GradeExplorer: Education Platform for Course Visualization and Student Performance Prediction

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Outline

- Introduction
- Prediction Experiment
- Visualization
- Visualization User Studies

Motivation and Introduction

Student Motivation

- Final grades are the typical form of assessment for students.
- The final grade summarizes a semester's worth of work in one letter.
- It's important for students to understand how they're doing in the class, and how to do well.
- However, students are mostly unaware of their relative performance in the class, and may be prone to anxiety or negligence about future exams and final grades.
- Further, some students do not seek help early enough, or do not realize they are falling behind.

Instructor Motivation

- With large class sizes at universities and in MOOCs it is impossible for instructors and TAs to keep track of individual student performance.
- Students fail who could have passed if appropriate remedial actions had been taken early enough.

1. Introduce an algorithm for predicting the probability distribution for a student's total score.
2. Create an interface for students to compare their current performance against historical data and visualize predicted future performance.

Related Works

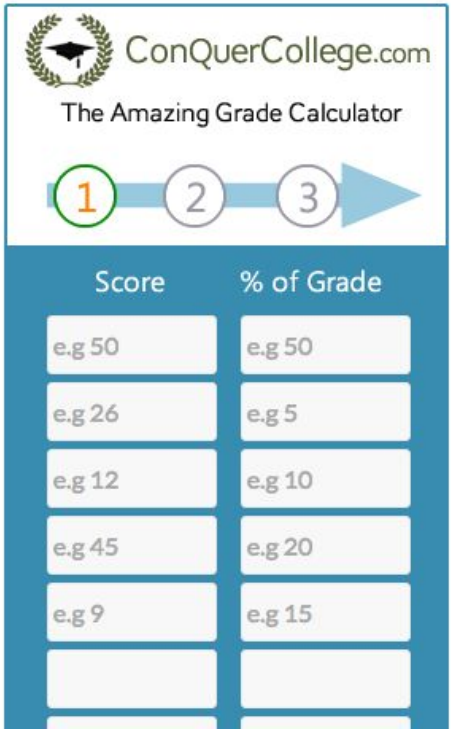
- **Student Performance Prediction** - Predicting academic success using student-related features such as gender, previous academic standing, etc.
- **Classifying Using Student Learning** - Predicting final course grades using features such as number of tries on homework, time spent on problems, amount of reading material, etc.
- **Dropout Prediction** - Predicting online course dropout using collection of demographic features, prior academic performance, and features related to the course such as project grade, section activity, and test grade.

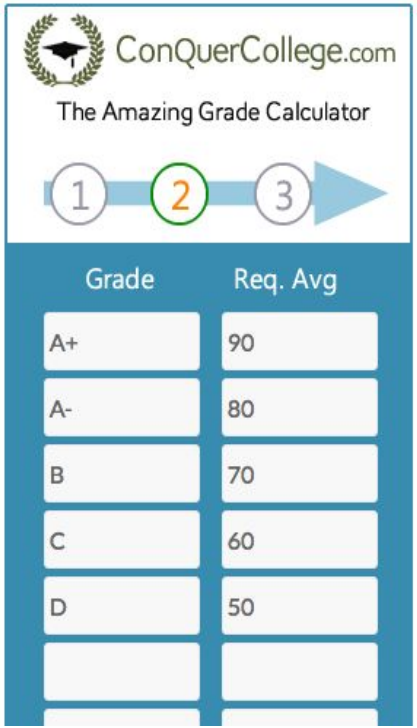
Related Works

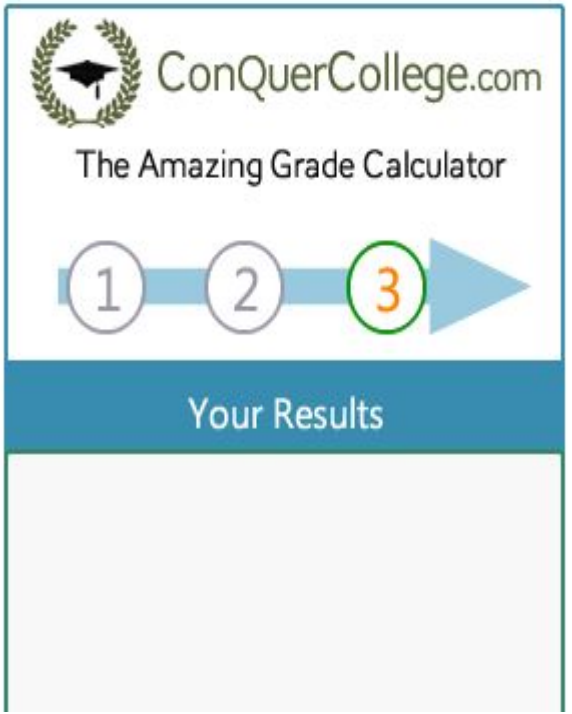
- **Final Grade Prediction**
  - A study predicting Pass/Poor/Fail on a Final Examination based on writing assignments.
  - A study conducted on a digital introductory signal processing class at UCLA determining the optimal time to make a prediction for a student's letter grade.
- **Key Differences**
  - Predict without data not necessarily available to the instructor or hard to organize
  - Computes the probability distribution of student total scores instead of final letter grades
  - Focus on predicting at any point during the semester
  - Handle different course structures

Related Works

The Amazing Grade Calculator

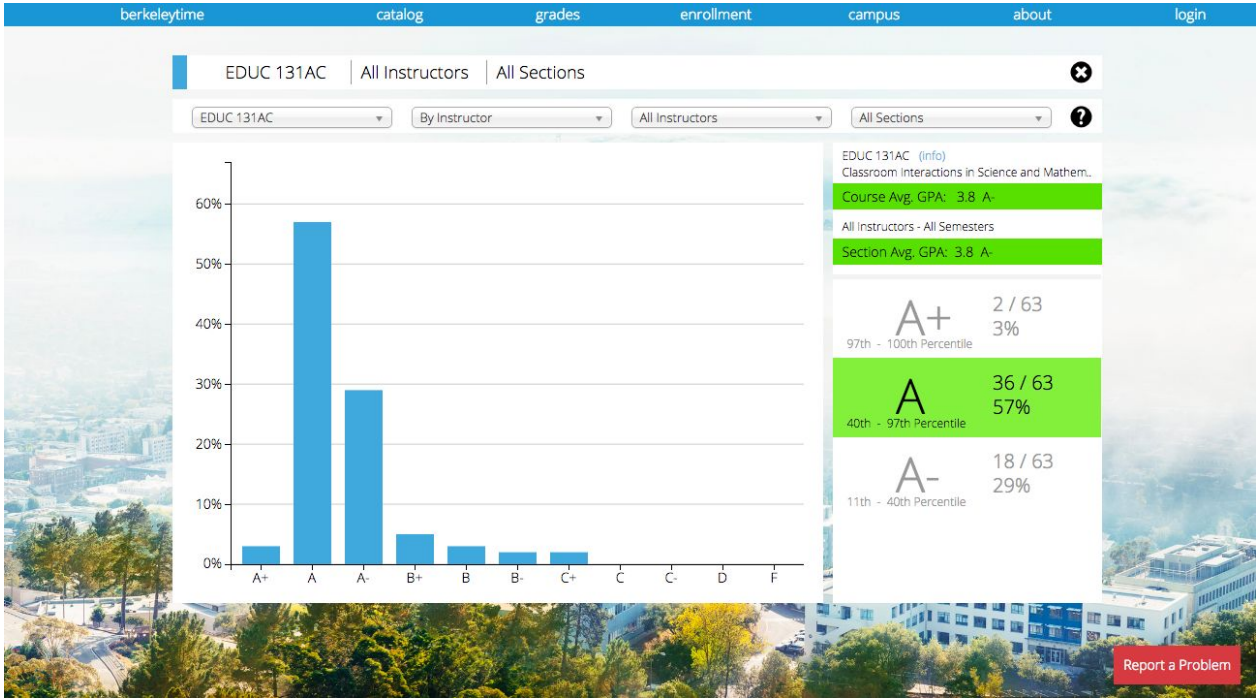






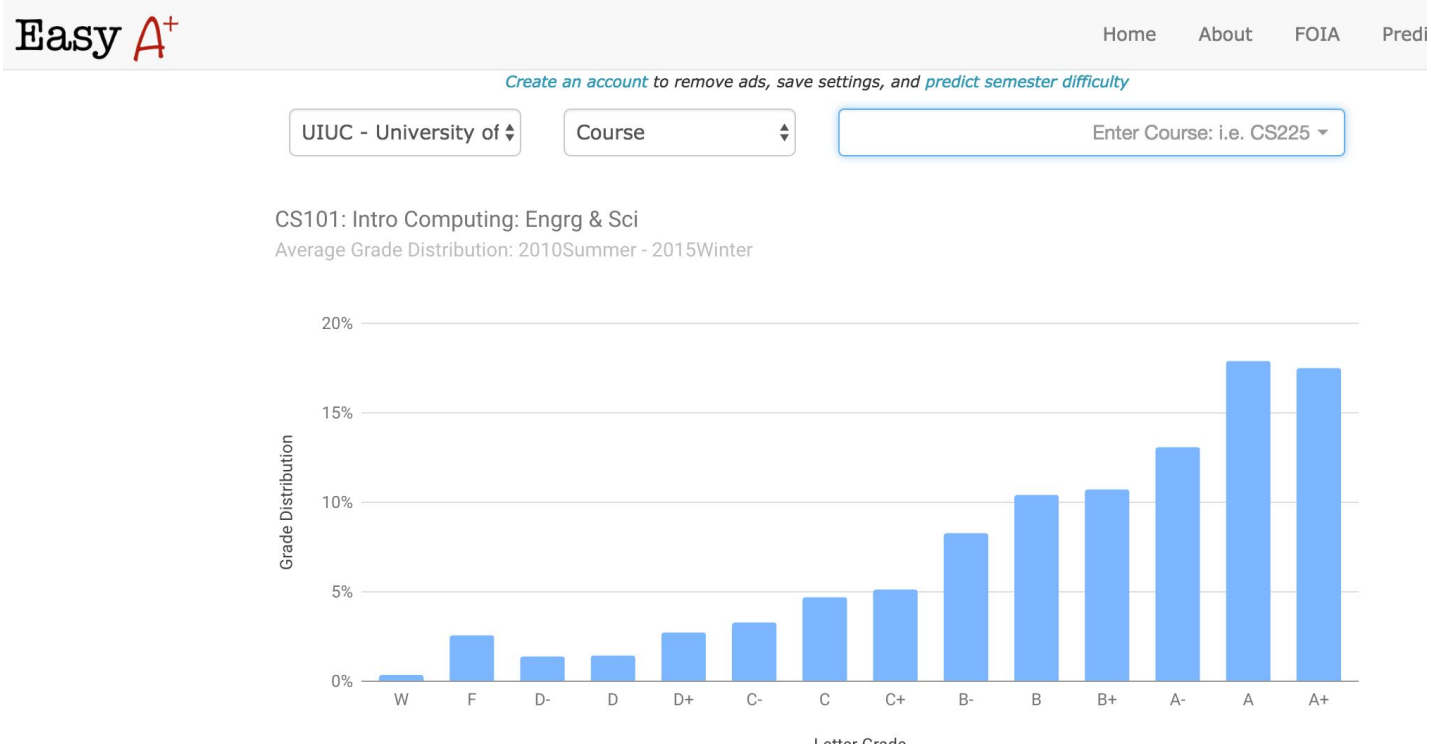
Related Works

BerkeleyTime



Related Works

Easy-A



Related Works

CMS

	Due	Weight	Max	High	Mean	Median	Deviation	Status
A0. The assert statement	February 7, 2016 11:59PM	1	1	1	1	1	0	Graded
A1. PhD Genealogy	February 12, 2016 11:59PM	5	100	100	92.9	95	7.3	Graded
H1. Program correctness	February 19, 2016 4:00PM	0.3	1	1	1	1	0	Graded
A2. Java practice	February 24, 2016 11:59PM	2	40	40	39.4	40	1.9	Graded
R1. Exception handling	March 3, 2016 11:59PM	0.3	1	1	1	1	0	Graded
R2. Loop invariants	March 6, 2016 11:59PM	0.3	1	1	1	1	0	Graded
A3. linked lists	March 9, 2016 11:59PM	5	100	100	88.6	93	13.8	Graded
Prelim 1	March 15, 2016 5:30PM	14	100	97	71.8	74	13.8	Graded
A4. Disease propagation	March 24, 2016 11:59PM	5	100	100	95.7	98	7.4	Graded
R3. Iterator/Iterable	April 12, 2016 11:59PM	0.3	1	1	1	1	0	Graded
A5. Connect Four	April 13, 2016 11:59PM	5	100	100	97.2	100	10.2	Graded
A6. Heaps	April 19, 2016 11:59PM	5	100	100	94.7	95	5.8	Graded
Prelim 2	April 26, 2016 11:59PM	16	100	99	75	77	14.3	Graded
A7. Shortest path	April 28, 2016 11:59PM	5	100	100	95.7	100	11	Graded
A8. Temple of Boom	May 10, 2016 11:59PM	5	100	102	91.3	93.5	12.8	Graded

Related Works

Term Code	Subject Code	Course Code	Course Title	Instructor	GPA	A	B	C	D	F	W	P	NP	
SP09	ANAR	100	Spec Topics/Anth Archaeology	Muniz, Adolfo A	3.613	60%	32%	0%	0%	0%	4%	4%	0%	
S308	ANAR	100	Spec Topics/Anth Archaeology	Braswell, Geoffrey E.	4	95%	0%	0%	0%	0%	0%	5%	0%	
SP11	ANAR	111	Anthropological Archaeology	Levy, Thomas E	3.15	34.8%	23.9%	17.4%	2.2%	0%	2.2%	2.2%	2.2%	
SP10	ANAR	111	Anthropological Archaeology	Levy, Thomas E	3.161	48.8%	26.8%	9.8%	0%	7.3%	0%	4.9%	2.4%	
SP08	ANAR	111	Anthropological Archaeology	Muniz, Adolfo A	3.397	43.2%	43.2%	0%	0%	0%	13.5%	0%	0%	
FA08	ANAR	111	Anthropological Archaeology	Muniz, Adolfo A	3.418	38.5%	46.2%	0%	2.6%	0%	2.6%	10.3%	0%	
WI09	ANAR	141	Prehistory of the Holy Land	Muniz, Adolfo A	4	75%	0%	0%	0%	0%	10%	10%	0%	

UCSD

AAA Asian/Asian American Studies																					
AAA 201	A	Landis Winona L.		Intro to Asian/ Asian Amer													Y		N		
	A+	A	A-	B+	B	B-	C+	C	C-	D+	D	D-	F	W	WP	WF	I	X	Y	P	S	Avg GPA
	0	6	8	6	1	1	1	0	0	0	0	0	0	2	0	0	0	1	0	0	0	3.54
%	0.0	23.1	30.8	23.1	3.8	3.8	3.8	0.0	0.0	0.0	0.0	0.0	0.0	7.7	0.0	0.0	0.0	3.8	0.0	0.0	0.0	

MiamiU

Intro to Agr & Applied Econ	215	001	112	3.309	34.8	19.6	29.5	7.1	3.6	3.6	.	.	.	.	.	.	1.8	.	.	.
Climate Change Econ & Policy	246	001	23	3.310	17.4	30.4	34.8	8.7	.	.	.	.	.	.	.	.	8.7	.	.	.
Independent Study	299	080	1	***													.	.	.	.
The Real Estate Process	306	001	23	3.043	13.0	30.4	30.4	13.0	8.7	4.3	.	.	.	.	.	.	.	.	.	.
The Internatl Ag Economy	319	001	19	2.921	15.8	10.5	47.4	5.3	15.8	5.3	.	.	.	.	.	.	.	.	.	.
Farming Systems Management	320	001	53	3.500	43.4	26.4	20.8	5.7	3.8	.	.	.	.	.	.	.	.	.	.	.
Cooperatives	323	001	20	3.325	35.0	25.0	20.0	10.0	10.0	.	.	.	.	.	.	.	.	.	.	.
Issues in Food Systems	340	001	7	3.833	57.1	28.6	.	.	.	.	14.3	.	.	.	.	.	.	.	.	.
Environmental Economics	343	001	38	2.897	23.7	18.4	21.1	15.8	13.2	2.6	5.3	.	.	.	.	.	.	.	.	.
Growth&Develpmt Global Econ	374	001	37	3.181	16.2	43.2	16.2	13.5	5.4	.	2.7	2.7	.	.	.	.	.	.	.	.
	375	001	5	***													.	.	.	.
	375	002	7	3.250	42.9		14.3	14.3	14.3	.	.	.	.	.	.	.	14.3	.	.	.

UWisconsin-Madison

ACADEMIC TERM

Use Ctrl + Click to select multiple terms

Fall 2015
Summer 2015
Spring 2015
Fall 2014
Summer 2014
Spring 2014

Exclude Small Class Results?

DEPARTMENT: AAAD

COURSE SUBJECT

CATALOG NUMBER

CLASS NUMBER

INSTRUCTOR (HELP)

Search | Clear

Criteria Selected: **Term(s):** Spring 2015 **Department:** AAAD
Results: 29

[1] (1 total page) | Spreadsheet (CSV)

#	TERM	DEPT	COURSE	CLS #	INSTRUCTOR	CLS GPA	STU GPA	A%	B%	C%	D%	VIEW
1	SP15	AAAD	AAAD-A 100	20417	Rosa, I	3.954	2.912	100	0	0	0	
2	SP15	AAAD	AAAD-A 110	20418	Wise, R	3.761	3.091	94.4	0	0	0	

IndianaU

Term: ALL
Instructor: ABADIR,CANDACE
Course Title: *AMER ART/CULT, 1913-PRE
Course Subject: AG EC
Course Number: 2
Avg Class GPA: Equal To .6923

Search | Clear Form

Course Dept	Course Title	Course Number	Section Number	Term	Course AU	Instructor	A Range	B Range	C Range	D Range	F	Avg Grade

No matches found for your search.

UMiami

Student Performance Prediction by density estimation

Goal

To find:

$$\text{Prob}(\text{ total score} = c \mid \text{ cumulative score at } t = ct \text{ })$$

$$\text{for } c \text{ in } [0, 100]$$

What is t and ct?

- Sum of weightings of completed assignments in the current semester (in %)
- E.g. Present semester

Assignment	HW 1	Prelim	HW 2	Final
Weighting (%)	10	20	10	60
t	10	30	40	100
Scores	90	80	95	85
ct	9	25	34.5	85.5

ct = 25 at t = 30

What is ct for past semester?

- Accommodates course structure different from that of current semester
- Find ct by linear interpolation of nearest available values
- E.g. Past semester

Assignment	HW 1	Quiz	Prelim	HW 2	Final
Weighting (%)	10	10	20	10	50
t	10	20	40	50	100
Scores	90	70	80	95	85
ct	9	16	32	41.5	84

Bayes Framework

$$P(\text{total score} = c \mid \text{cum score at } t = ct)$$

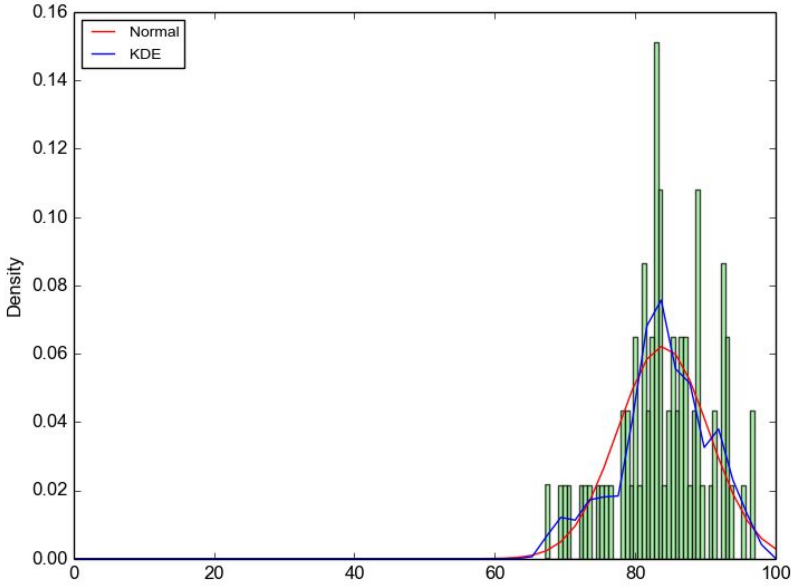
$$\propto$$

$$\underbrace{P(\text{cum score at } t = ct \mid \text{total score} = c)\, P(\text{total score} = c)}$$

To be estimated from historic data

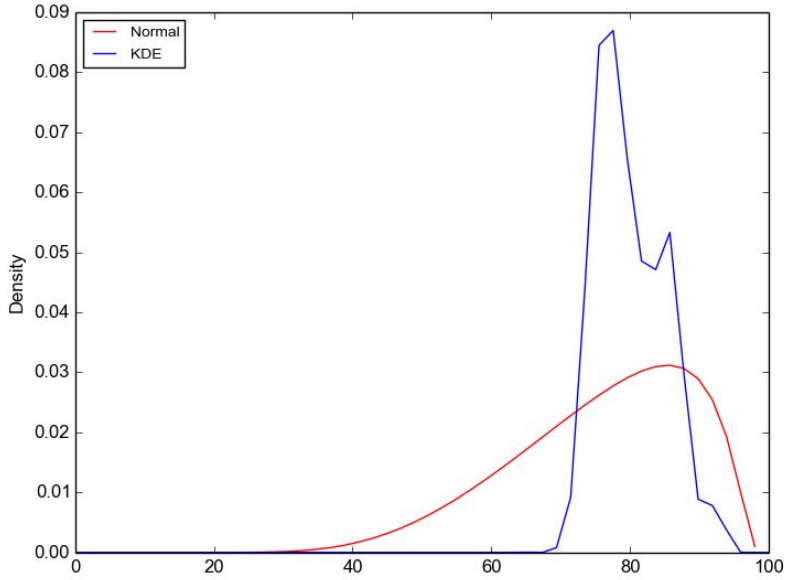
Density Estimation

P(total score = c) ∀ c ∈ [0, 100]



Density Estimation

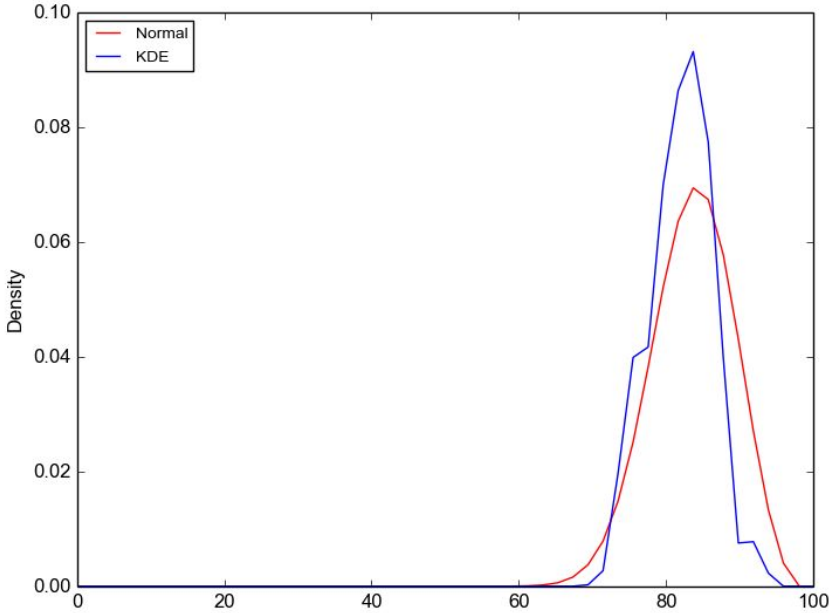
P(cum score at t = ct | total score = c) ∀ c ∈ [0, 100]



t = 24, ct = 22

Density Estimation

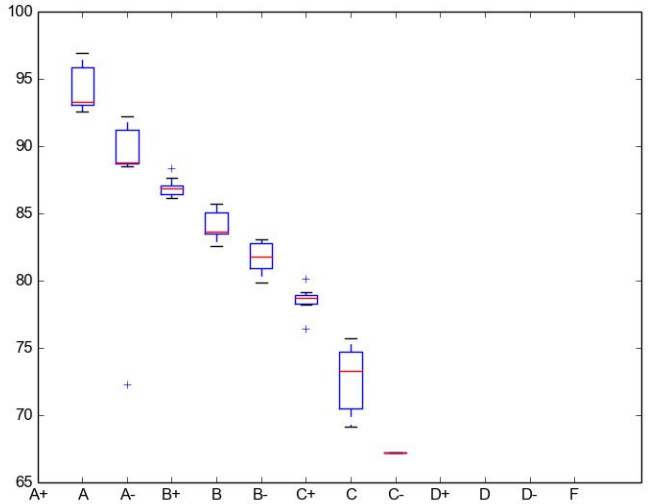
P(total score = c | cum score at t = ct) $\forall$ c $\in$ [0, 100]



t = 24, ct = 22

Predicting Grades

- Determine cutoff for each grade



- Integrate P(total score = c | cum score at t = ct) to obtain probability of each grade

Extending to Multiple Past Semesters

- Lump all historic data and proceed with algorithm
- Implement algorithm on each past semester individually to obtain grade predictions
  - Equal weightings on predictions by each semester
  - Optimal weightings on predictions by each semester

Evaluation and Results

Datasets

- **Cornell Stats Course (CSC)**
  - Course Enrollment- 80-100 students (graded) each semester
  - Course Structure

Semester	Lab % (13)	Prelim % (3)	Final %	Attendance %
S14	16	54	20	0
F14	16	54	20	0
S15	15	60	25	0
F15	14	60	25	1

Datasets

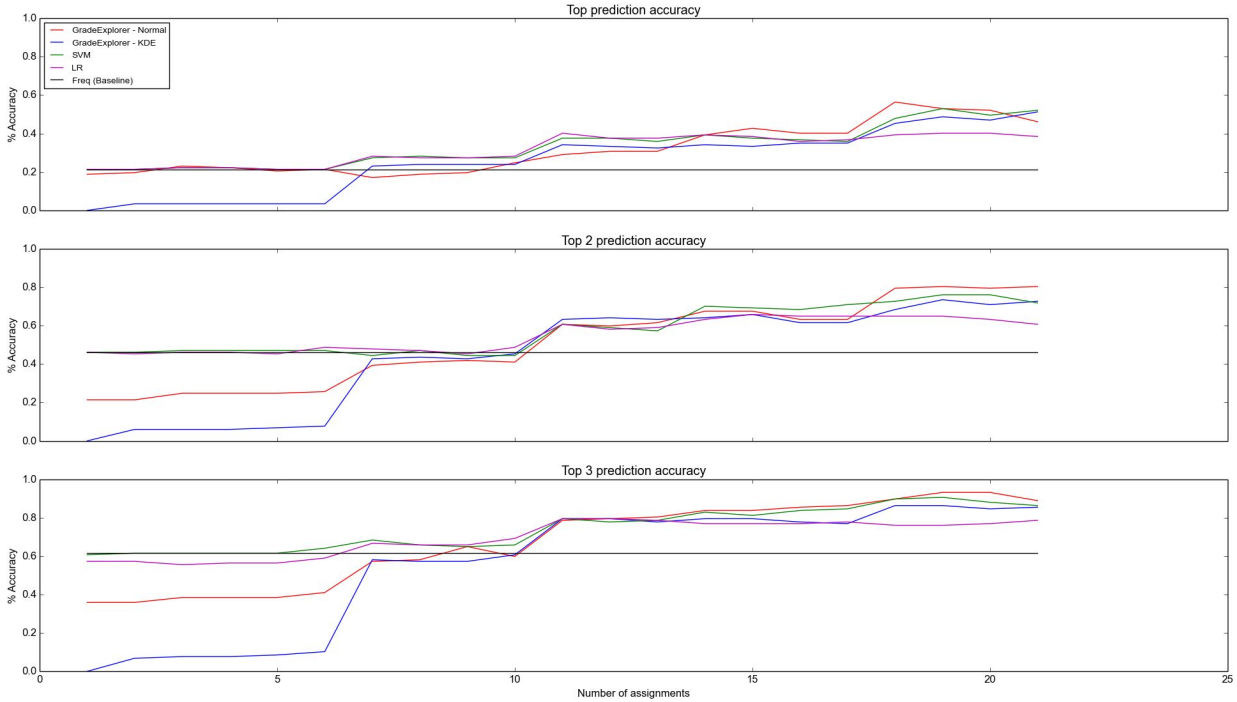
- **Cornell CS Course (CCC)**
  - Course Enrollment- 469 students (graded)
  - Course Structure

Lab (12)	Prelim (2)	Final	A1	A2	A3	A4	A5	A6	A7
2	30	30	4	4	4	6	4	8	8

Predicting Grades Using One Identical Semester

Train - CCC

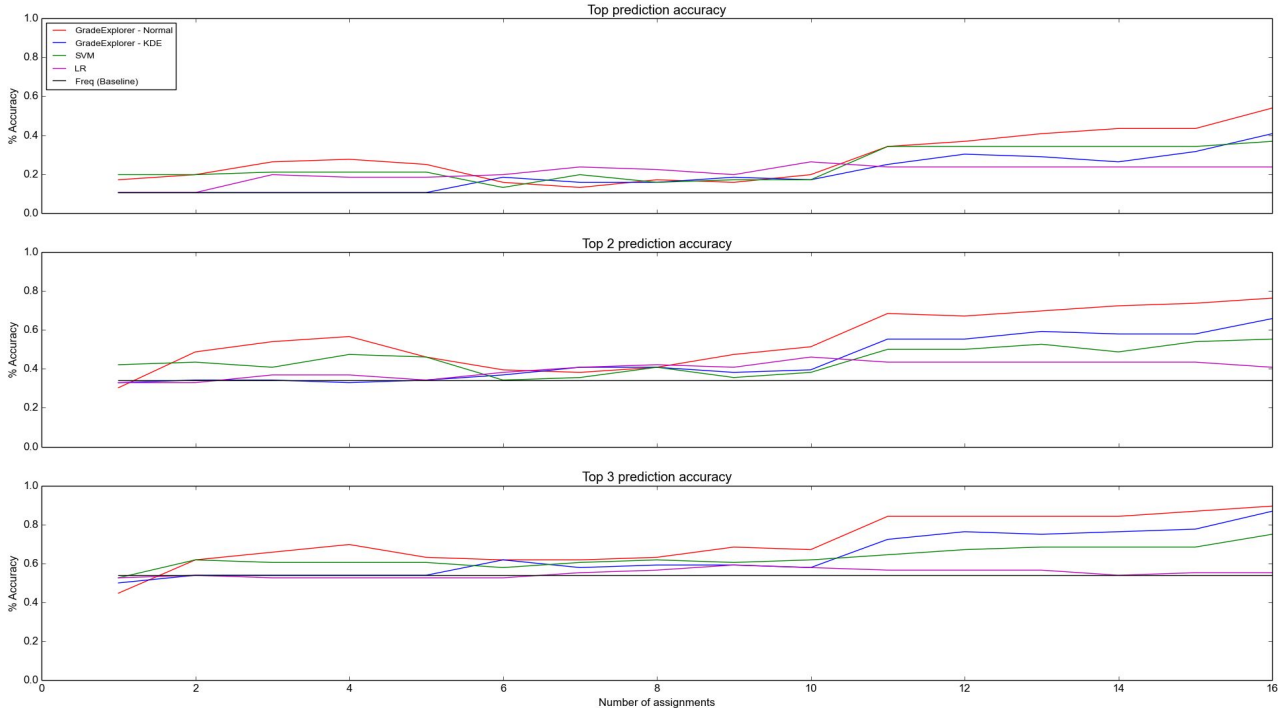
Test - CCC



Predicting Grades Using One Similar Semester

Train
CSC S14

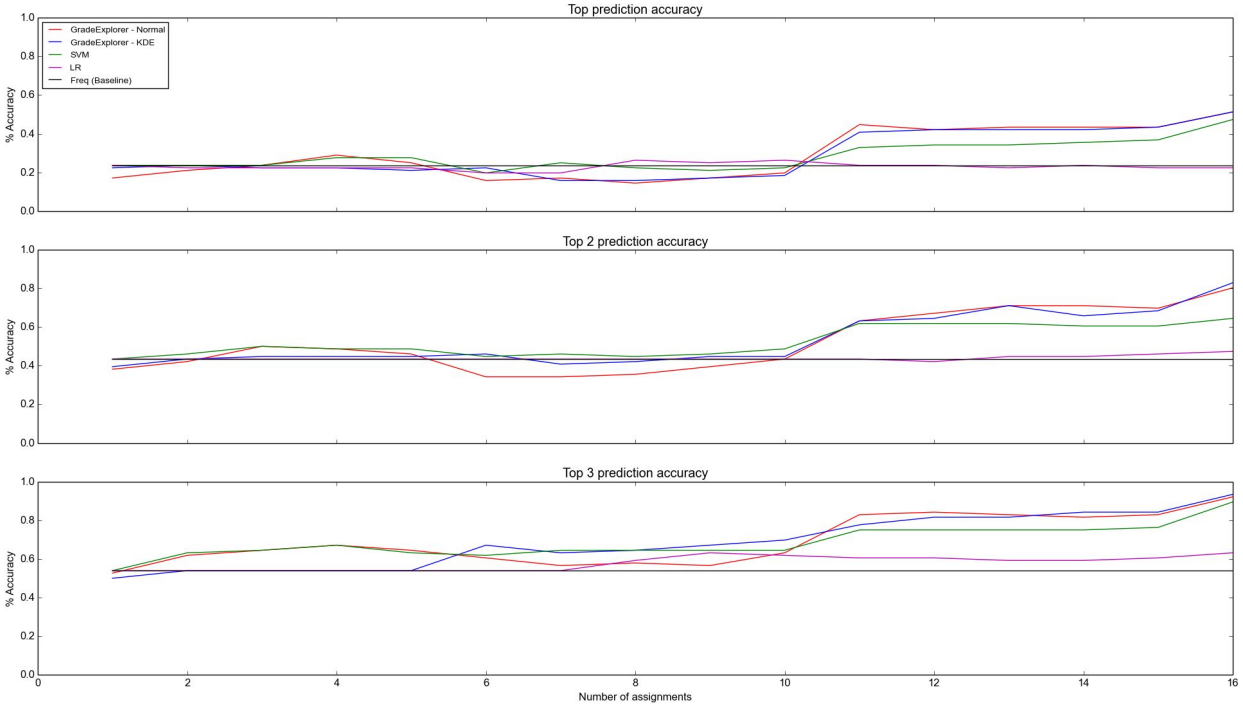
Test
CSC F14



Predicting Grades Using All Semesters Weighted

Train
CSC all sem - F14

Test
CSC F14



Summary of Prediction Results

- For a small amount of training data (one semester (100)) density estimation outperforms SVM and LR (~10%)
- Both SVM and KDE improve with more training data (multiple semesters).
- At Add Date (Number of Assignments = 2), accuracy is 60% but this is a result of guessing the most probable grades.
- At Drop Date (Number of Assignments = 8), accuracy is 60-70%.
- At “Stress Time” (Number of Assignments = 11), sharp increase in accuracy to 80%.
- By Final Exam, accuracy is over 90% with multiple semesters.

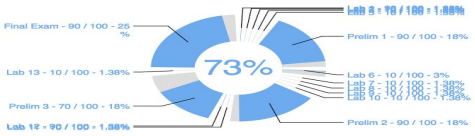
Visualizations

Input Your Grades

Lab 1	Lab 2	Lab 3	Lab 4	Lab 5	Preli-m 1	Lab 6	Lab 7	Lab 8	Lab 9	Lab 10	Preli-m 2	Lab 11	Lab 12	Preli-m 3	Lab 13	Final Exam
90 / 100	10 / 100	10 / 100	10 / 100	10 / 100	90 / 100	10 / 100	10 / 100	10 / 100	10 / 100	10 / 100	90 / 100	10 / 100	90 / 100	70 / 100	10 / 100	90 / 100

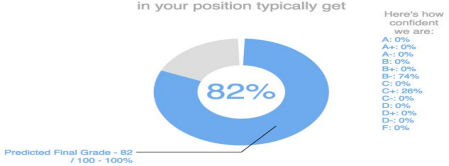
Your Current Status

Here's your current weighted average

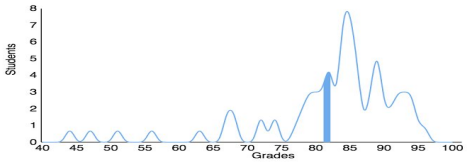


Your Future Status

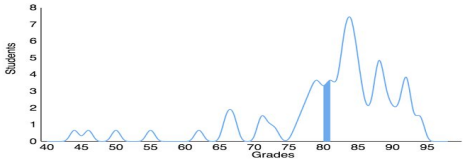
Here's the final grade students in your position typically get



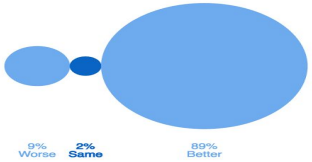
Here's your performance relative to the past data up to



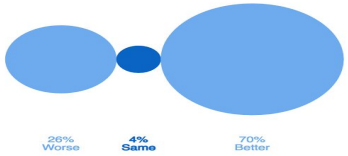
Here's how we predict you would perform relative to past data at the end of the semester



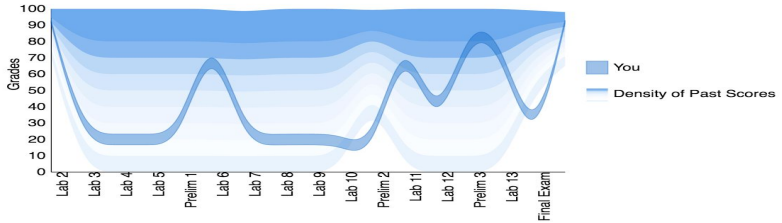
Approximately 9% of students are worse off, 2% are the same, and 89% are better.



Approximately 26% of students are worse off, 4% are the same, and 70% are better.



Here's the distribution of how students performed on the assignments overall



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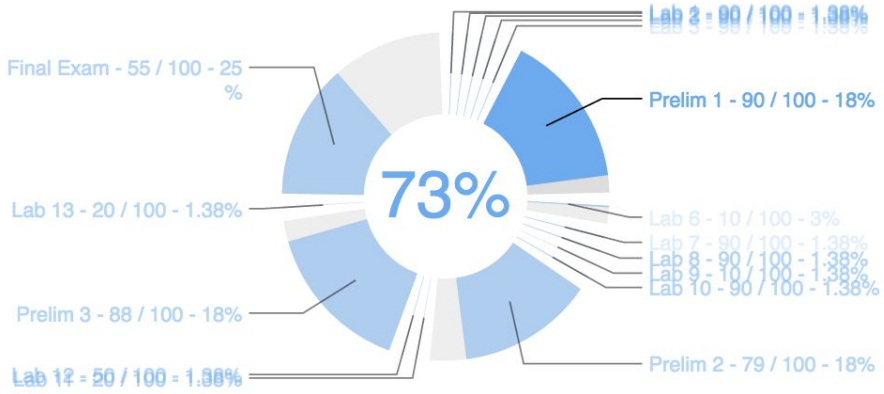

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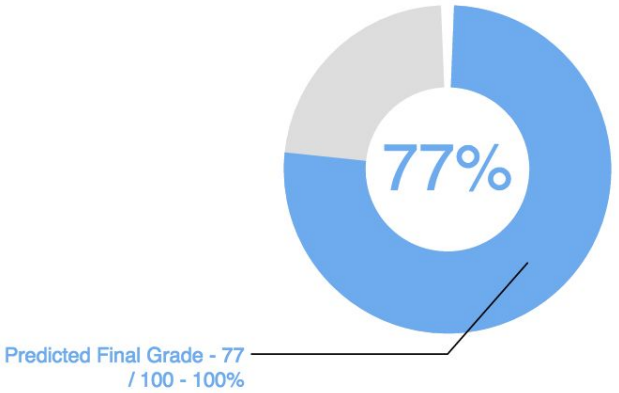
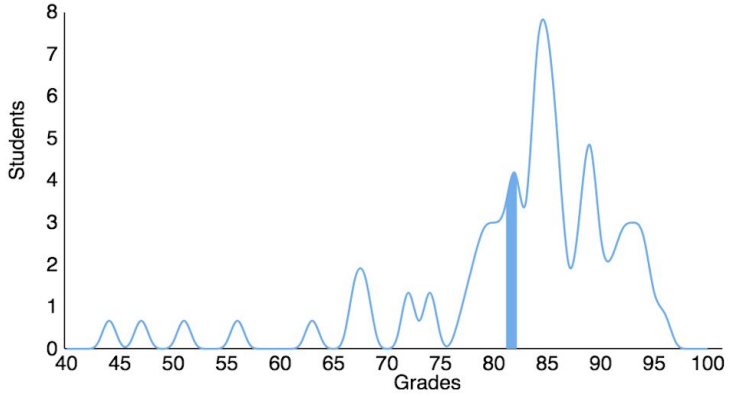


Here's how confident we are:

A: 0%
A+: 0%
A-: 0%
B: 0%
B+: 0%
B-: 10%
C: 0%
C+: 90%
C-: 0%
D: 0%
D+: 0%
D-: 0%
F: 0%

Here's your performance relative to the past data up to



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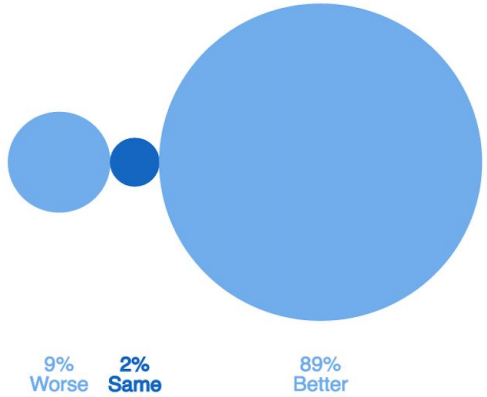

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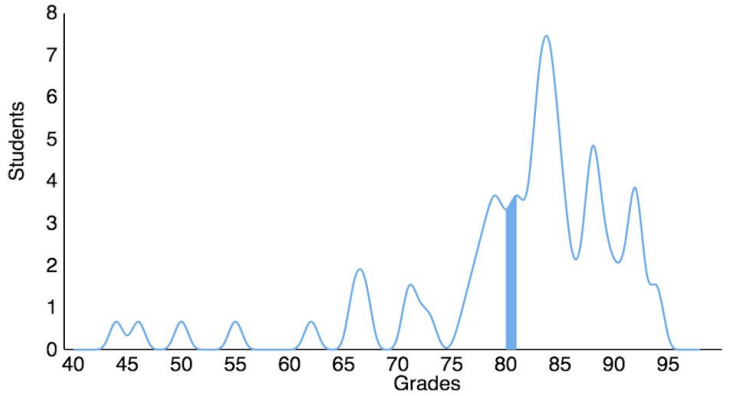

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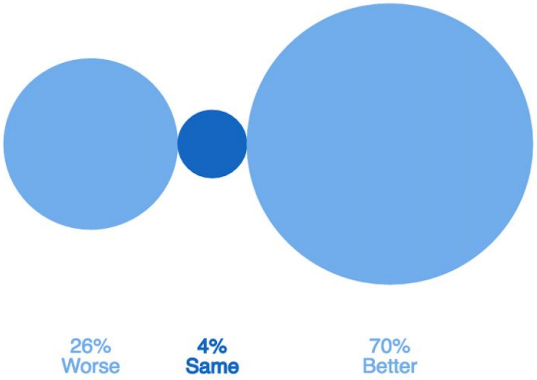

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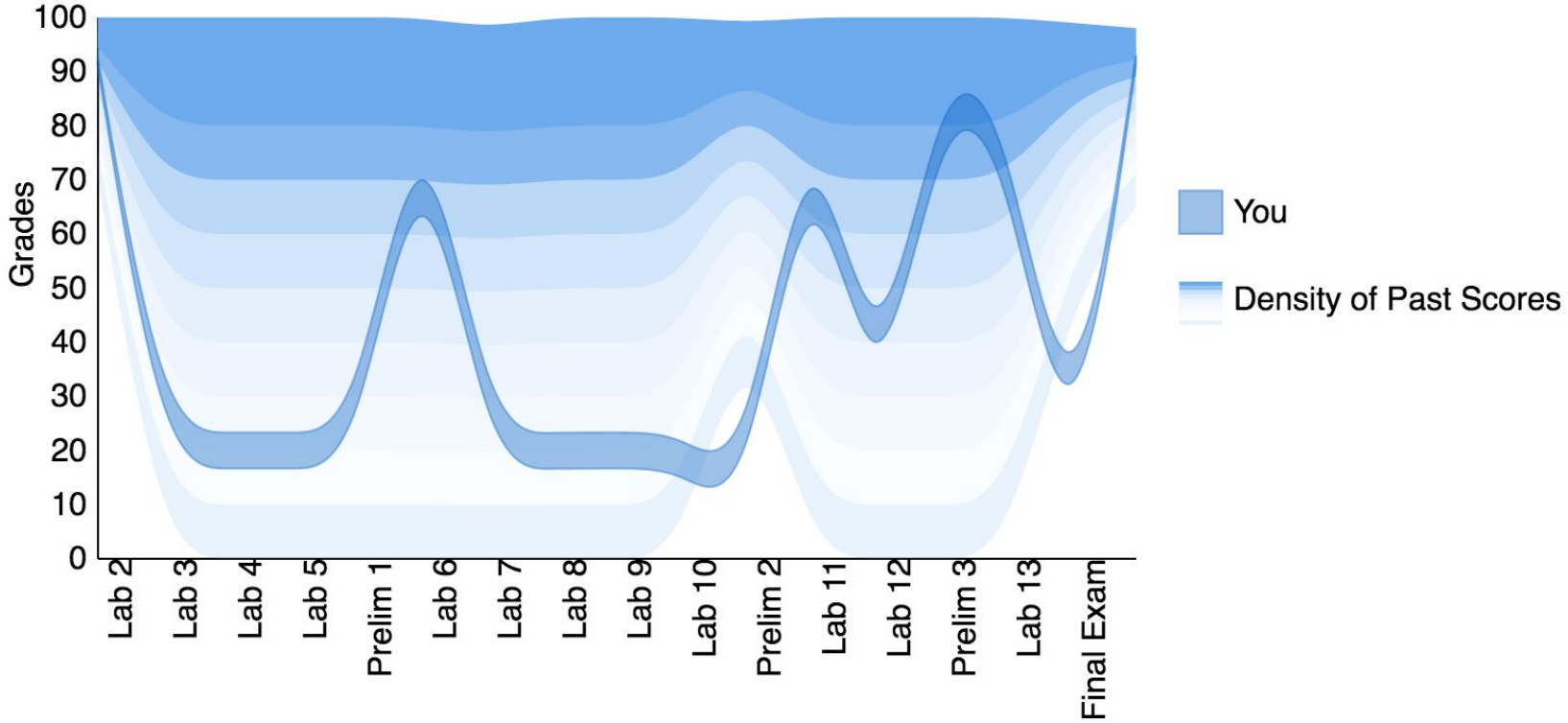

Results - User Studies

Results (Qualitative)

- “This has the potential to be a really useful app for students concerned about their grade in a class.”
- “Besides that [referring to a particular graph] this is really helpful.”
- “Well at least now I know I’m getting a C”
- “It’s good to know there’s some people doing worse than me”
- “Overall, I think this is a great software for students to use, but there are some improvements that should be made. I think we should be allowed to input grades for the later assignments/prelim grades without filling out all of the assignments before it.”

Future Work

- Include S/U predictions
- Determine a heuristic strategy to select optimal weightings
- Evaluate other density estimation techniques.

- Allow input of arbitrary grade orderings (i.e. HW1, HW7, Prelim 2)
- More interactivity in the graphs and ways to explore data through interaction

Acknowledgements

Anton Gilgur

Wenyu Zhang

The CS 6360 course staff and students

Melissa Smith and Walker White

Questions?