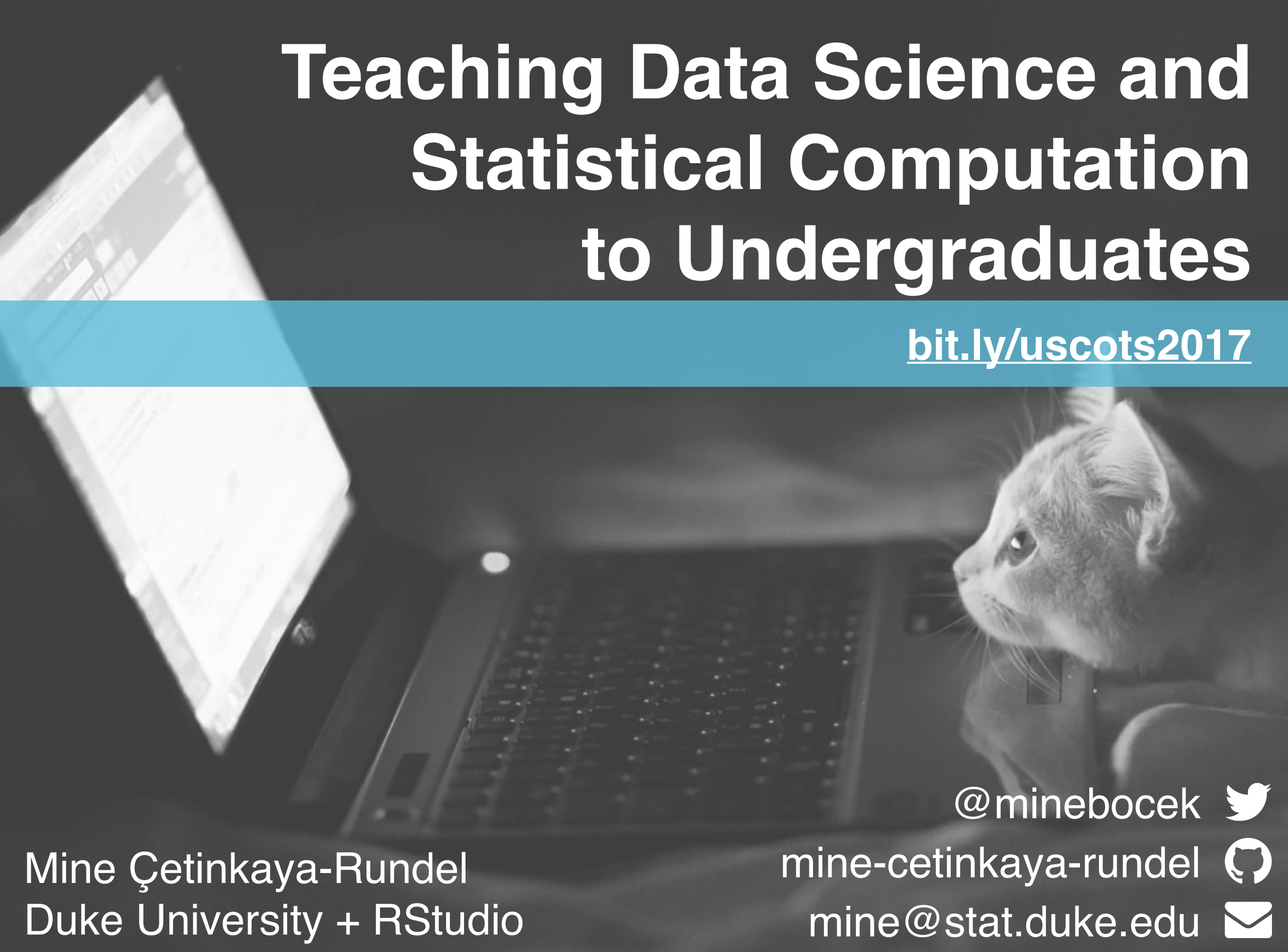
Teaching Data Science and Statistical Computation to Undergraduates

bit.ly/uscots2017



Mine Çetinkaya-Rundel
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I'm interested in stats, but I have no idea where to get started!

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Sta 101

I'm interested in stats, but I have no idea where to get started!

Calculus

I'm interested in stats, but I have no idea where to get started!

Probability

I'm interested in stats, but I have no idea where to get started!

Regression


I'm interested in stats, but I have no idea where to get started!
Intro to data science and statistics

motivation

computation

interest & impact

course overview

data analysis examples

curricular considera-tions

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curricular considera-tions

goal:

a course that provides a common (gateway) experience to students wanting to get started with stats, and that is

1. modern
2. places data front and center
3. quantitative (but not mathematical)
4. different than HS stats
5. challenging (but not intimidating)

this course should…

emphasize modern and multivariate EDA + data visualization

start at the beginning of data analysis cycle with data collection and cleaning

encourage + enforce working collaboratively (think, code, write, present)

teach (not just expect) reproducible computation

approach statistics from a model based perspective

underscore effective communication of findings

and maybe more importantly…

ask questions that students want to answer

equip students with the tools to answer questions of their own choosing

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this course doesn't yet exist, but…

Better Living Through Data Science:

Exploring / Modeling / Predicting / Understanding

Combines techniques from statistics, math, computer science, and social sciences, to learn how to use data to understand natural phenomena, explore patterns, model outcomes, and make predictions. Case studies include examples from election forecasts, movie reviews, and online dating match algorithms. Discussions around reproducibility, data sharing, data privacy will accompany these case studies. Gain experience in data wrangling and munging, exploratory data analysis, predictive modeling, and data visualization, and effective communication of results. Course will focus on R statistical computing language. No computing background necessary. For students in the FOCUS Program.

Part of the What If? Explaining the Past/Predicting the Future cluster.

first-year seminar for undergrads interested in quantitative fields

course overview

curriculum:

data gathering + wrangling, EDA + visualization, multivariate modeling, basic inference, communication

structure:

teams: in class exercises + projects
indivudual: homework + take home midterm and final

applications:

movie reviews, airline delays, paris paintings, basketball, professor evals, etc.

assessment:

not just final work but also the process, peer evaluations and contribution diagnostics

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core:

R +
RStudio Server

toolkit:

(mostly) `tidyverse`

reproducibility:

R Markdown +
Git/GitHub

R + RStudio Server

goal:

get started "like a knife through butter" to minimize time to first data visualization

how:

avoid local installation with RStudio Server (Pro)

at the end:

provide instructions for + help with local install

R Markdown

reproducibility:

train new analysts whose only workflow is a reproducible one

efficiency:

consistent formatting + built in “show your work”
= easier grading

pedagogy:

code + output + prose together

syntax highlighting + notebooks FTW!

key to success:

iterative development: knit early, and often

Git + GitHub

version control:

lots of mistakes along the way, need ability keep track of history (revert)

accountability:

transparent commit history

collaboration:

platform and interface designed to enable collaboration

early intro:

mastery
takes time,
start early (day one)

marketability + discoverability

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data expeditions

pairs of grad students, work with course instructor to formulate a question, and a pathway through a dataset to explore the question

element of an undergraduate course that introduces students to exploratory data analysis

graduate student participants receive a travel grant

Source: http://bigdata.duke.edu/data-expeditions

meet the experts

Sandra Van Ginhoven
PhD, Art History

Hilary Coe Cronheim
PhD, Art History

data source: auction catalogs

89 Deux tableaux très riches de composition, d'une belle exécution, & dont le mérite eſt très remarquable, chacun de 17 pouces 3 lignes de haut, ſur 23 pouces de large; le premier, peint ſur bois, vient du Cabinet de Madame la Comteſſe de Verrue; il repréſente un départ pour la chaſſe : on y voit ſur le devant un

10660

enrichi... Le ſecond tableau, qui eſt ſur toile, fait voir un terrein d'une grande étendue, près la mer qui eſt à gauche, & ſur laquelle ſont des vaiſſeaux : on y voit auſſi des bagages que l'on décharge d'un charriot, des hommes, des femmes, des enfants, deux chevaux qui mangent, & des mulets chargés de bagages.

Two paintings very rich in composition, of a beautiful execution, and whose merit is very remarkable, each 17 inches 3 lines high, 23 inches wide; the first, painted on wood, comes from the Cabinet of Madame la Comtesse de Verrue; it represents a departure for the hunt: it shows in the front a child on a white horse, a man who gives the horn to gather the dogs, a falconer and other figures nicely distributed across the width of the painting; two horses drinking from a fountain; on the right in the corner a lovely country house topped by a terrace, on which people are at the table, others who play instruments; trees and fabriques pleasantly enrich the background.

data transcription

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	
1	name	sale	lot	dealer	year	origin_author	origin_cat	school_pntg	diff_origin	price	count	subject	authorstandard	artistliving	authorstyle	author	winnir
2517	R1777-86	R1777	86	R	1777	D/FL	D/FL	D/FL	0	620.0	1	2 femmes, enfants, paysage vu à travers une arcade	Bega, Cornelis Pieterszoon	0	n/a	Corneille Bega	Lebrun
2518	R1777-87	R1777	87	R	1777	D/FL	D/FL	D/FL	0	12,000.0	1	Course du hareng	Wouwerman, Philips	0	n/a	Philippe Wouwerman	Donjeu
2519	R1777-88	R1777	88	R	1777	D/FL	D/FL	D/FL	0	8,000.0	1	Paysage sablonneux	Wouwerman, Philips	0	n/a	Philippe Wouwerman	Lambe
2520	R1777-89a	R1777	89	R	1777	D/FL	D/FL	D/FL	0	5,300.0	1	Départ pour la chasse	Wouwerman, Philips	0	n/a	Philippe Wouwerman	Langlie

	R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD	AE	AF	AG	AH
1	winningbidder	winningbiddertype	endbuyer	Interm	type_interm ed	Height_in	Width_in	Surface_Rect	Diam_in	Surface_Rnd	Shape	Surface	material	mat	quantity	nfigures	engraved
2516	Feuillet	D	D	0		16	20	320			squ_rect	320	toile	t	1	0	0
2517	Lebrun, Jean-Baptiste-Pierre	D	D	0		13.25	11	145.75			squ_rect	145.75	bois	b	1	0	0
2518	Donjeux, Vincent	D	D	0		23	29.25	672.75			squ_rect	672.75	toile	t	1	50	0
2519	Lambert, John (Chevalier Lambert)	C	C	0		23	30	690			squ_rect	690	toile	t	1	0	1
2520	Langlier, Jacques for Poullain, Antoine	DC	C	1	D	17.25	23	396.75			squ_rect	396.75	bois	b	1	0	0

	AG	AH	AI	AJ	AK	AL	AM	AN	AO	AP	AQ	AR	AS	AT	AU	AV	AW	AX	AY	AZ	BA	BB	BC	BD	BE	BF
1	nfigures	engraved	original	prevcoll	othartist	paired	figures	finished	lrgfont	relig	landsALL	lands_sc	lands_figs	lands_ment	arch	mytho	peasant	othgenre	singlefig	portrait	still_life	discauth	history	allegory	pastorale	other
2516	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
2517	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0
2518	50	0	0	1	0	0	1	1	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
2519	0	1	0	0	0	0	0	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2520	0	0	0	1	0	1	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0

paris paintings

data:

painting
auction data
1764 - 1780

[3,393 x 57]

visualize:

data visualization to explore patterns and possible interactions (mostly) with `ggplot2`

clean:

data cleaning (mostly) with `dplyr`

model:

model price and log(price) and perform procedural and expert opinion based model selection

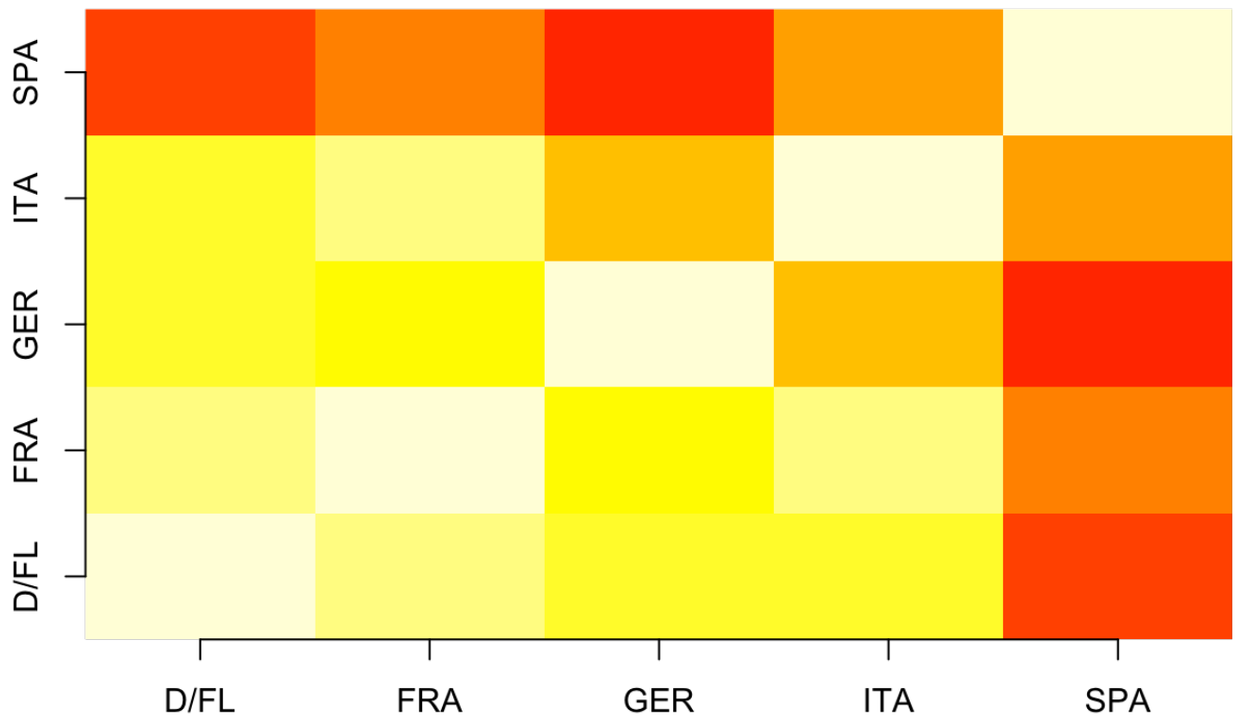
sample exploration #1

similarity of schools

Calculate a similarity score between different classes of art - score between 0 and 1, higher scores reflect a greater degree of similarity among features; i.e. a score of 1 would indicate identical vectors while a score of 0 would indicate vectors with no features in common.

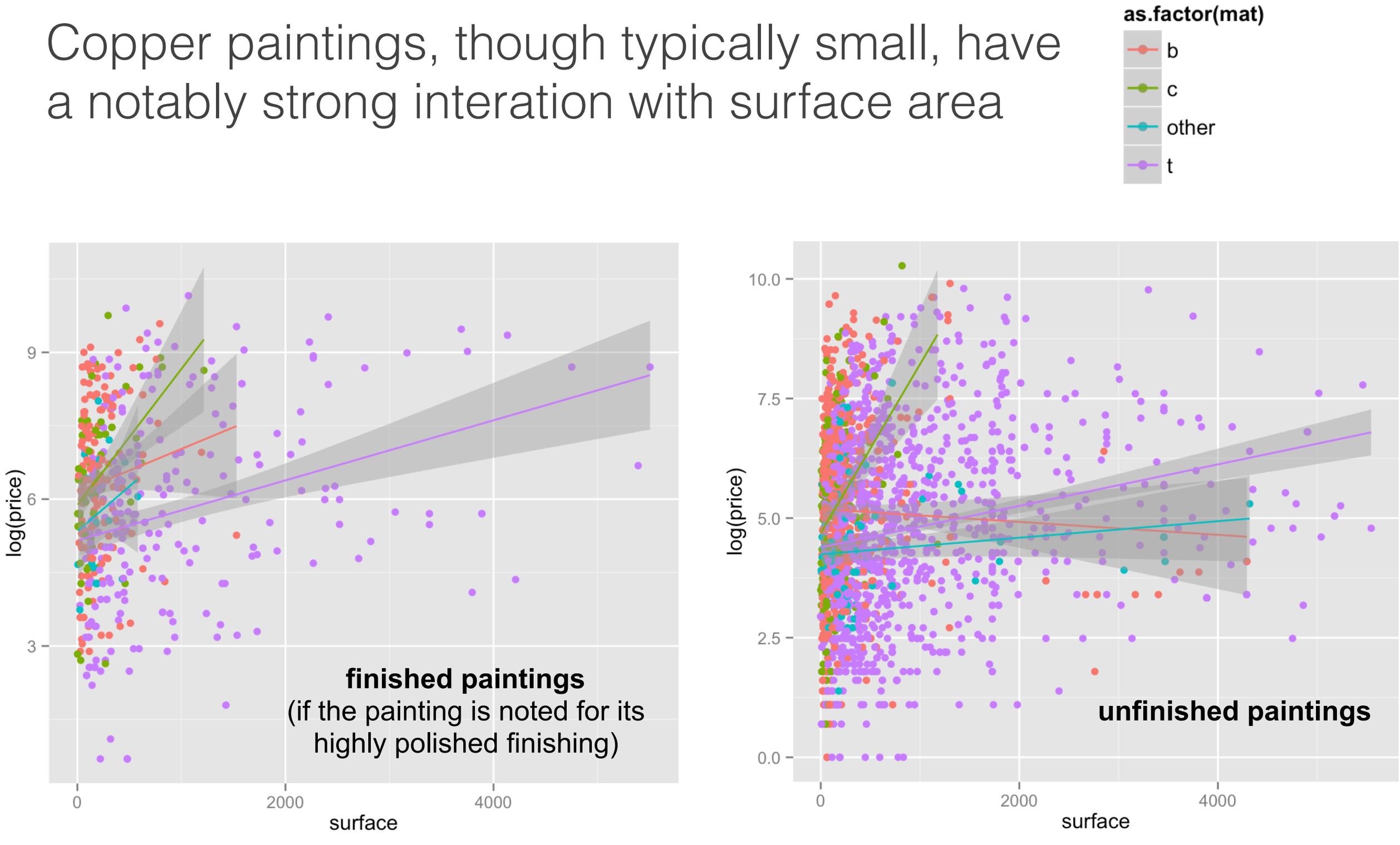
```
similarity = function (vec1, vec2) {
  mag1 = sqrt(vec1 %*% vec1)
  mag2 = sqrt(vec2 %*% vec2)
  return(vec1 %*% vec2 / mag1 / mag2)
}
```

Spanish art is most notably different from the other schools (Lighter colors indicate similarities, while deep red indicates large differences).



material and price

Copper paintings, though typically small, have a notably strong interation with surface area



student experience

non-standard application piqued student interest

“massive” data overwhelming but expert input refreshing

unfamiliar variables made narrative challenging

novel application pushed creativity

basketball

2014-15 Schedule & Results

Date		[Rk] Opponent	Duke Rank	Location (Venue)	Score (OT)	Att.	Tip Time	TV
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3/22	!!!	vs. San Diego State	4	Charlotte, N.C. (Time Warner Cable Arena)	W 68-49	18,482	2 p.m.	CBS
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10	30-Nov		**Army**	4	Durham, N.C. (	W	93-73	9,314	12 p.m.	ESPNU
11	3-Dec	#	at [2] Wisconsin	4	Madison, Wisc.	W	80-70	17,279	9:30 p.m.	ESPN
12	15-Dec		**Elon**	2	Durham, N.C. (	W	75-62	9,314	7 p.m.	ESPNU
13	18-Dec		vs. Connecticut	2	East Rutherford,	W	66-56	16,541	8 p.m.	ESPN
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19	13-Jan	*	**Miami**	4	Durham, N.C. (	L	74-90	9,314	9 p.m.	ESPNU
20	17-Jan	*	at [6] Louisville	4	Louisville, Ky. (	W	63-52	22,791	12 p.m.	ESPN
21	19-Jan	*	**Pittsburgh**	5	Durham, N.C. (	W	79-65	9,314	7 p.m.	ESPN
22	25-Jan		at St. Johns	5	New York, N.Y	W	77-68	19,812	2 p.m.	FOX
23	28-Jan	*	at [8] Notre Dan	4	Notre Dame, In	L	73-77	9,149	7:30 p.m.	ESPN2
24	31-Jan	*	at [2] Virginia	4	Charlottesville,	W	69-63	14,593	7 p.m.	ESPN
25	4-Feb	*	**Georgia Tech**	4	Durham, N.C. (	W	72-66	9,314	7 p.m.	ESPN2
26	7-Feb	*	[10] **Notre Dam**	4	Durham, N.C. (	W	90-60	9,314	1 p.m.	CBS
27	9-Feb	*	at Florida State	4	Tallahassee, Fla	W	73-70	11,498	7 p.m.	ESPN
28	14-Feb	*	at Syracuse	4	Syracuse, N.Y. (	W	80-72	35,446	6 p.m.	ESPN
29	18-Feb	*	[15] **North Car**	4	Durham, N.C. (	W	92-90 •	9,314	9 p.m.	ESPN/ACCN
30	21-Feb	*	**Clemson**	4	Durham, N.C. (	W	78-56	9,314	4 p.m.	ESPN
31	25-Feb	*	at Virginia Tech	4	Blacksburg, Va.	W	91-86 •	9,847	9 p.m.	ESPN2
32	28-Feb	*	**Syracuse**	4	Durham, N.C. (	W	73-54	9,314	7 p.m.	ESPN
33	4-Mar	*	**Wake Forest**	3	Durham, N.C. (	W	94-51	9,314	8 p.m.	ACCN
34	7-Mar	*	at [19] North Ca	3	Chapel Hill, N.C	W	84-77	21,750	9 p.m.	ESPN
35	12-Mar	$$$	vs. N.C. State	2	Greensboro, N.C	W	77-53	22,026	7 p.m.	ESPN
36	13-Mar	$$$$	vs. [11] Notre D	2	Greensboro, N.C	L	64-74	22,026	9 p.m.	ESPN
37	20-Mar	!!	vs. Robert Morr	4	Charlotte, N.C. (	W	85-56	16,945	7 p.m.	CBS
38	22-Mar	!!!	vs. San Diego S	4	Charlotte, N.C. (	W	68-49	18,482	2 p.m.	CBS
39	27-Mar	!!!!	vs. [19] Utah	4	Houston, Texas	W	63-57	21,168	7:45 p.m.	CBS
40	29-Mar	!!!!!	vs. [7] Gonzaga	4	Houston, Texas	W	66-52	20,744	4 p.m.	CBS
41	4-Apr	!!!!!!	vs. [23] Michiga	4	Indianapolis, In	W	81-61	72,238	6 p.m.	TBS/TNT
42	6-Apr	!!!!!!!	vs. [3] Wisconsi	4	Indianapolis, In	W	68-63	71,149	9:15 p.m.	CBS

basketball

gather:

scrape data with `rvest`

clean:

clean the data with (mostly) `dplyr`

visualize:

visualize the data with `ggplot2` and `shiny`

Mine CetinkayaRundel
@minebocek

Students upset b/c website they need to scrape data from for hw assignment is down. Bad assignment or good lesson in working w/ real data?

RETWEET
1

LIKES
10

9:48 AM - 26 Nov 2015

motivation

computation

interest & impact

course overview

data analysis examples

curricular considera-tions

interest

duke focus:

first-year undergrads

modeling cluster: “What if? Explaining the Past, Predicting the Future”

interest in What If:

no hard data, but “definitely significant increase in applications the last two years than previous years”

interest in DS:

% of What If applicants interested in DS

2015: 76%
2016: 83%

impact

pipeline for stats:

2014: 19% declared
2015: 31% declared
2016: ~40%
expressed interest

diversity:

% female
2014: 44%
2015: 50%
2016: 35%

~25% in Probability

curricular:

basis for
gateway to stats
major course
to be offered in
Spring 2018!

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curricular considerations

move away from ad-hoc computing education and/or expecting students to pick it up along the way

uniformity of tools is important: choose a toolkit that works for you and stick to it throughout the curriculum

teach computing early and often!

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bit.ly/uscots2017