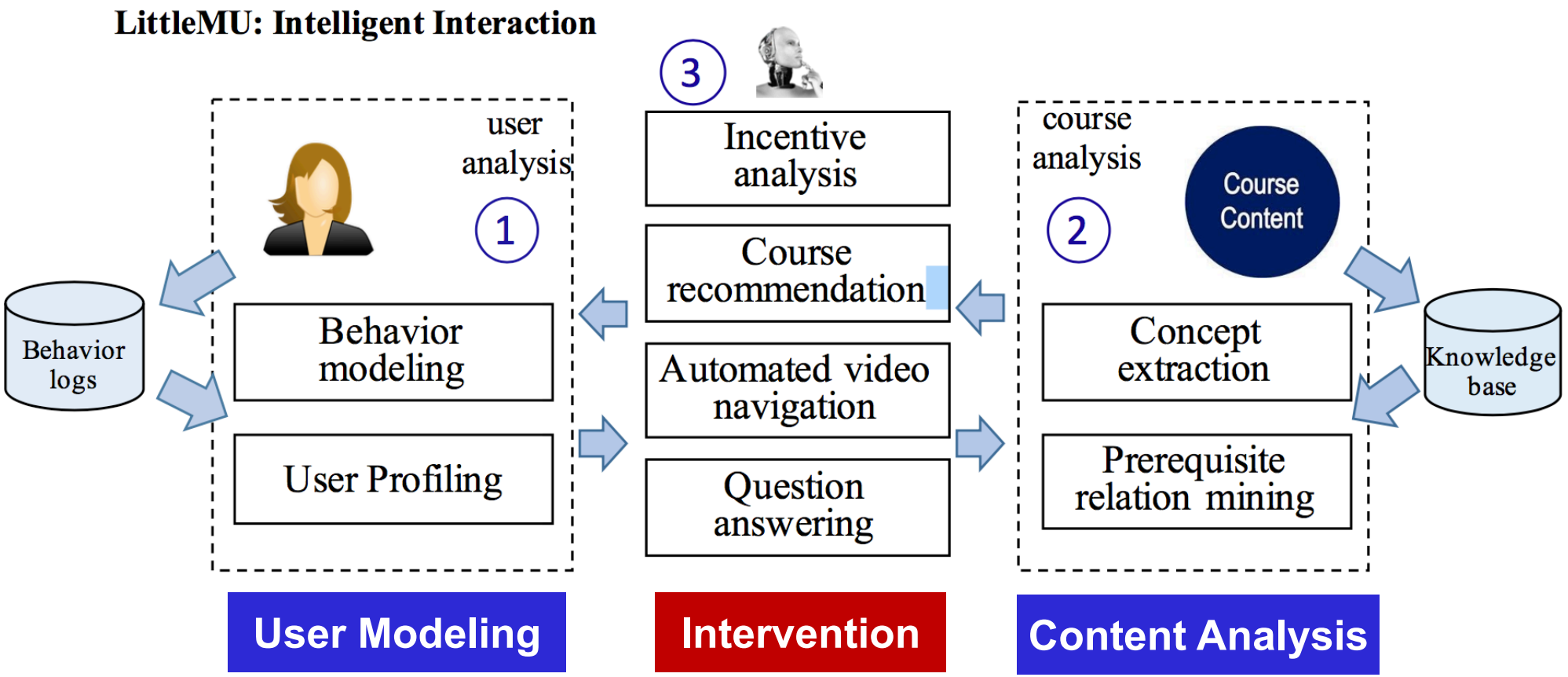








LittleMU (小木)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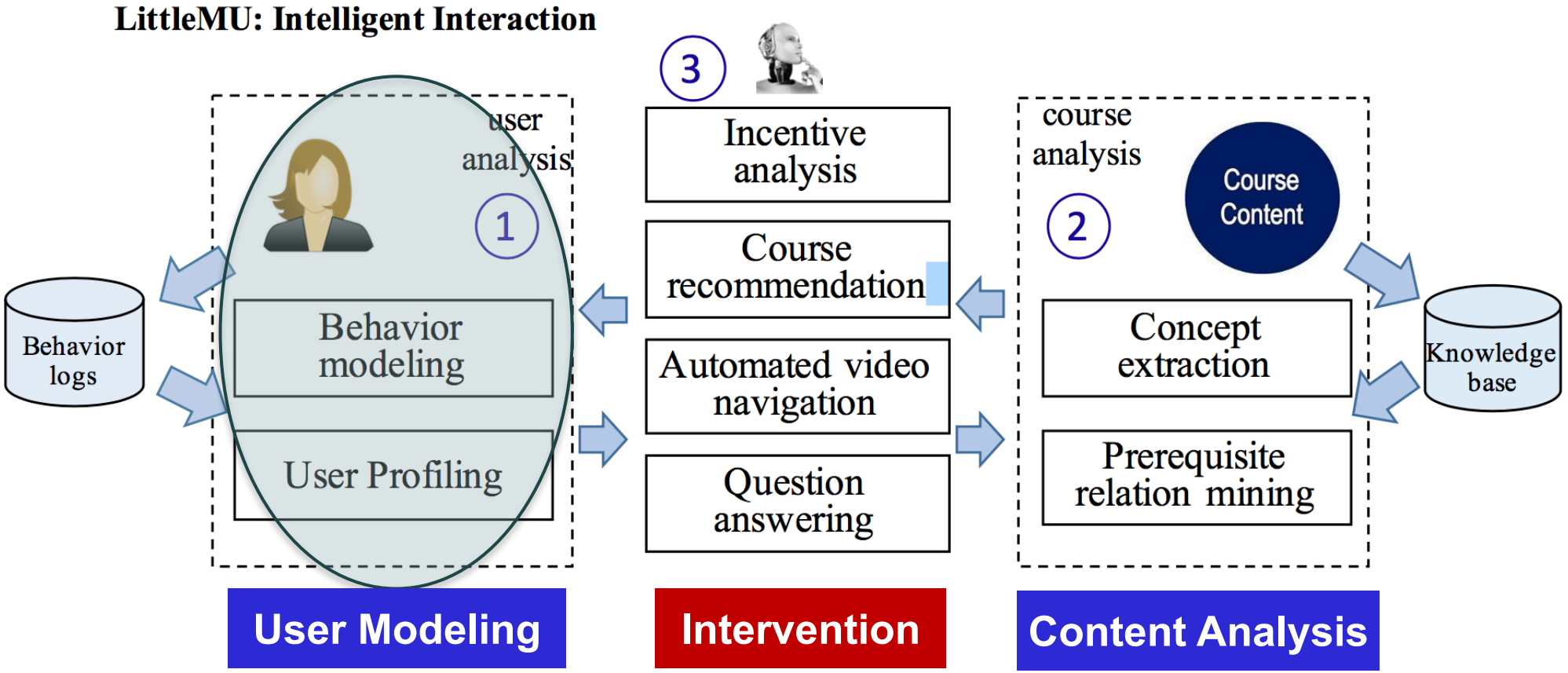
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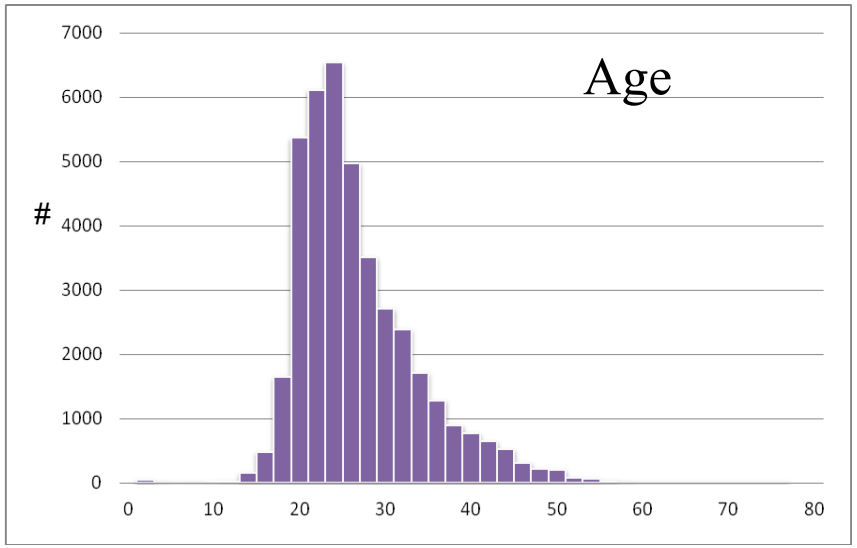
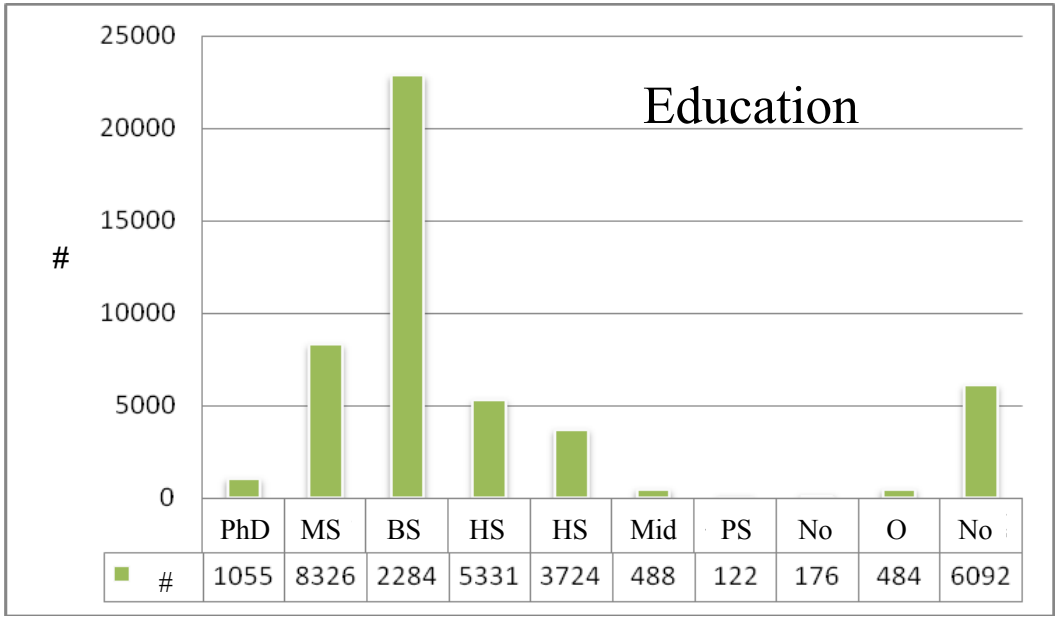
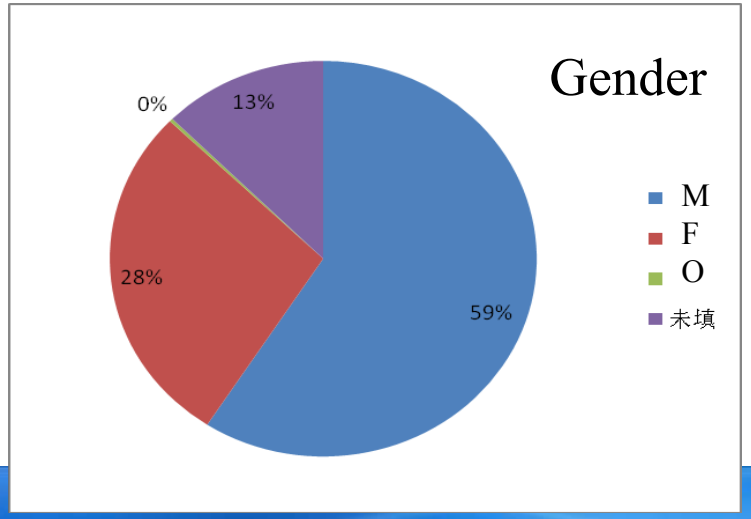
MOOC user

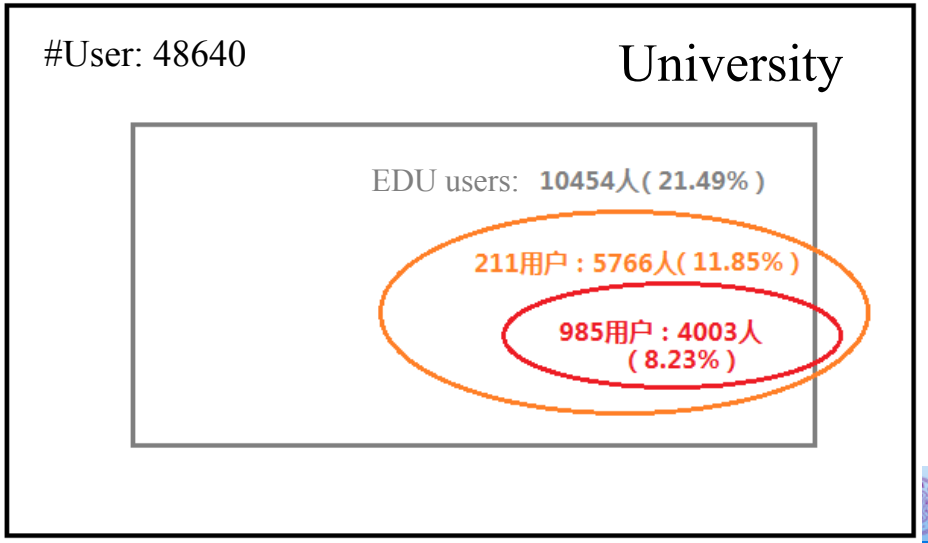
- Who is who? background, where from?
- Why MOOC? motivation? degree?
- What is personalization? preference?

Demographic distribution

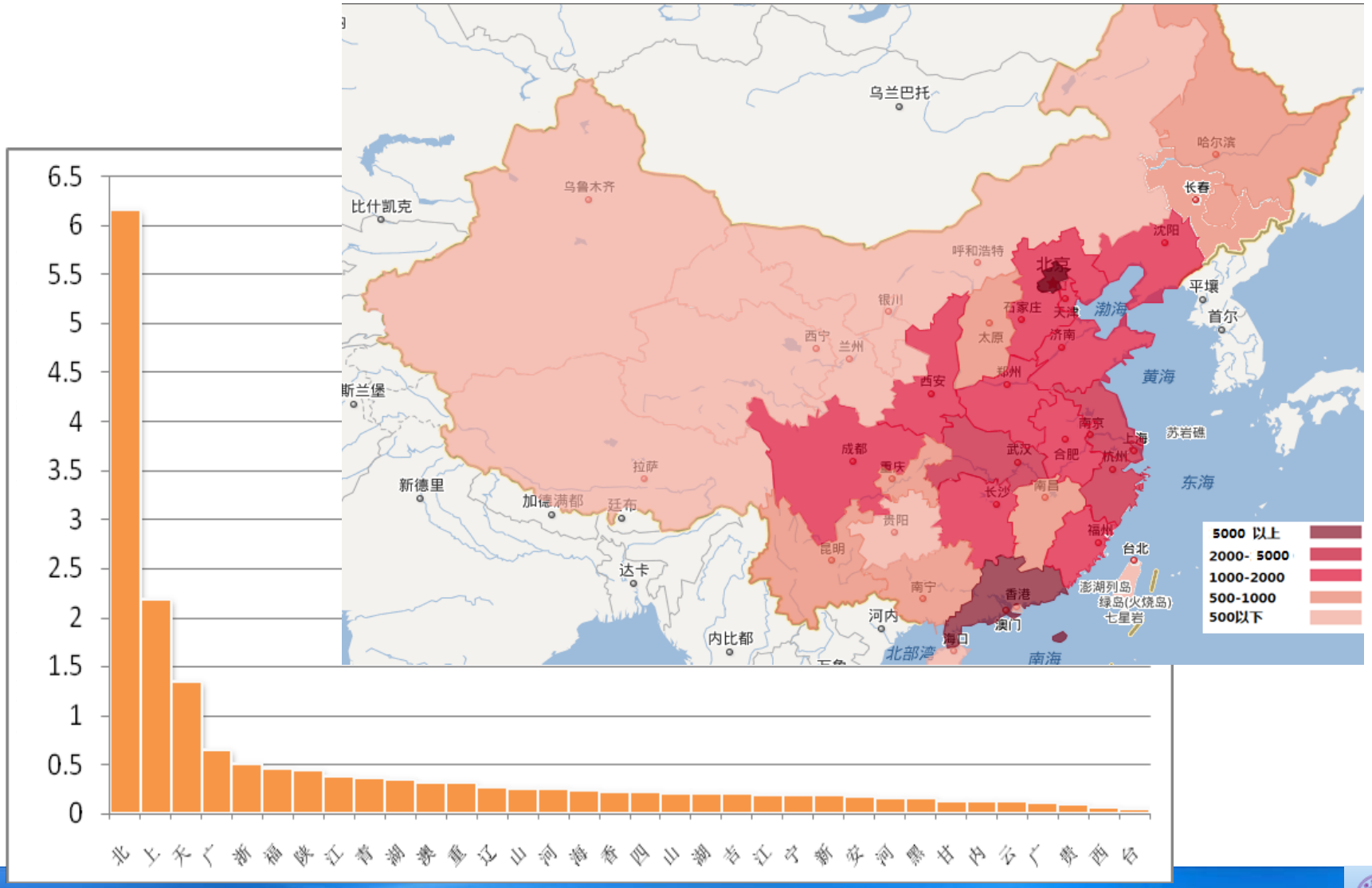




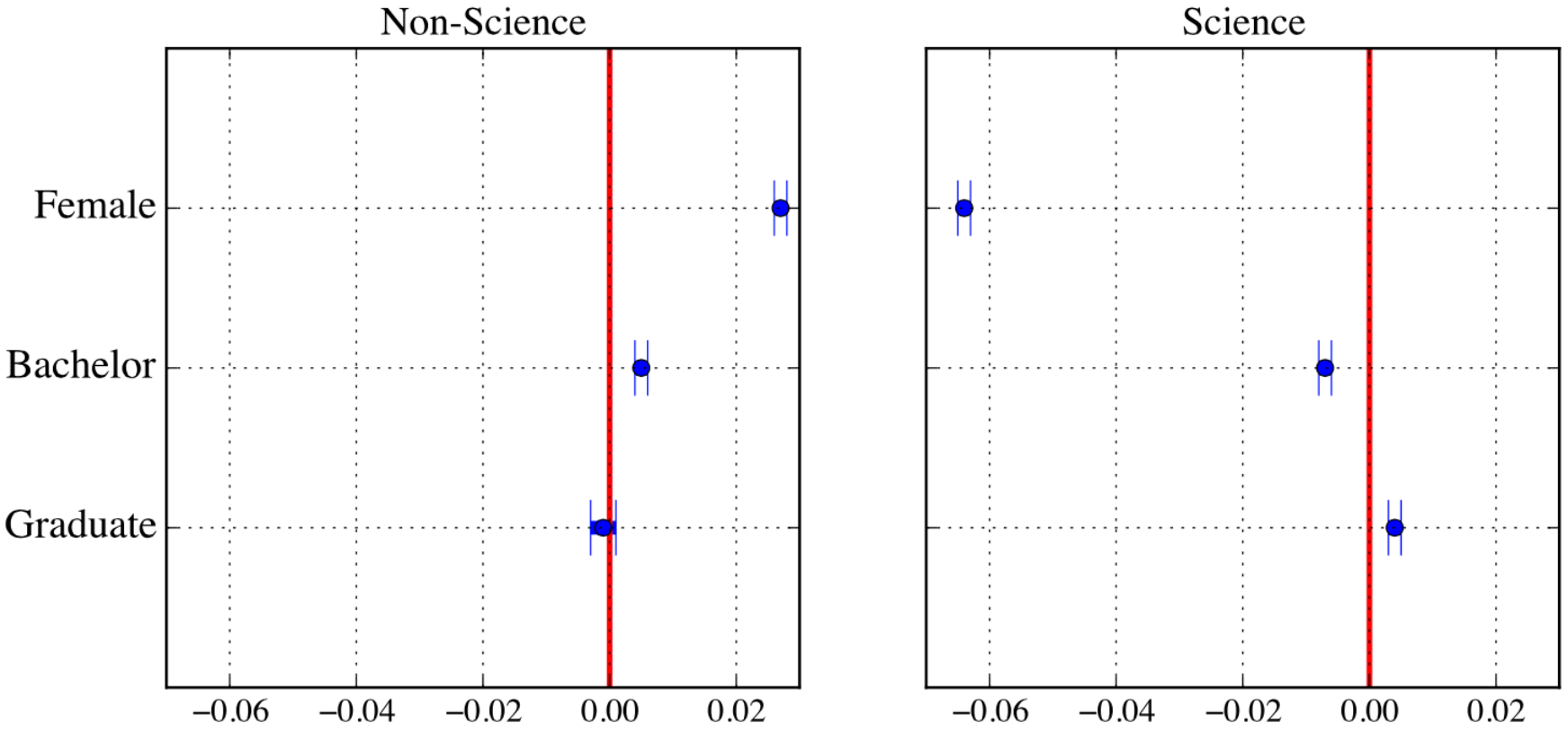




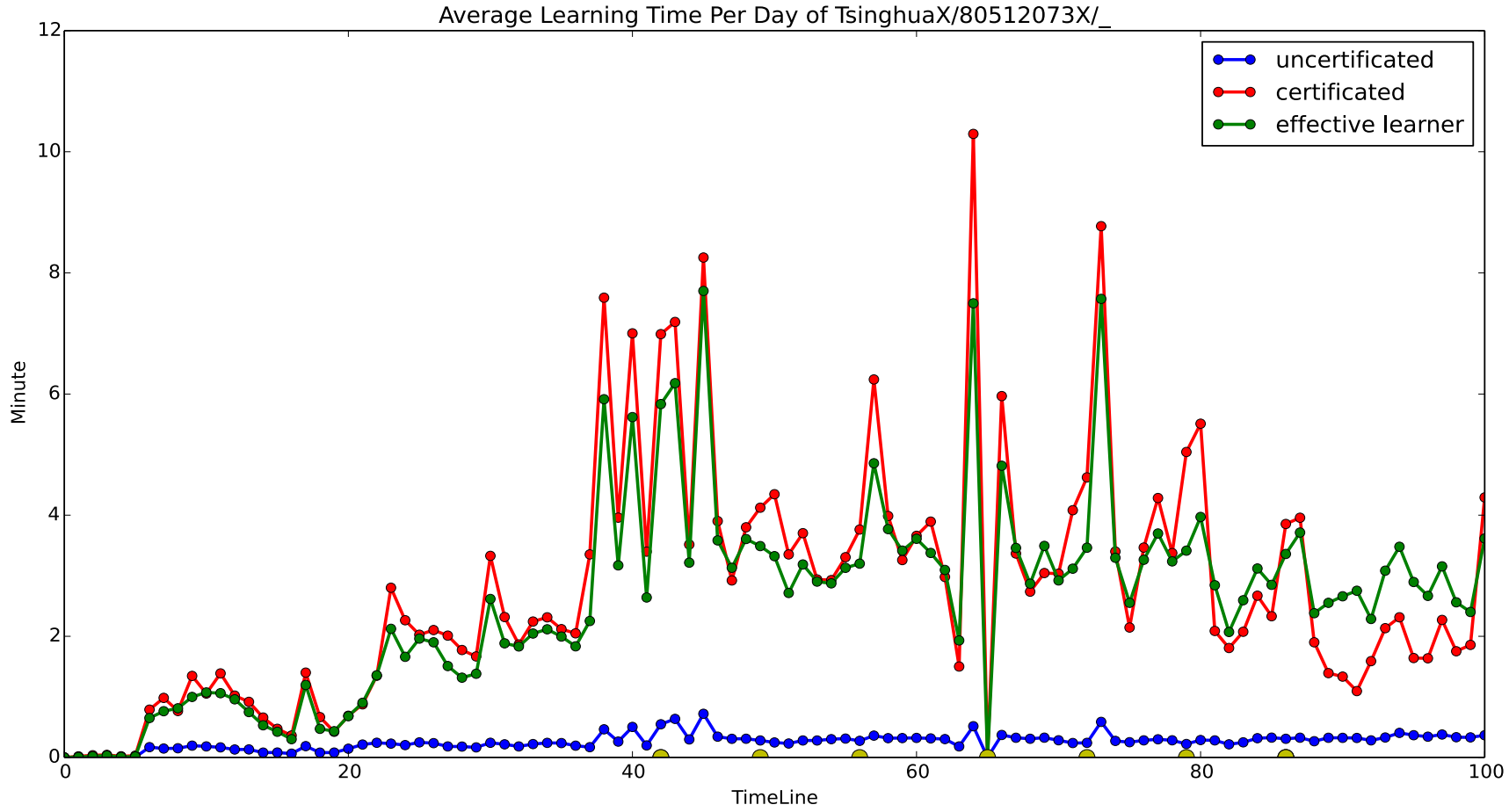
Geographic Distribution



Basic Analysis

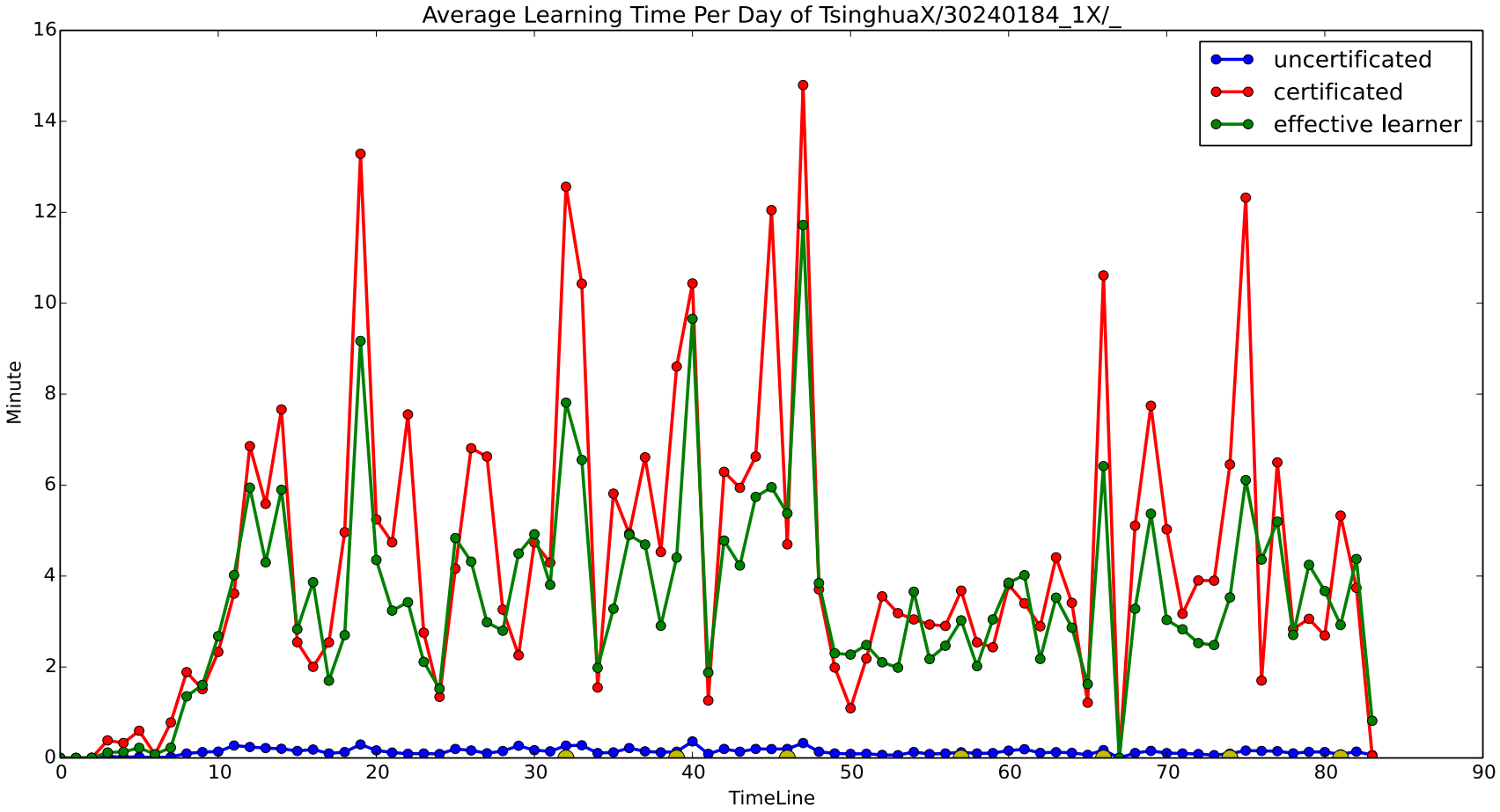


Average Learning Time Per Day of "Financial Analysis and Decisions"



36% of the students do not watch video and 52% do not finish the assignments

Average Learning Time Per Day of "Data Structure"



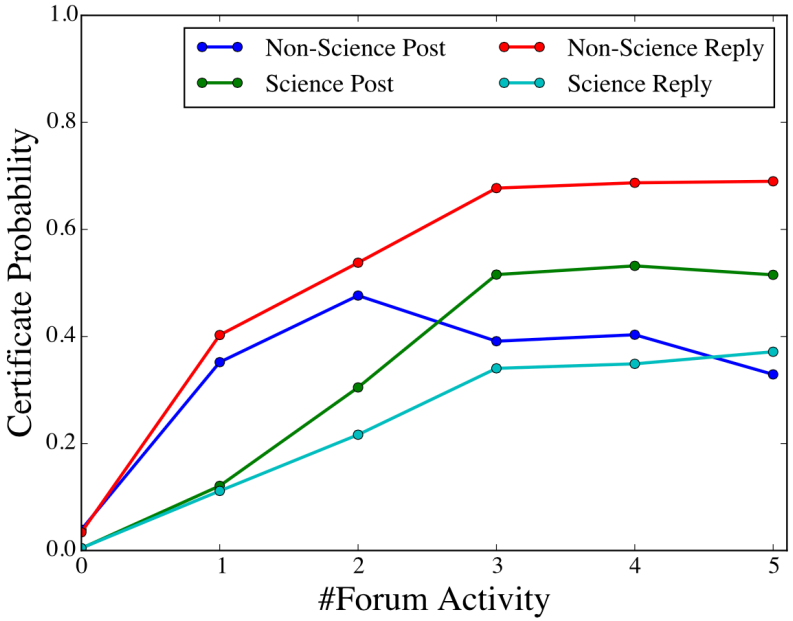
Certificate Rate

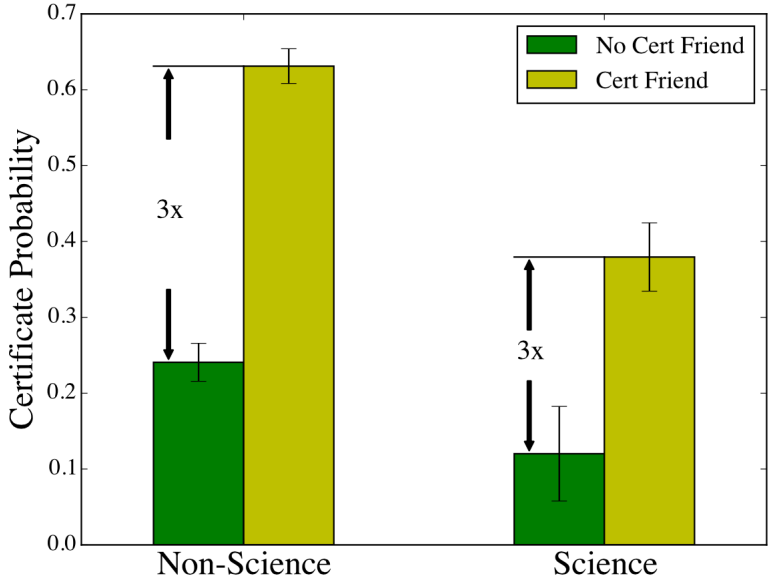
	Model 1		Model 2	
	Non-Science (1)	Science (2)	Non-Science (3)	Science (4)
Female	0.014***	-0.003	0.002*	0.001
	(0.002)	(0.002)	(0.001)	(0.002)
New Post	—	—	0.004***	0.038***
			(0.001)	(0.008)
Reply	—	—	0.004**	0.001*
			(0.002)	(0.001)
Video	—	—	0.000***	-0.000
			(0.000)	(0.000)
Assignment	—	—	0.003***	0.000***
			(0.000)	(0.000)
Bachelor	0.014***	0.003*	0.011***	-0.001
	(0.002)	(0.002)	(0.001)	(0.001)
Graduate	0.007***	0.004	0.013***	0.001
	(0.002)	(0.002)	(0.002)	(0.002)
Effort	-0.072***		-0.072***	
	(0.003)		(0.003)	
Constant	0.286***	0.018***	0.280***	0.006
	(0.013)	(0.006)	(0.011)	(0.004)
Obs.	74,480	19,269	74,480	19,269
R^2	0.024	0.001	0.462	0.363

Basic Analysis

- The highest certificate rate is **14.95%**
- The lowest is only **0.84%**
- Overall, the rate of science courses is lower than that of non-science courses

Forum activity vs. Certificate





Forum activity vs. Certificate

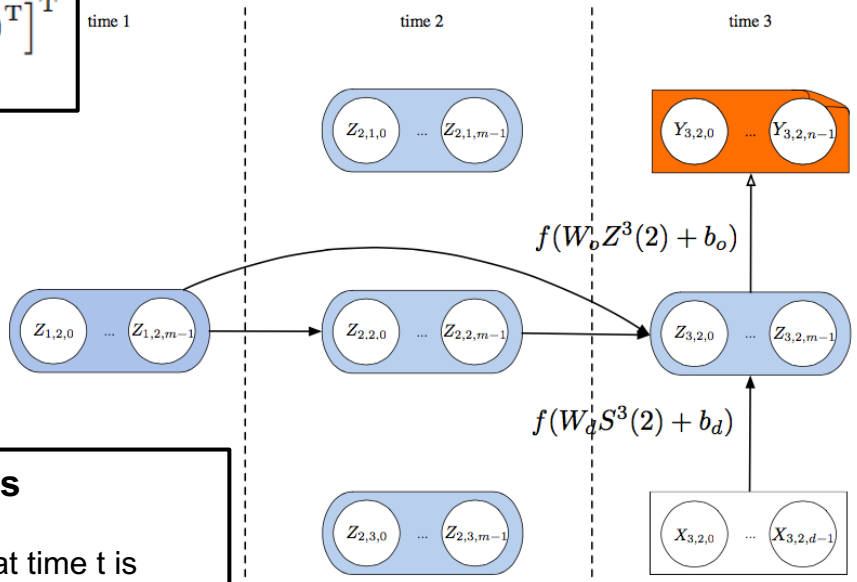
“近朱者赤”(Homophily)

– Certificate Probability tripled when one is aware that she has certificate friend(s)

Dynamic Factor Graph Model

Model: incorporating deep learning and factor graphs

$$Y^t(i)^* = f(W_o Z^t(i) + b_o)$$
$$Z^t(i)^* = f(W_d S^t(i) + b_d)$$
$$S^t(i) = \left[\mathbf{Z}_{t-p}^{t-1}(i)^{\mathrm{T}}, X^t(i)^{\mathrm{T}}\right]^{\mathrm{T}}$$



Prediction labels:
Activities we are interested in, e.g., assignments performance and getting certificates.

$$Y^t(i) = [Y_{t,i,0}, Y_{t,i,1}, \ldots, Y_{t,i,n-1}]^{\mathrm{T}}$$

Latent learning states

Every student's status in at time t is associated with a vector representation

$$Z^t(i) = [Z_{t,i,0}, Z_{t,i,1}, \ldots, Z_{t,i,m-1}]^{\mathrm{T}}$$

All features: time-varying attributes:
1.Demographics
2.Forum Activities
3. Learning Behaviors

$$X^t(i) = [X_{t,i,0}, X_{t,i,1}, \ldots, X_{t,i,d-1}]^{\mathrm{T}}$$

[1] Jiezhong Qiu, Jie Tang, Tracy Xiao Liu, Jie Gong, Chenhui Zhang, Qian Zhang, and Yufei Xue. Modeling and Predicting Learning Behavior in MOOCs. **WSDM'16**, pages 93-102.

Certificate Prediction

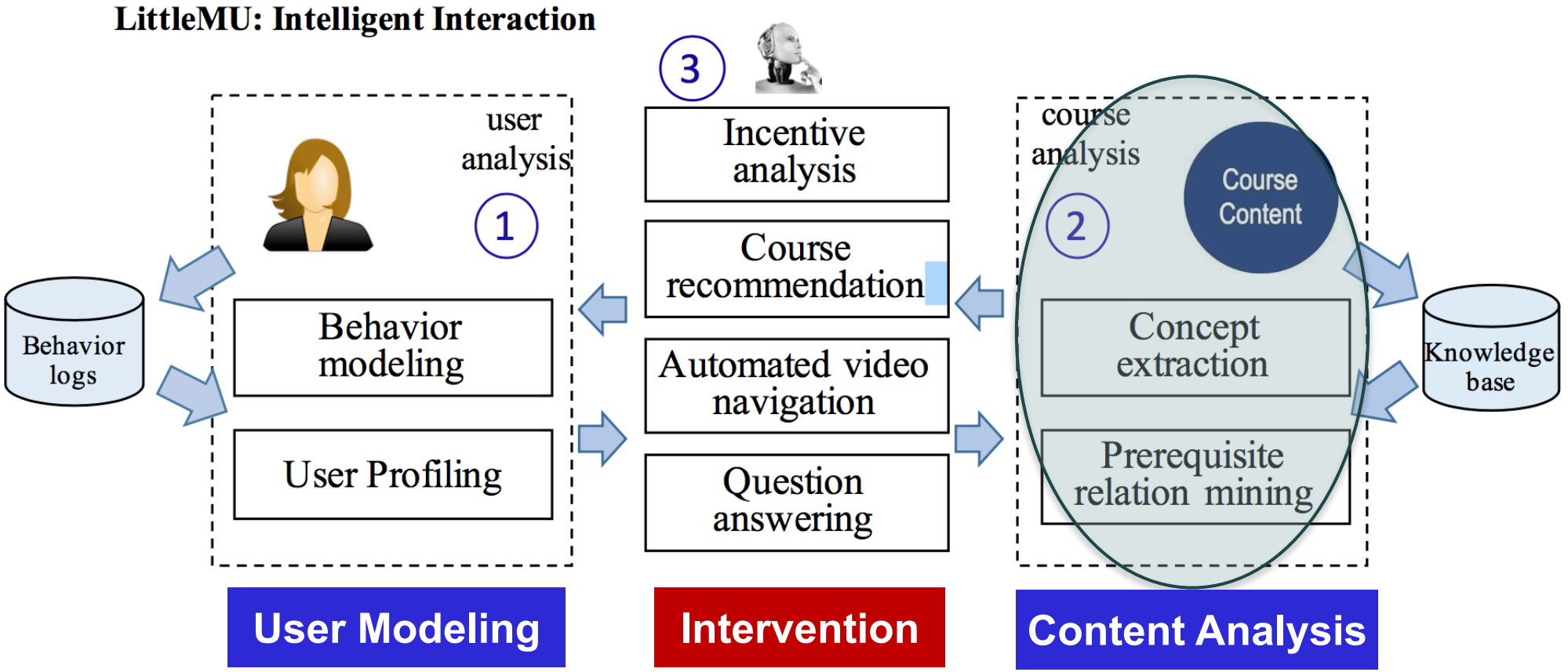
Category	Method	AUC	Precision	Recall	F1-score
Science	LRC	92.13	**83.33**	46.51	59.70
	SVM	92.67	52.17	83.72	64.29
	FM	94.48	61.54	74.42	67.37
	LadFG	**95.73**	73.91	**79.07**	**76.40**
Non-Science	LRC	94.16	76.93	89.20	82.57
	SVM	93.94	76.96	88.60	82.37
	FM	94.87	**80.22**	86.23	83.07
	LadFG	**95.54**	79.76	**89.01**	**84.10**

- LRC, SVM, and FM are different baseline models
- LadFG is our proposed model

Predicting more

- Dropout
  - KDDCUP 2015, 1,000+ teams worldwide
- Demographics
  - Gender, education, etc.
- User interest
  - computer science, mathematics, psychology, etc.
- …

LittleMU (小木)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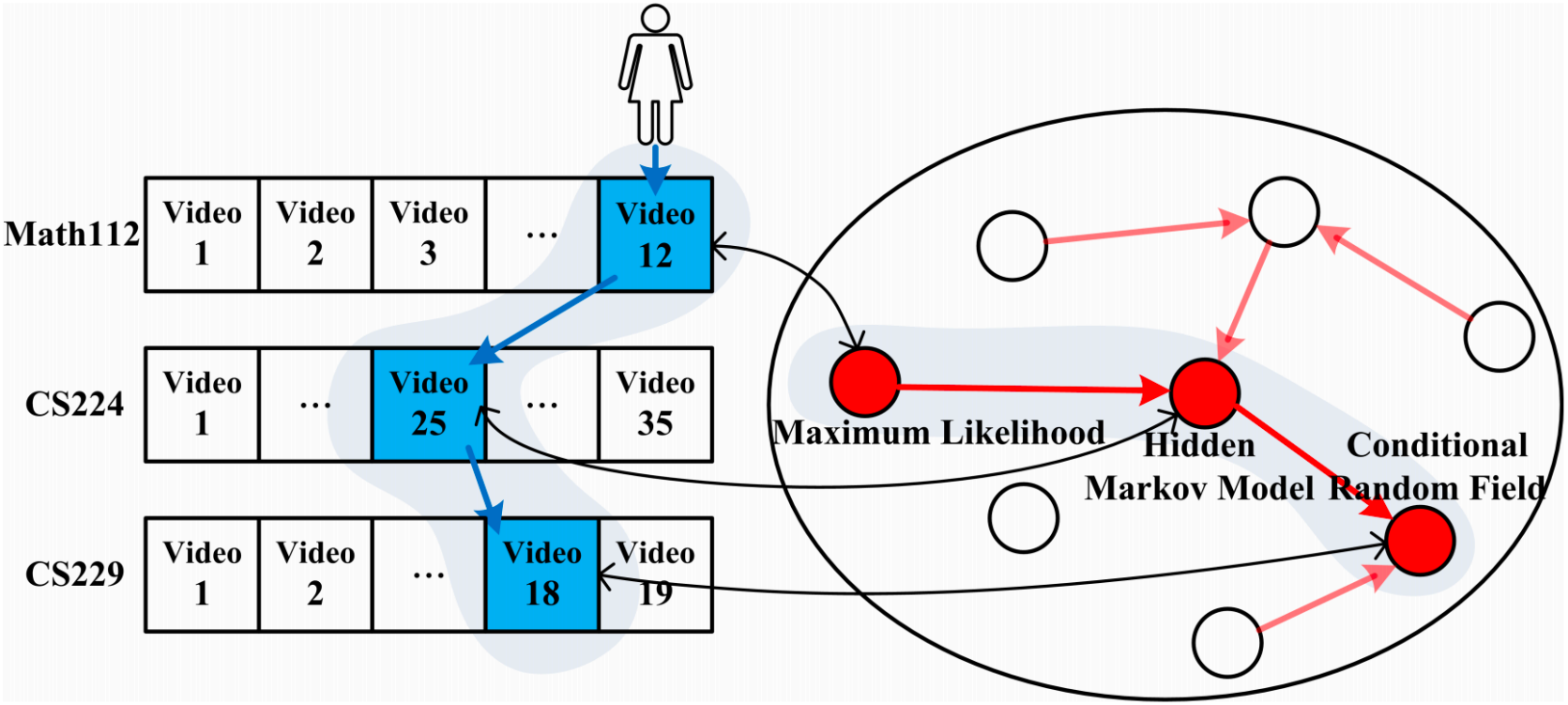
Knowledge Graph



- How to extract concepts from course scripts?
- How to recognize (prerequisite) relationships between concepts?

Concept Extraction

Candidate Concept Extraction → Semantic Representation Learning → Graph-based Ranking

In this course, we will teach some basic knowledge about data mining and its application in business intelligence.

Video script

data mining

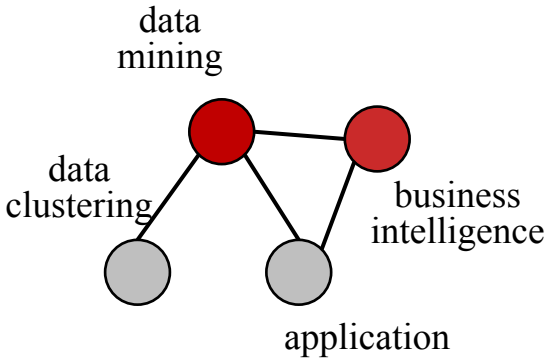
0.8	0.2	0.3	…	0.0	0.0

business intelligence

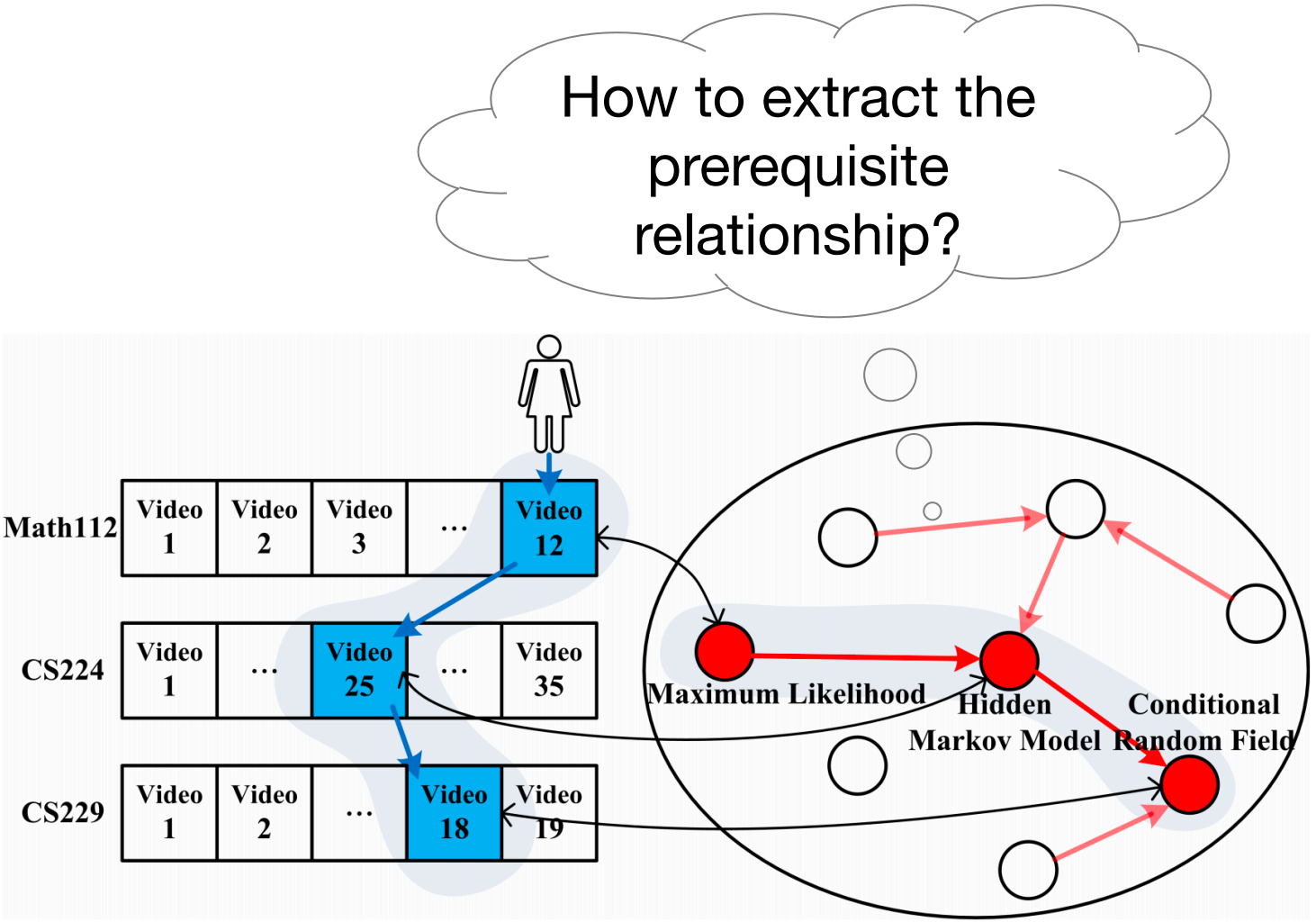
0.1	0.1	0.2	…	0.8	0.7

Vector representation

Learned via embedding or deep learning



Prerequisite Relationship



[1] Liangming Pan, Chengjiang Li, Juanzi Li, and Jie Tang. Prerequisite Relation Learning for Concepts in MOOCs. **ACL'17**.

Prerequisite Relationship Extraction

- Step 1： First extract important concepts
- Step 2： Use Word2Vec to learn representations of concepts

data mining

0.8	0.2	0.3	…	0.0	0.0

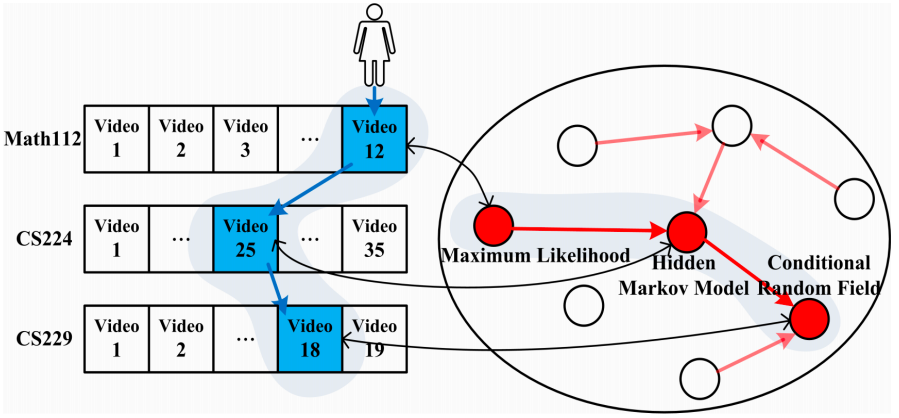
business intelligence

0.1	0.1	0.2	…	0.8	0.7

Vector representation
Learned via embedding or deep learning

Prerequisite Relationship Extraction

- Step 1： First extract important concepts
- Step 2： Use Word2Vec to learn representations of concepts
- Step 3： Distance functions
  - Semantic Relatedness
  - Video Reference Distance
  - Sentence Reference Distance
  - Wikipedia Reference Distance
  - Average Position Distance
  - Distributional Asymmetry Distance
  - Complexity Level Distance



Result of Prerequisite Relationship

Classifier		ML		DSA		CAL	
	M	1	10	1	10	1	10
SVM	P	63.2	60.1	60.7	62.3	61.1	61.9
	R	68.5	72.4	**69.3**	67.5	**67.9**	68.3
	F_1	65.8	65.7	64.7	64.8	64.3	64.9
NB	P	58.0	58.2	62.9	62.6	60.1	60.6
	R	58.1	60.5	62.3	61.8	61.2	62.1
	F_1	58.1	59.4	62.6	62.2	60.6	61.3
LR	P	66.8	67.6	63.1	62.0	62.7	63.3
	R	60.8	61.0	64.8	66.8	63.6	64.1
	F_1	63.7	64.2	63.9	64.3	61.6	62.9
RF	P	**68.1**	**71.4**	**69.1**	**72.7**	**67.3**	**70.3**
	R	**70.0**	**73.8**	68.4	**72.3**	67.8	**71.9**
	F_1	**69.1**	**72.6**	**68.7**	**72.5**	**67.5**	**71.1**

Table 2: Classification results of the proposed method(%).

- SVM, NB, LR, and RF are different classification models
- It seems that with the defined distance functions, RF achieves the best

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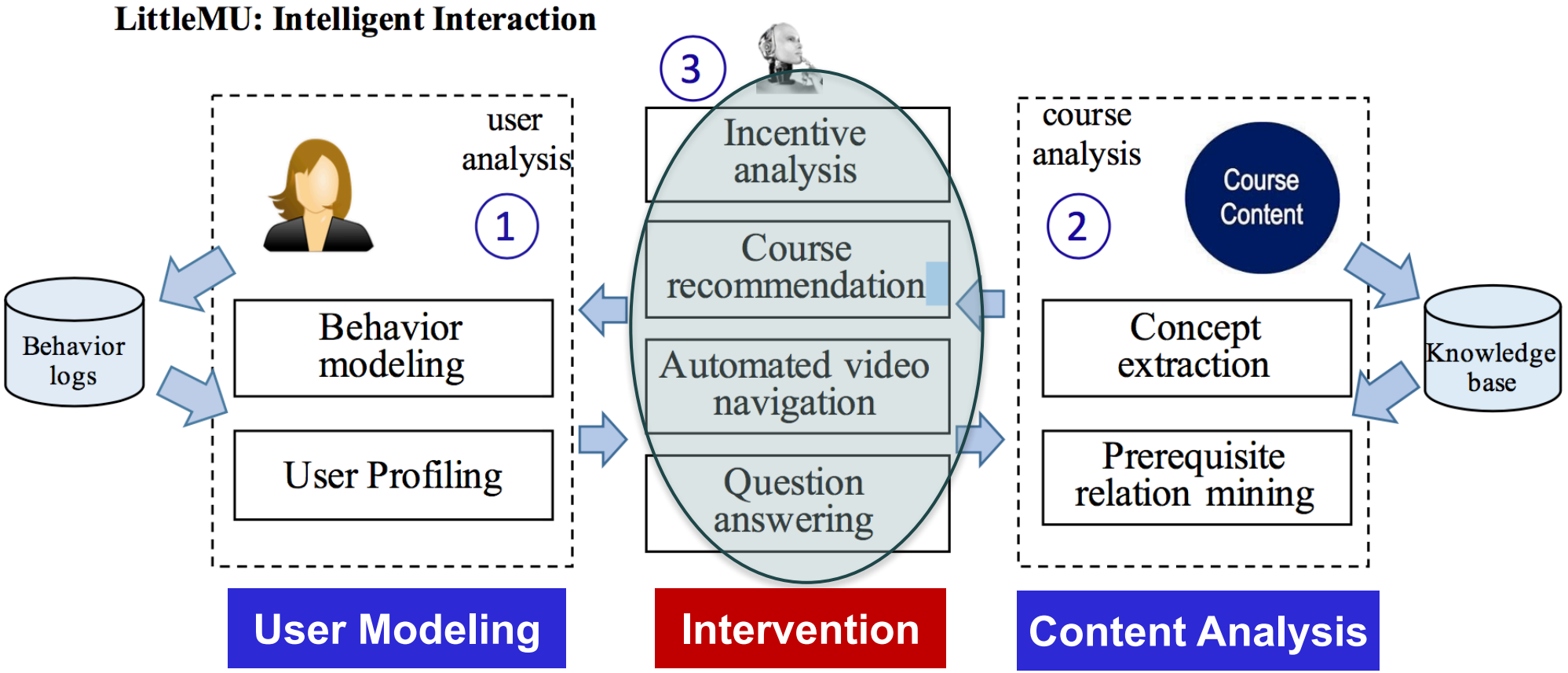
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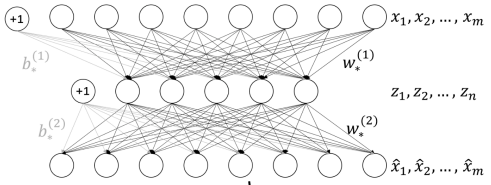
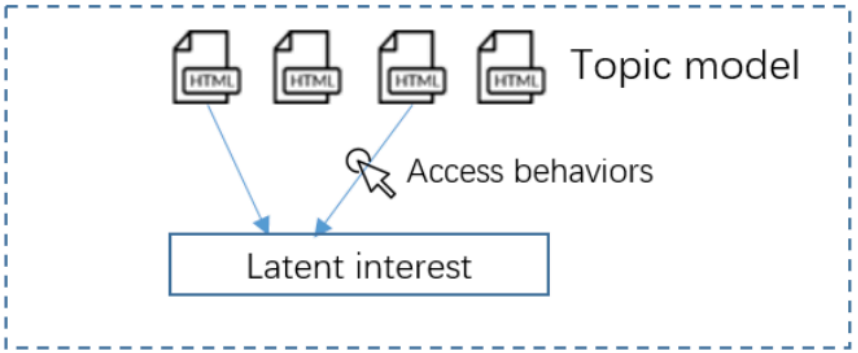
course analysis
2
Course Content
Concept extraction
Prerequisite relation mining
Knowledge base
User Modeling
Intervention
Content Analysis

What we already have…

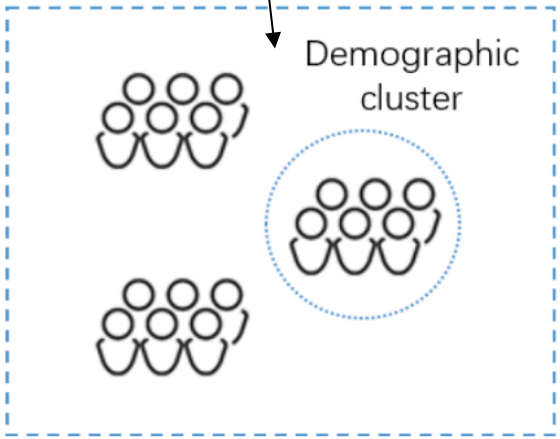


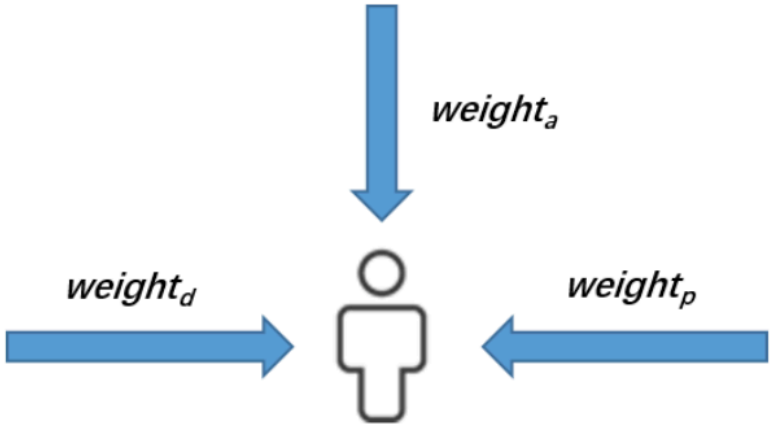
Deep Neural Networks

Latent interest model

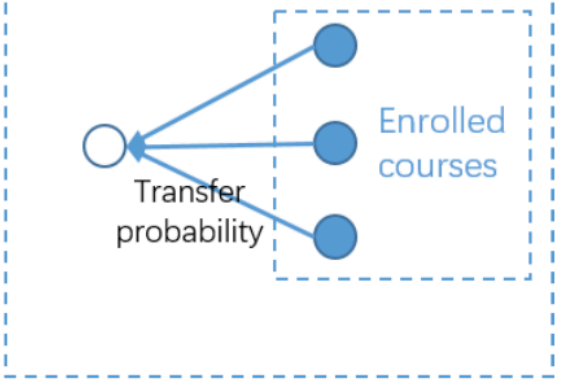


User demographics

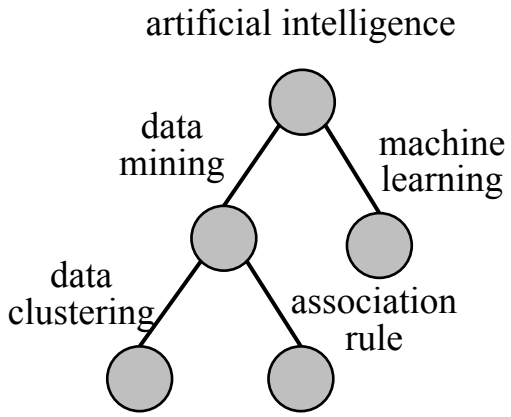




Course prerequisite



What we can do?



User

Knowledge

- Let start with a simple case
  - Course recommendation based on user interest

Course Recommendation

Course topic analysis

Low frequency

LDA training

User clustering

Course perquisite modeling

High frequency

Latent interest modeling

Collaborative filtering

With the learned user model

Recommendation result

Rule based adjustment

[1] Xia Jing, Jie Tang, Wenguang Chen, Maosong Sun, and Zhengyang Song. Guess You Like: Course Recommendation in MOOCs. **WI'17**.

Course Recommendation

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公司金融学

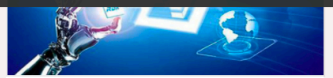
7 天前开课 422人

管理会计学

5 天前开课 328人

大学计算机教程

9 个月前开课 14267人



IC设计与方法

3 个月前开课 818人

托福考试准备：来自考试举办方的指导

edX 推荐

水力学

9 个月前开课 2349人

孝亲之礼

9 个月前开课 499人

陆游词鉴赏

8 个月前开课 850人

贞观之治

4 个月前开课 214人

IELTS雅思考试备考

edX 推荐

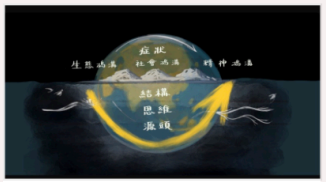
Course Recommendation: Guess you like

猜你喜欢

换一换

决胜移动互联网：创业者的商业模式课（2017春）

3 个月前开课 3083人



u.lab 0x: 基于觉察的系统创变：感知和共创未来…

8 个月前开课 5132人

金融工程导论（2017春）

3 个月前开课 1492人

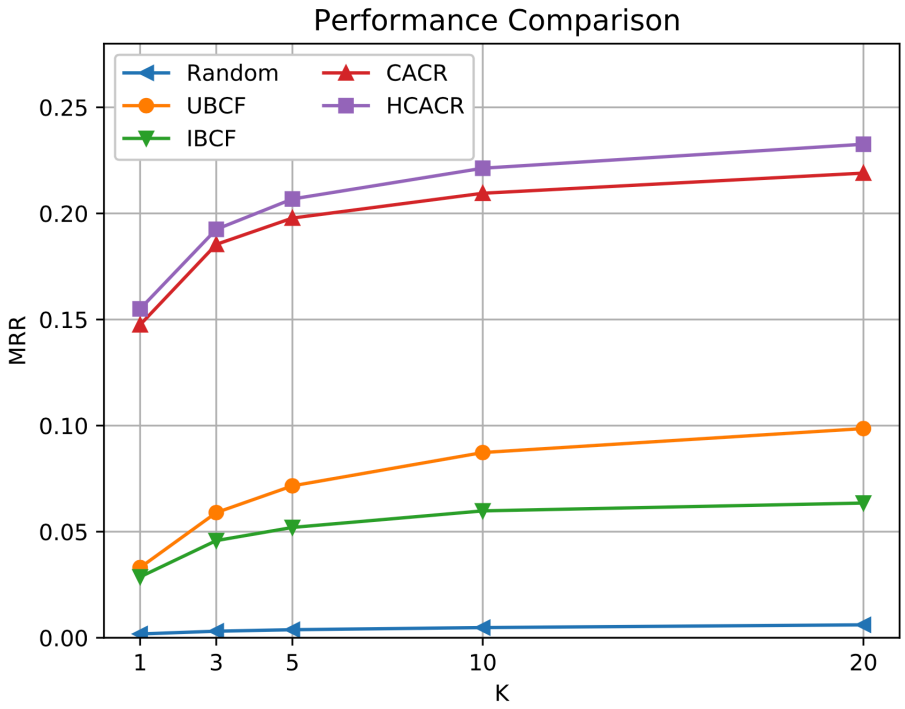
分布式计算与数据管理（微慕课）

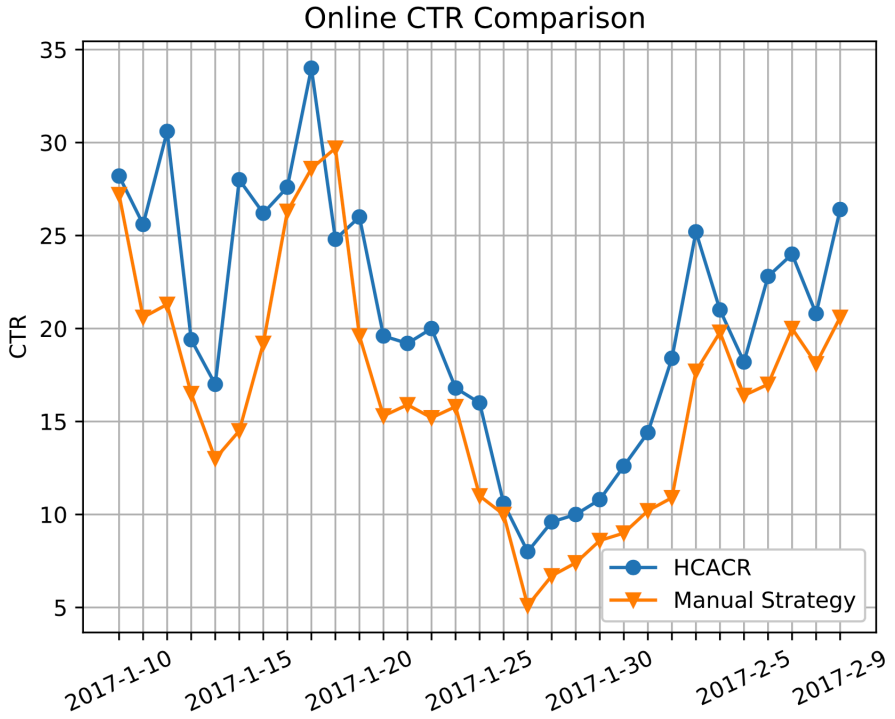
5 个月前开课 1099人

现代生活美学(2017春)

3 个月前开课 2907人

Online A/B Test





Top-k recommendation accuracy (MRR)

Comparison methods:

HCACR – Hybrid Content-Aware Course Recommendation

CACR – Content-Aware Course Recommendation

IBCF – Item-Based Collaborative Filtering

UBCF – User-Based Collaborative Filtering

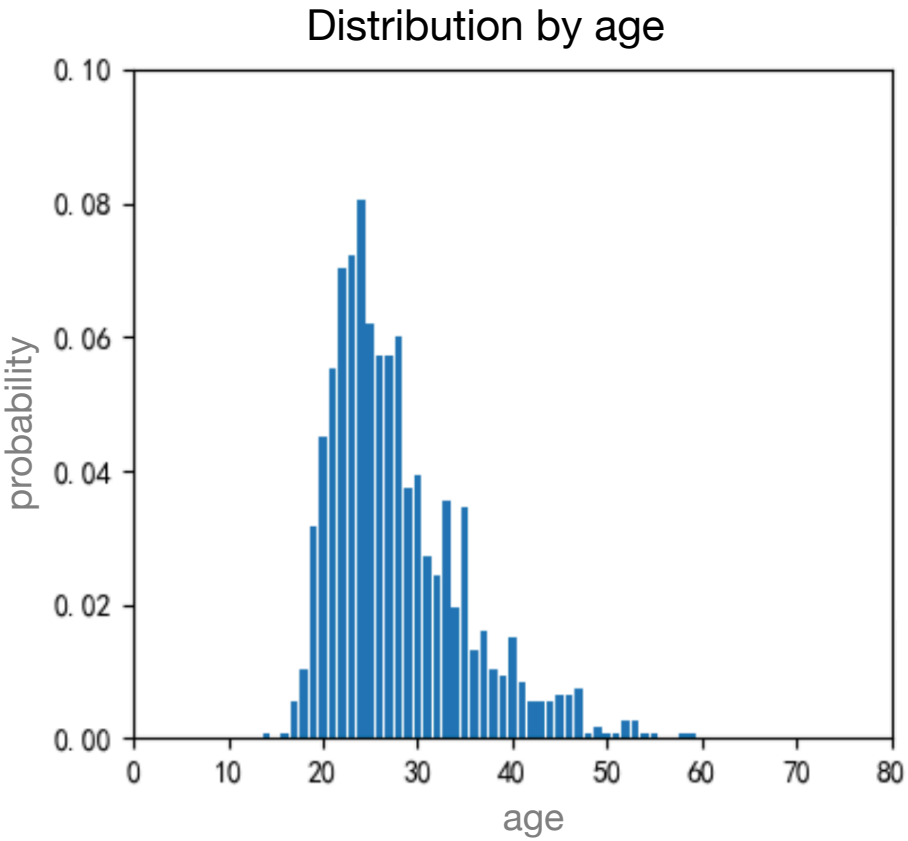
Online Click-through Rate

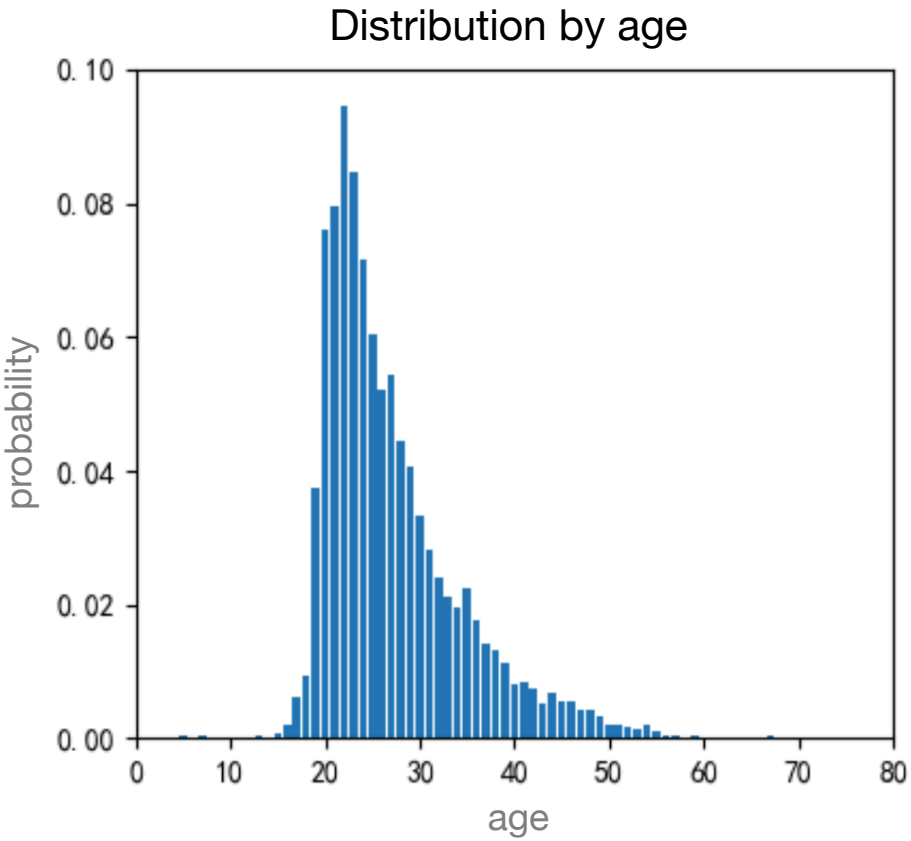
Comparison methods:

HCACR – Our method

Manual strategy

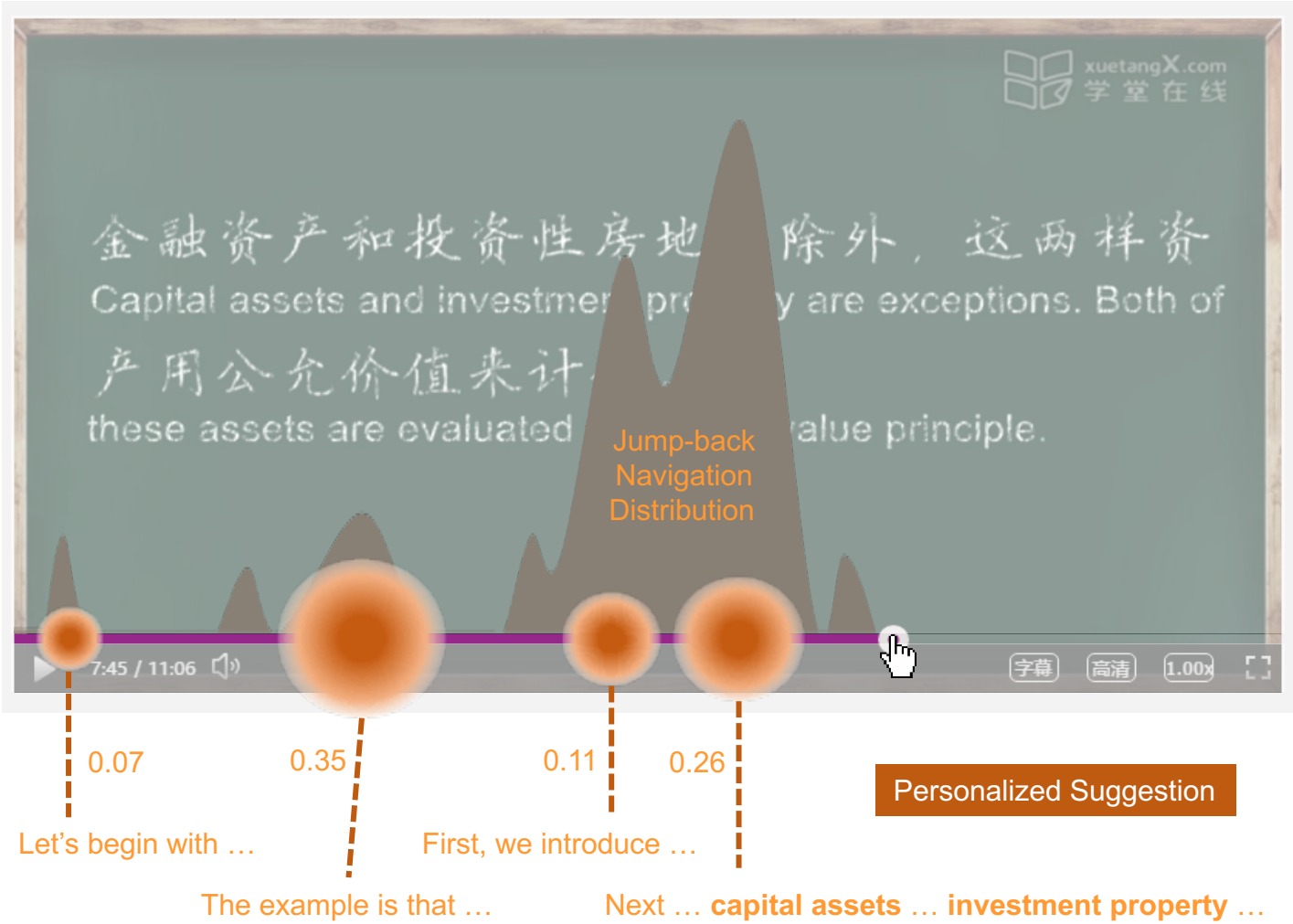
More Analysis



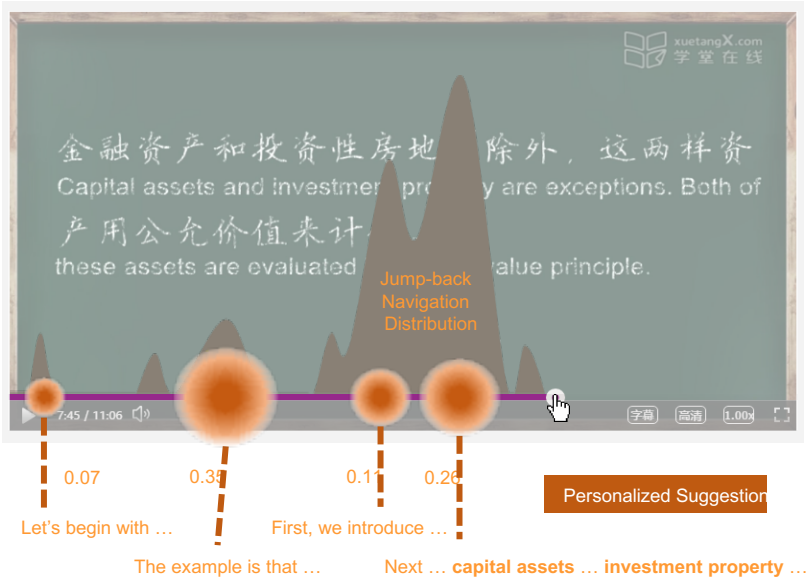


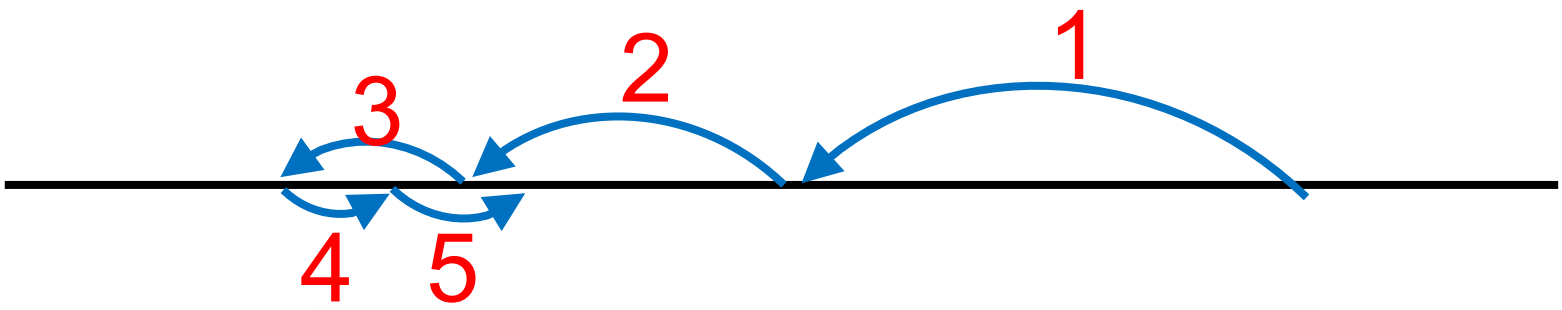
- Let start the simplest case
  - Course recommendation based on user interest
- What can we else?
  - Interaction when watching video?

Smart Jump
—Automated suggestion for video navigation



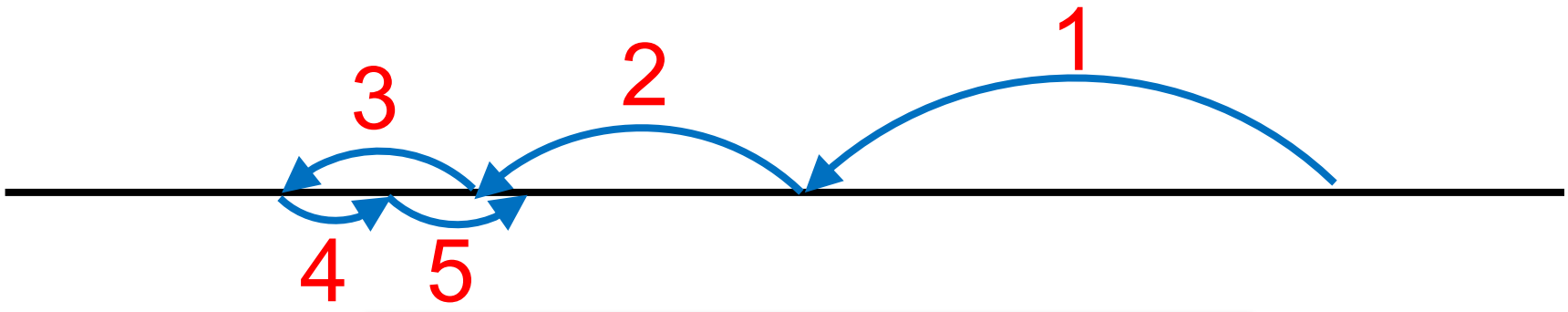
Average Jump



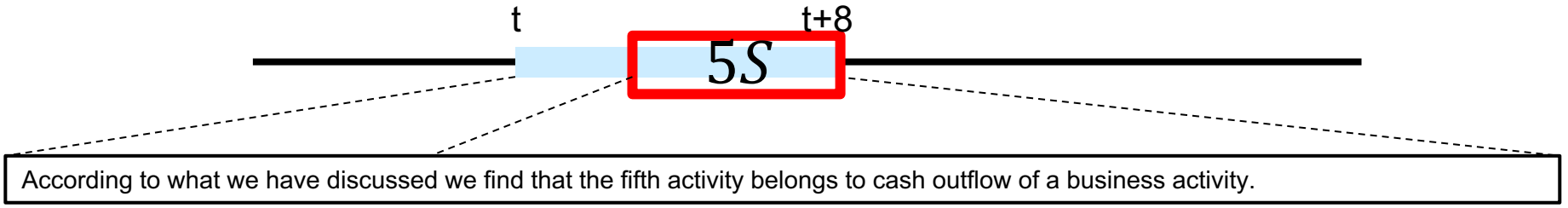


On Average: 2.6 Clicks = 5 seconds

Two Numbers



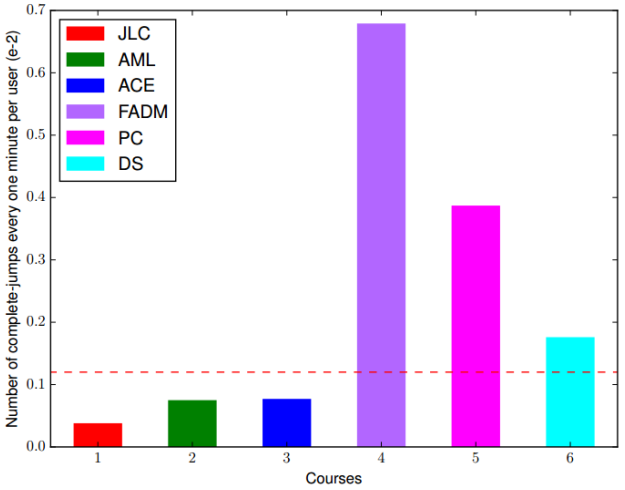
On Average: 2.6 Clicks = 5 seconds



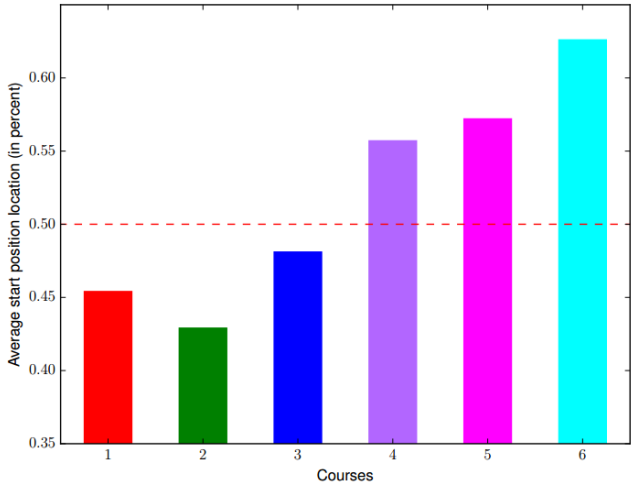
According to what we have discussed we find that the fifth activity belongs to cash outflow of a business activity.

$$5S \times 8{,}000{,}000\ users = 1.3\ years$$

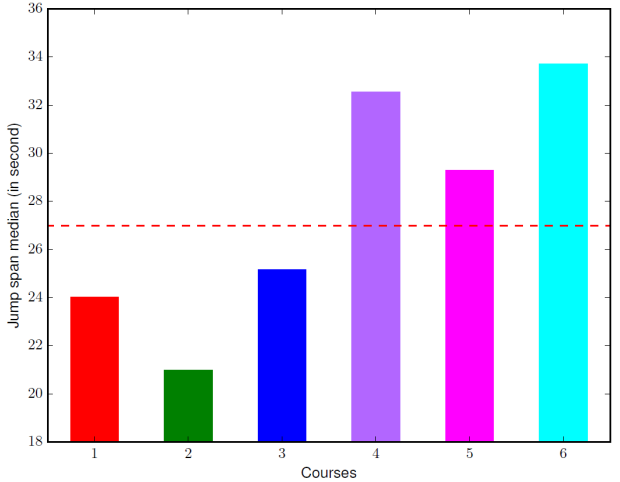
Observations – Course Related



Science courses contain much more frequent jump-backs than non-science courses.

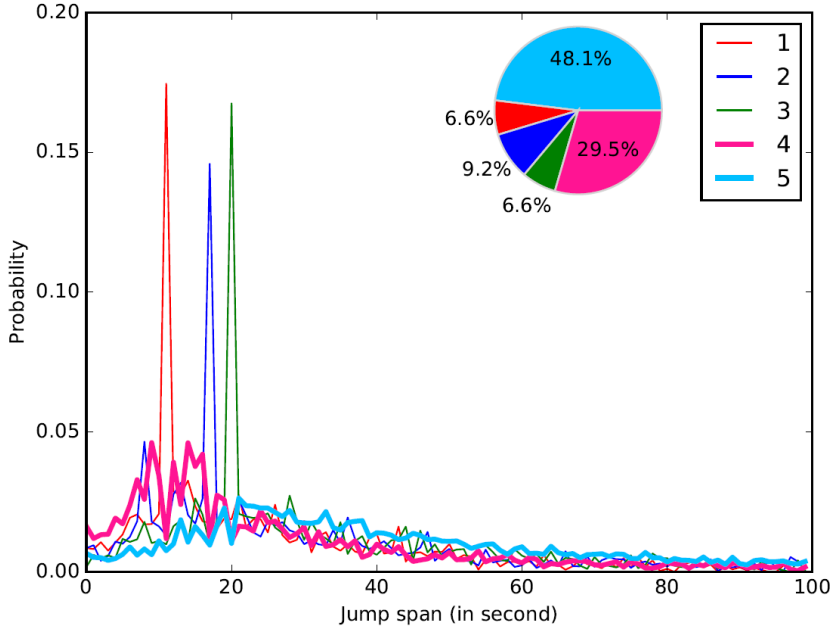


Users in non-science courses jump back earlier than users in science courses.



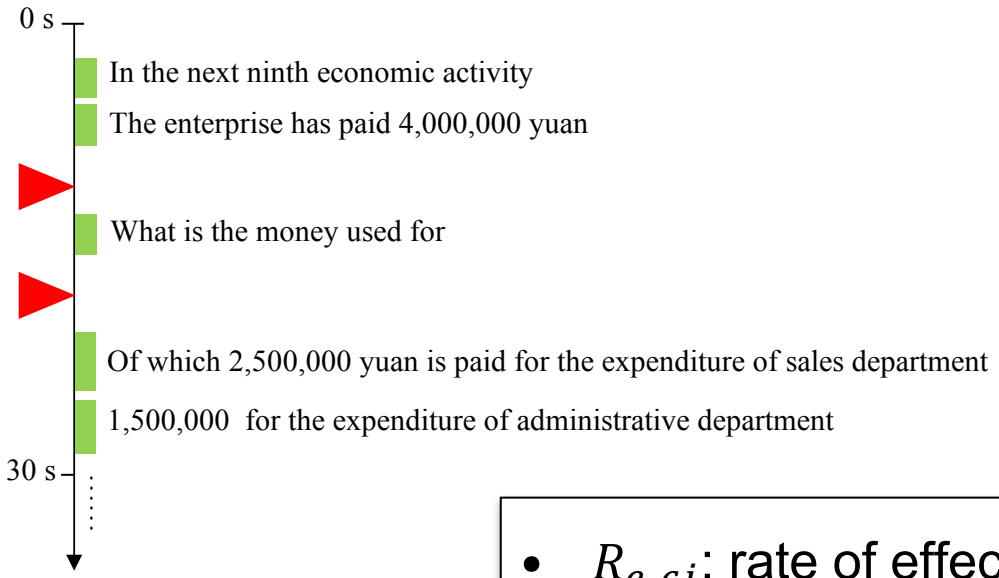
Users in science courses are likely to rewind farther than users in non-science courses.

Observations – User Related



- 6.6% users prefer 10 seconds
- 9.2% users prefer 17 seconds
- 6.6% users prefer 20 seconds

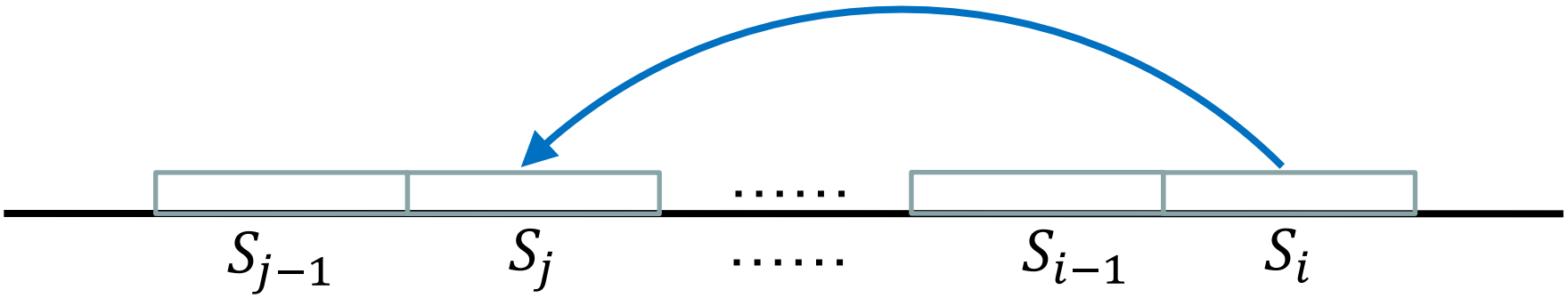
Video Segmentation



$$\underset{\Delta t}{\operatorname{argmax}}\ 2\frac{R_{e\_cj}\cdot R_{n\_s}}{R_{e\_cj}+R_{n\_s}}$$

- R_{e_cj}: rate of effective complete-jumps (start position and end position located in different segments).
- R_{n_s}: rate of non-empty segments (contains at least one start position or end position of some complete-jumps).

Problem Formulation



$$\underset{\Theta}{\operatorname{argmax}}\ P(s_j|u, v, s_i; \Theta)$$

[1] Han Zhang, Maosong Sun, Xiaochen Wang, Zhengyang Song, Jie Tang, and Jimeng Sun. Smart Jump: Automated Navigation Suggestion for Videos in MOOCs. **WWW'17**, pages 331-339.

Prediction Results

Course	Model	AUC	Recall	Precision	F1-score
Science	LRC	72.46	64.28	25.95	37.37
	SVM	71.92	64.06	25.45	36.42
	FM	**74.02**	**68.36**	**27.61**	**39.28**
Non-science	LRC	72.59	72.96	**69.23**	70.69
	SVM	73.52	79.03	68.39	**73.28**
	FM	**73.57**	**79.82**	67.56	72.88

- LRC, SVM, and FM are different models
- FM is defined as follows

$$\hat{y}(\mathbf{x}_i) = w_0 + \sum_{j=1}^{d} w_j x_{i,j} + \sum_{j=1}^{d-1} \sum_{j'=j+1}^{d} x_{i,j} x_{i,j'} \langle \mathbf{p}_j, \mathbf{p}_{j'} \rangle$$

Top-k Accuracy

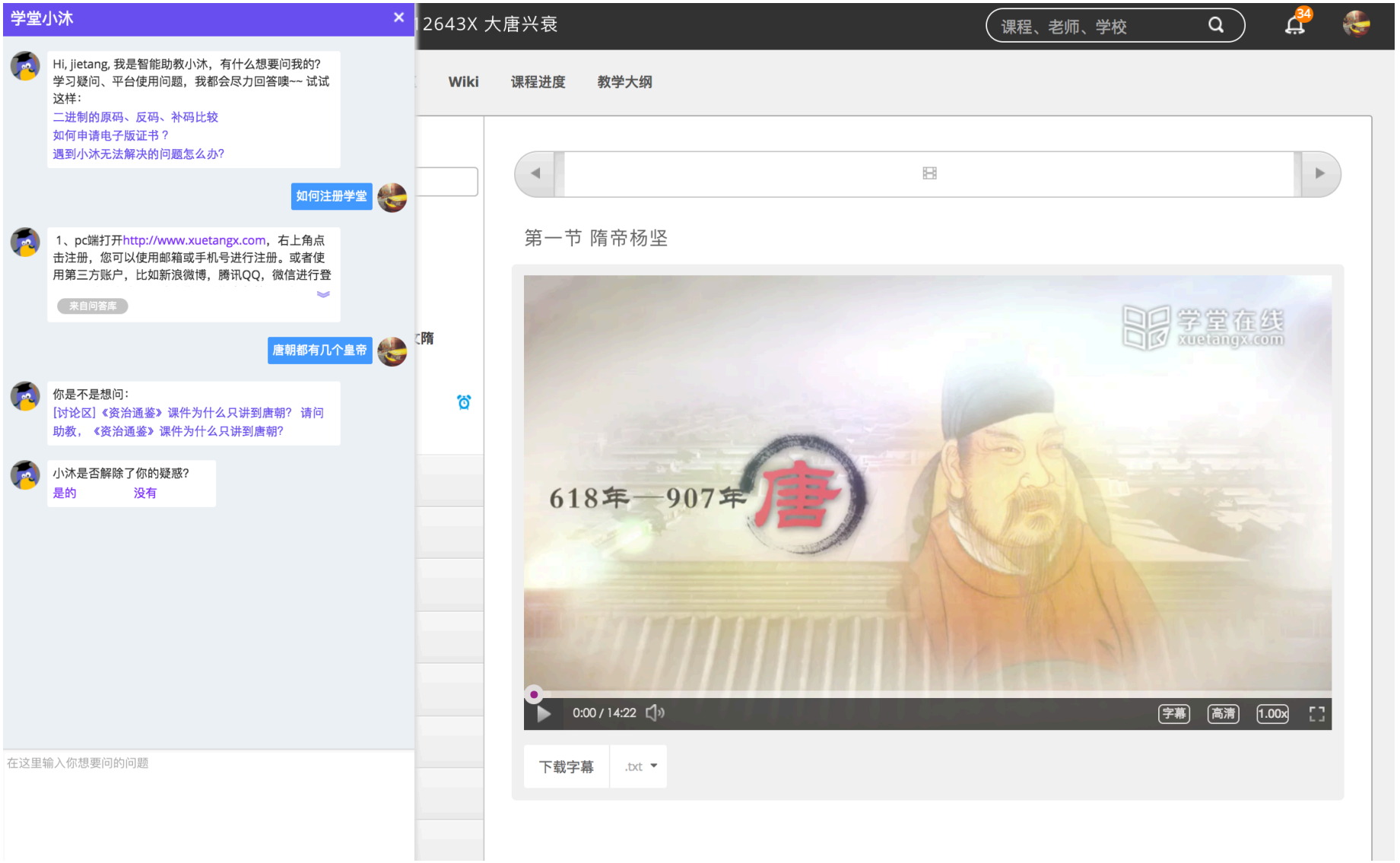
- Hits@n to evaluate the ranking performance
- Baseline is based on distribution of all users
- Our method based on FM outperforms baseline over ~10%

Course	Method	n = 1	n = 2	n = 3	n = 5
Science	Baseline	33.21	53.21	66.15	81.99
	FM	37.05	60.40	76.04	89.59
Non-science	Baseline	39.26	62.61	76.64	91.30
	FM	42.25	72.42	88.43	96.05

More

- Let start the simplest case
  - Course recommendation based on user interest
- What can we else?
  - Interaction when watching video?
- Even more
  - ?

LittleMU (小木)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你是不是想问：
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小沐是否解除了你的疑惑?
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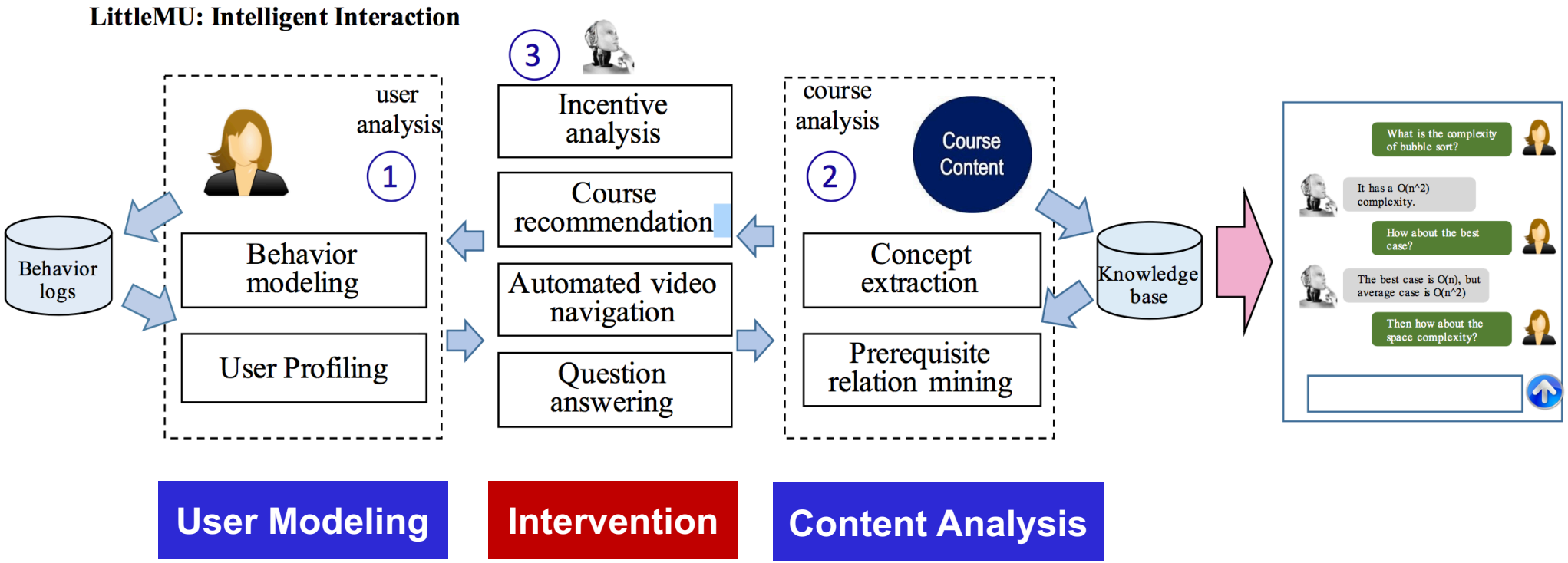
LittleMU (小木)


LittleMU: Intelligent Interaction
user analysis
1
Behavior logs
Behavior modeling
User Profiling
3
Incentive analysis
Course recommendation
Automated video navigation
Question answering
course analysis
2
Course Content
Concept extraction
Prerequisite relation mining
Knowledge base
What is the complexity of bubble sort?
It has a O(n^2) complexity.
How about the best case?
The best case is O(n), but average case is O(n^2)
Then how about the space complexity?
User Modeling
Intervention
Content Analysis

Recent Publications

- Liangming Pan, Chengjiang Li, Juanzi Li, and Jie Tang. Prerequisite Relation Learning for Concepts in MOOCs. In ACL'17.
- Xia Jing, Jie Tang, Wenguang Chen, Maosong Sun, and Zhengyang Song. Guess You Like: Course Recommendation in MOOCs. WI'17.
- Han Zhang, Maosong Sun, Xiaochen Wang, Zhengyang Song, Jie Tang, and Jimeng Sun. 2017. Smart Jump: Automated Navigation Suggestion for Videos in MOOCs. In WWW'17 Companion.
- Jiezhong Qiu, Jie Tang, Tracy Xiao Liu, Jie Gong, Chenhui Zhang, Qian Zhang, and Yufei Xue. 2016. Modeling and Predicting Learning Behavior in MOOCs. In WSDM'16. 93–102.
- Jie Gong, Tracy Xiao Liu, Jie Tang, and Fang Zhang. Incentive Design on MOOC: a Field Experiment on XuetangX, Management Science (top in management). Submitted.
- Jie Tang, Tracy Xiao Liu, Zhenyang Song, Xiaochen Wang, Xia Jing, Jiezhong Qiu, Zhenhuan Chen, Chaoyang Li, Han Zhang, Liangmin Pan, Yi Qi, Xiuli Li, Jian Guan, Juanzi Li, and Maosong Sun. LittleMU: Enhancing Learning Engagement Using Intelligent Interaction on MOOCs. submitted to KDD.
- 李曼丽, 徐舜平, 孙梦嫽. MOOC 学习者课程学习行为分析——以 “电路原理” 课程为例[J]. 开放教育研究, 2015, 21(2): 63-69.
- 薛宇飞, 黄振中, 石菲. MOOC 学习行为的国际比较研究--以 “财务分析与决策” 课程为例[J]. 开放教育研究, 2015 (2015 年 06): 80-85.
- 薛宇飞，敬峡，裘捷中，唐杰，孙茂松. 一种在线课程中的作业互评方法：中国，201510531490.2.（中国专利申请号）
- 唐杰,张茜,刘德兵. 用户退课行为预测方法及装置. 201610292389.0 （中国专利申请号）

Thank you !

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Jie Gong (**NUS**), Jimeng Sun (**GIT**)

Maosong Sun, Tracy Liu, Juanzi Li (**THU**)

Xia Jing, Zhenhuan Chen, Liangmin Pan, Jiezhong Qiu, Han Zhang, Zhengyang Song, Xiaochen Wang, Chaoyang Li, Yi Qi (**THU**)

Jie Tang, KEG, Tsinghua U,
Download all data & Codes,

http://keg.cs.tsinghua.edu.cn/jietang
http://arnetminer.org/data
http://arnetminer.org/data-sna