Mini-Project 1

ECE/CS 498DS

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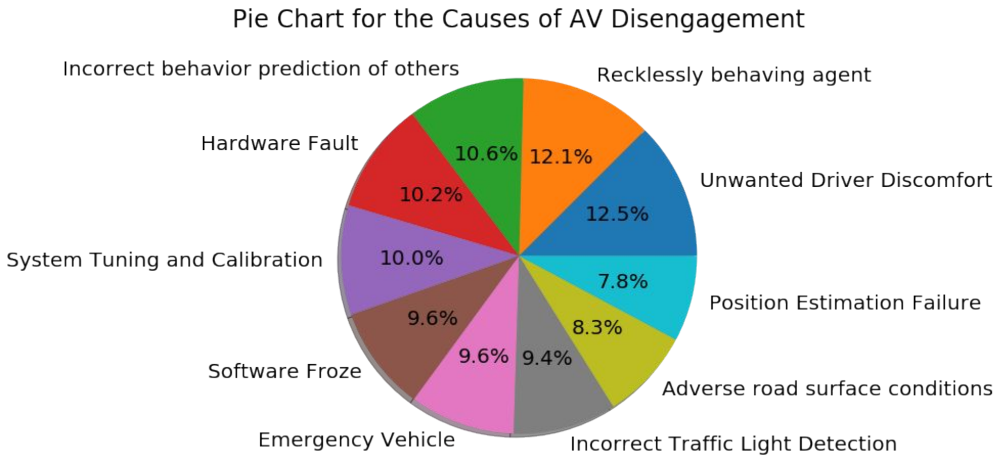
Task 0

2(a) – Total Disengagements	1024
2(b) - # Unique Months	15
2(c) – Unique Locations	'urban-street', 'highway'
2(d) - # Unique Causes	10
2(e) - # Rows with missing values	532 (Reaction Time)

Qn 3 - Causes of AV Disengagement

Pie chart:

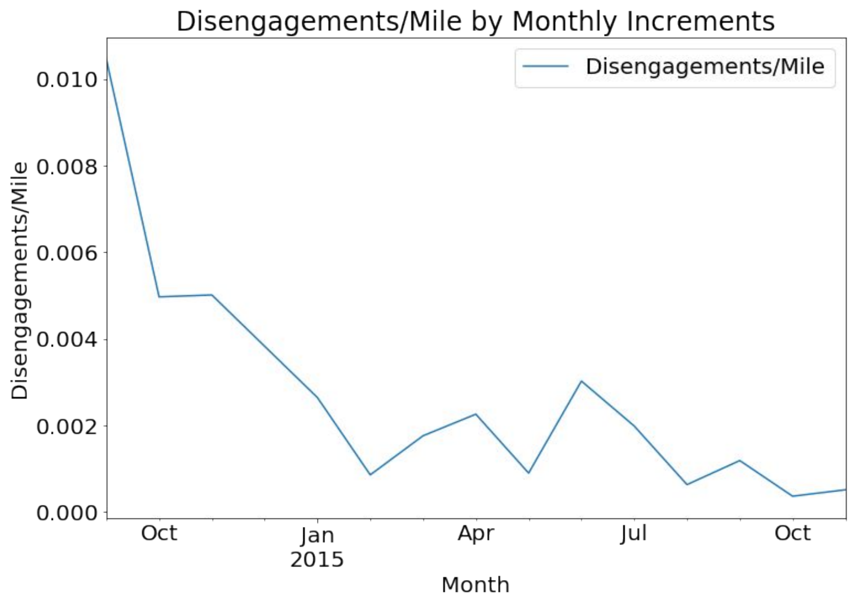


Top 2 causes of disengagement:

The number 1 cause of disengagement is "Unwanted Driver Discomfort" at 12.5%

The number 2 cause of disengagement is "Recklessly behaving agent" at 12.1%

Qn 4 - Trend of disengagement/mile



This trend is generally curving downwards as time progresses. This indicates that generally, AV software has been maturing, as there are less disengagements per mile.

Task 1

Qn 1 – Interpreting Distributions

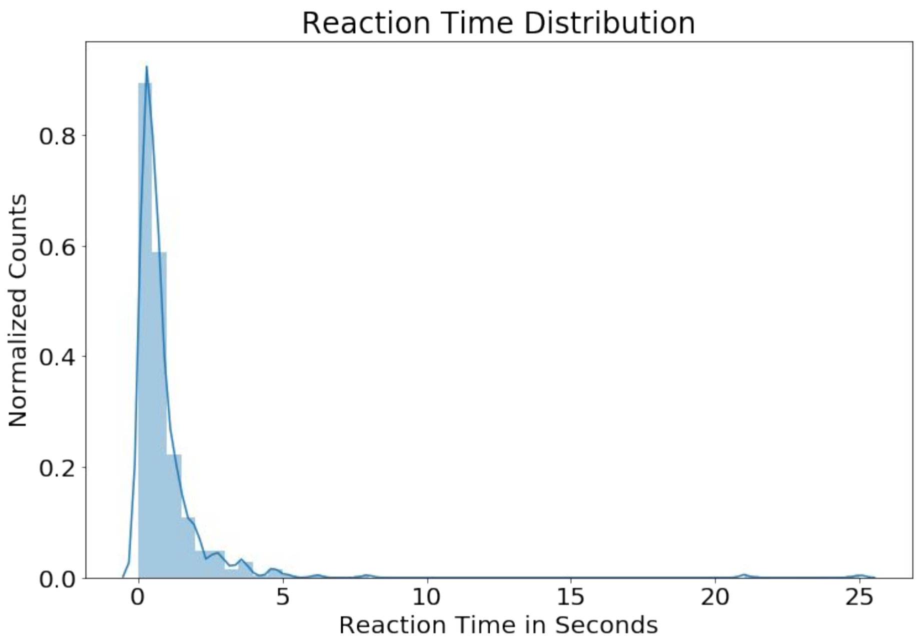
(a) Gaussian – If a random sample is drawn from a Gaussian Distribution, then it will be symmetrically centered around the mean of the distribution with a standard deviation of the population.

(b) Exponential – If a random sample is drawn from an exponential distribution, then it will be approximately constantly decrease at a decreasing rate with a peak near 0.

(c) Weibull – If a random sample is drawn from a Weibull distribution, then it will follow the curve of the distribution, depending on the shape parameter k. If k=1 the sample distribution will look exponential, if k=2 the sample distribution will look like a Rayleigh dist., and if k is between 3 and 4, it will look symmetric.

Qn 2 – Probability distribution of reaction times

Plot:



What distribution does it fit and what is the significance?

The distribution looks like it fits an exponential distribution - indicating that ,generally, the drivers are more likely to react within the first few seconds, rather than after about 3 seconds.

Task 1

Qn 3 – Average Reaction times

(a) Over entire dataset: 0.929770325 s

(b) Over entire dataset per location:

highway: 1.480000 s

urban-street: 0.92865 s

Qn 4 – Hypothesis Testing

State the Null and Alternate Hypothesis:

$$H_0: \mu_r = 1.09$$
$$H_A: \mu_r \neq 1.09$$

Statistic Value

Z = -2.0986

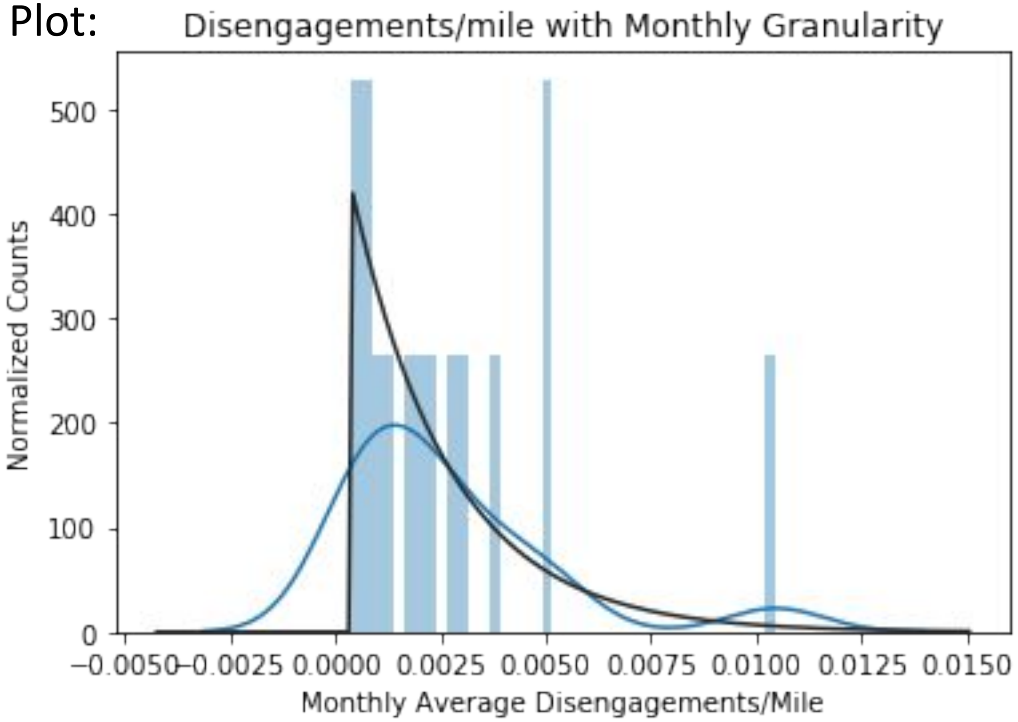
P-value = 0.035

Outcome of the hypothesis test

P-value is less than 0.05 and therefore we Reject the Null Hypothesis and conclude that the two times are statistically different.

Qn 5 – Probability distribution of disengagements/mile

Plot:



What distribution does it fit and what is the significance?

This distribution looks roughly exponential indicating that, each month, the average disengagements/mile tends to be shorter rather than longer.

Task 2

Qn 1

(a) Bernoulli distribution

(b) Probability of disengagement/mile on a cloudy day:
0.005902556

(c) Probability of disengagement/mile on a clear day:
0.000519566

(d) Probability of automatic disengagement/mile
(i) on a cloudy day: 0.002806365
(ii) on a clear day: 0.0002639067

(e) What approximation did you use? State the obtained probability in mathematical notation.

P(X >= 150) where X ~ Binomial(n = 12000, p = 0.001652) = 1.1102230246251565e-16

Qn 2 – Hypothesis Testing Concepts

(a) The normal distribution represents the distribution of a random variable under an assumption represented by the null hypothesis.

(b) No, never. Rejecting the null hypothesis just means there is statistically significant evidence that goes against the null, not necessarily that there is enough evidence to support the alternative hypothesis.

Task 2

Qn 3 – Z-test

State the Null and Alternate Hypothesis:

H_0 : p1 <= p2

H_A : p1 > p2

Where p1 = x1 / n1

Where x1 is the sum of disengagements when cloudy

Where n1 is prob_cloudy * total miles driven in autonomous mode

Similar logic applies to p2, x2, and n2 where cloudy is replaced with clear

Statistic Value = 38.1986

P-value= 0.0

Outcome of the hypothesis test: Reject Null

Conclusion: There is statistical difference between the proportions of disengagements.

Qn 4 – Conditional Probability

(Write both the probability expression and the computed probability value)

(a)

P(Reaction Time > 0.6s | Cloudy) = 0.4735516

(b)

P(Reaction Time > 0.9s | Clear) = 0.28125

Qn 5 – Conditional Probability and Total Probability

(Write both the probability expression and the computed probability value)

P(slow) = P(slow|cloudy)P(cloudy)+P(slow|clear)P(clear)

P(accident per mile involving Av) = (P(slow) * n(disengagements))/n(miles) = n(accidents)/n(miles) = 0.00067917

Task 2

Qn 6 – Comparing AVs to human drivers

Because the probability of a AV/driver system causing an accident is about 6x10^-4, it is worse than the probability of a human driver causing a car accident. This is because under the AV/driver system 300 times worse than the probability of a human driver causing a car accident. This even gives the claim against the use of current AV's since the addition of an AV system to a car makes human driver performance worse.

Qn 7 – KS Test

State the Null and Alternate Hypothesis:

H_0 : D1 == D2

H_A : D1 != D2

Statistic Value = 0.0563317

P value = 0.68725

Where D1 is distribution of disengagement reaction time when the weather is cloudy

Where D2 is distribution of disengagement reaction time when the weather is clear

Outcome of the hypothesis test: Fail to Reject Null

Conclusion: The two sample distributions are most likely from the same population distribution.

Task 3

Qn 3 – Conditional Probability Tables for NB classifier

	Class	P(Location = urban-street|Class)	P(Location = highway|Class)
0	Perception System	1.000000	0.000000
1	Computer System	0.922078	0.077922
2	Controller	1.000000	0.000000

	Class	P(Weather = clear|Class)	P(Weather = cloudy|Class)
0	Perception System	0.000000	1.000000
1	Computer System	0.636364	0.363636
2	Controller	0.003509	0.996491

	Class	P(Trigger = manual|Class)	P(Trigger = automatic|Class)
0	Controller	0.882759	0.117241
1	Computer System	0.497925	0.502075
2	Perception System	0.177083	0.822917

Qn 4 – NB Classifier Accuracy:
0.7951219

Qn 5 – NB Cross Validation Accuracy:
0.7980487

Task 3

Qn 6 – Is your NB model doing better than chance? Explain.

If the NB model operated based on chance, then presumably, it would work only 0.1 times, as by blindly guessing, there is a 1/10 chance to get it right. The NB model was on average correct 79.80% percent of the time, and thus is doing better than chance.

Qn 7 – Assumptions in NB in this context of AV safety analysis

By using a Naive Bayes Model, we assume conditional independence of the factors (weather, location, typeoftrigger). However, this assumption may not be sound, as higher-risk situations (such as on a cloudy day or on the highway) may increase the likelihood of a manual trigger, as the driver may be more nervous.

Qn 8 – Possible improvements to increase classification accuracy

In terms of local semantics, I think that in addition to all the factors pointing to the Class, I think that weather and location should also point to type of trigger

Insights on AV safety

- List some insights on AV safety that you have gained by performing data analysis on the CA DMV dataset
    - AV's perform very well on the highway, however, under cloudy conditions in urban streets, they perform poorly. This indicates that modern perception systems still need to be improved to operate under times of increased stress (e.g. decreased contrast from cloudiness, small objects like rain, and failure to react/detect important information).
    - Producers also need to improve their Controller systems for urban performance, as they only create disengagements on urban-streets.
- Would you ride in an AV based on the data you have analyzed?
    - No, because while the AV/Driver system does better than chance, it is not better than just driving a car by ourselves.
- What do you think about the future of AVs and how soon they will be deployed?
    - AV deployment is directly related to the probability that the AV will cause a crash. Not being in the industry and not knowing the progress of present-day AV's , we can't give a specific time. However, assuming that no one will buy a worse product than what they have now, AV's will be deployed once the probability of an AV causing a crash is lower than a human causing a crash.
- What would you change about the MP? What other analysis would you have done?
    - Split dataset into different makes (if dataset allows)

Individual Contributions

Sam Chyu – Task 0 Slides, Task 1, Task 1 Slides, Task 2, Task 3

Andro Manukov – Task 0, Task 1, Task 2, Task 2 Slides, Task 3 Slides