1 EDA warm up! (13 points)

(6) a. To honor 4th of July (i.e. today!), a popular US news magazine wants to write an article on how much Americans know about capitals of their states. They devise a test that lists 100 cities and each respondent must guess the state in which the city can be found. Each correct answer earns one point, for a maximum of 100. The random sample of 5000 people had a distribution of scores that was *normally* distributed with mean $\underbrace{62}_{\mu}$ and standard deviation $\underbrace{12}_{\sigma}$.

(2)i. How many countries can identify correctly the central 95% of the people in this sample?

Normal model : 95% of the answers are in the interval : $[\mu-2\sigma, \mu+2\sigma] \rightarrow$

$[62-2\times12, 62+2\times12] \rightarrow$

$[38, 86]$

95% of people can identify between 38 and 86 countries

(2)ii. A journalist claims that a score of 45 (and below) should be considered poor. Do you agree or not? Justify your answer scientifically.

$$Z_{score} = \frac{x-\mu}{\sigma} = \frac{45-62}{12} \simeq -1.42$$

↓

not between $[-1, 1]$

So unusual but not rare

(2)iii. Can you decide from the given information whether there are any outliers or not (either too smart or not that smart people)? What extra diagram/sketch (except the actual scores) would you need and how you were going to use it for answering?

No I need a boxplot

(7) b. The boxplots show the age of people involved in accidents according to their role in the accident.

(1) i. Which role involved the youngest person and what is the age?

passenger <1

(1) ii. Which role had the lowest median age and what is the age?

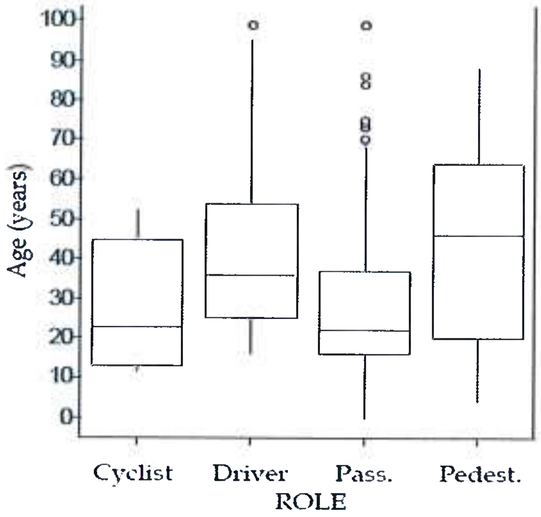
passenger 21

(1) iii. Which role had smallest range of ages and what is it?

cyclist 40

(1) iv. Which role had the largest IQR of ages and what is it?

pedestrian 44



(3) v. A journalist asks you the tricky question: "Which role generally involves the oldest people?" Justify your answer scientifically in order to impress the journalist.

pedestrian

- median age for pedestrians is ~45, while for the other groups is between 22-35

- theoldest 50% of pedestrian group (45-87) is older than the younger 75% of cyclist & passenger

....

5 Modeling homelessness (15 points)

Homelessness is a problem in many large U.S. cities. To better understand the problem, a multiple regression was used to model the rate of homelessness based on several explanatory variables. The following data were collected for 50 large U.S. cities. The regression results appear below.

Homeless	number of homeless people *per 10,000 in a city*
Poverty	percent of residents with income under the poverty line
Unemployment	percent of residents unemployed
Temperature	average yearly temperature (in degrees F.)
Vacancy	percent of housing that is unoccupied
Rent Control	indicator variable, 1 = city has rent control, 0 = it has not

Dependent variable is **Homeless.** R squared (R^2)= 38.4%, Adjusted R^2 = 31.5%

Variable	**Coefficient**	**SE (Coeff.)**	**t-ratio**	**p-value**
Intercept	-4.275	3.465	-1.23	0.2239
Poverty	0.0823	0.0823	1.00	0.3228
Unemployment	0.159	0.218	0.73	0.4699
Temperature	0.135	0.0587	2.30	0.0262
Vacancy	-0.247	0.138	-1.79	0.0809
Rent Control:1	2.944	1.37	2.15	0.0373

(2) a. Which variables are associated with the number of homeless people in a city (using a 95% significance level)?

temperature & rent-Control (p-value <005)

NB: vacancy is >005

(4) b. Explain the meaning of the coefficients: **Temperature** and **Rent Control** in the *context of this problem.*

temperature

For cities with fixed poverty, unemployment, etc (all variables), an increase in 1°F leads to a increase of 0.14 homeless per 10.000

Rentcontrol: for cities with fixed other variables, cities with rent control have 2.94 homeless people more than cities without

(2) c. Do the results suggest that having rent control laws in a city causes higher levels of homelessness? Explain.

No.

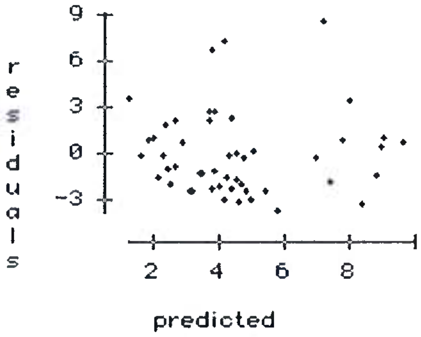
this is an observational study, so I cannot establish causal relations.

(4) d. If we created a new model by adding several more explanatory variables, which statistic should be used to compare them—the R^2 or the adjusted R^2? Explain.

Adjusted R^2 because it controls for models with different # of predictors

(3) e. Using the plot of residuals vs predicted values below, can you conclude that the above regression is a good fit (in terms of distribution of residuals)? Justify your choice.

* seems random enough (no obvious relations), so it is a good fit



6 PCA-phobia (10 points)

Ten participants are given a battery of personality tests, comprising the following items: Anxiety; Agoraphobia; Arachnophobia; Adventure; Extraversion; and Sociability (with a scoring range of 0 to 100). The purpose of this project is to ascertain whether the correlations among the six variables can be accounted for in terms of comparatively few latent variables or factors.

Part	Anx	Agora	Arach	Adven	Extra	Socia
1	71	68	80	44	54	52
2	39	30	41	77	90	80
3	46	55	45	50	46	48
4	33	33	39	57	64	62
5	74	75	90	45	55	48
6	39	47	48	91	87	91
7	66	70	69	54	44	48
8	33	40	36	31	37	36
9	85	75	93	45	50	42
10	45	35	44	70	66	78

(3) i. Provide some descriptive statistics on the dataset (mean, st. deviations for each item) and justify whether normalization is needed for this problem.

anx :	53.1	sd : 19.04
agora:	52.8	sd : 18.08
arach:	58.5	sd : 22.24
adven :	564	sd : 17.99
Extra :	59.3	sd : 17.70
Socia :	58.5	sd : 18.44

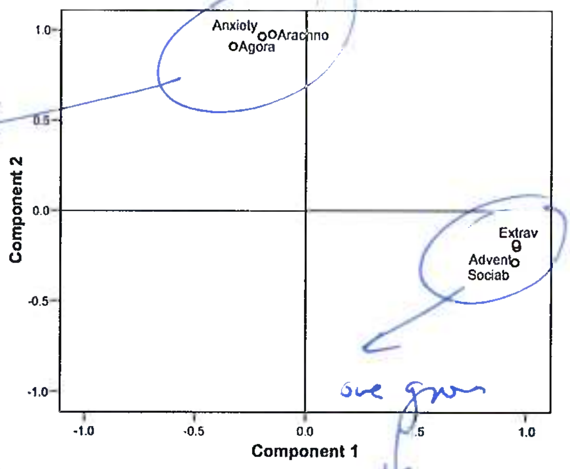
all close so might not be necessary to normalize

(2) ii. Running PCA on this (small) dataset gives the following results in terms of the principal components (NB: here the full results with 6 components are presented), along with the eigenvalues and the % of variance explained by each eigenvalue. As an experienced data scientist how many eigenvalues would you pick? Justify your choice.

Component	Total	% of Variance
1	4.164	69.397
2	1.612	26.862
3	.144	2.396
4	.052	.867
5	.023	.383
6	.006	.095

First two PCAs explain ≅ 96.3% of the variance in data. They also are > 1 (eigenvalues) So we pick $\boxed{2}$

(4) iii. The plot for two PCs is given below. How would you communicate to a non-data-scientist your final conclusion from this dataset by using this figure and the results from ii.)? Can you predict (without computing) what would be the correlations between the initial 6 variables?



one group ↓ expect correlation

one group ↓ high correlation

I have two groups of phobias one general and one related to social

7 (fast) regularization check questions (6 points)

Explain in one or two sentences why the statements are true (or false).

(2)a. L2 (Ridge) regularization is more robust to outliers than L1 (Lasso).

there is no difference.

(2)b. In terms of feature selection, L2 (Ridge) regularization is preferred (to L1-Lasso) since it comes up with sparse solutions.

No, lasso ⇒ feature selection (sparse) because many coefficients go to 0

(2)c. Nearly all the algorithms we have been through this course, have a tuning parameter which is performing regularization (even if we didn't call it that). In the concept of using PCA as a dimension reduction technique (i.e. reduce training data down to k dimensions with PCA and use these as features), one claims that higher k means less regularization. Do you agree or not?

Yes, ↑k more parameters ⇒ less generalization
less regularization

Bonus question (1 point)

What is Jerry's favorite color?

Answer: _________