Congratulations! You passed!

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1. To help you practice strategies for machine learning, this week we'll present another scenario and ask how you would act. We think this "simulator" of working in a machine learning project will give an idea of what leading a machine learning project could be like! **1 / 1 point**

You are employed by a startup building self-driving cars. You are in charge of detecting road signs (stop sign, pedestrian crossing sign, construction ahead sign) and traffic signals (red and green lights) in images. The goal is to recognize which of these objects appear in each image. As an example, this image contains a pedestrian crossing sign and red traffic lights.

$$y^{(i)} = \begin{bmatrix} 0 \\ 1 \\ 0 \\ 1 \\ 0 \end{bmatrix} \begin{matrix} \text{“stop sign”} \\ \text{“pedestrian crossing sign”} \\ \text{“construction ahead sign”} \\ \text{“red traffic light”} \\ \text{“green traffic light”} \end{matrix}$$

Your 100,000 labeled images are taken using the front-facing camera of your car. This is also the distribution of data you care most about doing well on. You think you might be able to get a much larger dataset off the internet, which could be helpful for training even if the distribution of internet data is not the same.

You are getting started with this project. What is the first thing you do? Assume each of the steps below would take about an equal amount of time (a few days).

- (•) Train a basic model and do error analysis.
- ( ) Invest a few days in thinking on potential difficulties, and then some more days brainstorming about possible solutions, before training any model.
- ( ) Spend a few days collecting more data using the front-facing camera of your car, to better understand how much data per unit time you can collect.
- ( ) Spend some time searching the internet for the data most similar to the conditions you expect on production.

Expand

Correct
Applied ML is highly iterative. Having a basic model to do an error analysis can point you in the most promising directions with a lot of certainties.

2. Your goal is to detect road signs (stop sign, pedestrian crossing sign, construction ahead sign) and traffic signals (red and green lights) in images. The goal is to recognize which of these objects appear in each image. You plan to use a deep neural network with ReLU units in the hidden layers. For the output layer, a softmax activation would be a good choice for the output layer because this is a multi-task learning problem. True/False? **1 / 1 point**

- ( ) True
- (•) False

Expand

Correct
Softmax would be a good choice if one and only one of the possibilities (stop sign, speed bump, pedestrian crossing, green light and red light) was present in each image.

3. When trying to determine what strategy to implement to improve the performance of a model, we manually check all images of the training set where the algorithm was successful. True/False? **1 / 1 point**

- (•) False
- ( ) True

Expand

Correct
Correct. This set should be too large to manually check all the images. It is better to focus on the images that the algorithm got wrong from the dev set. Also, choose a large enough subset that we can manually check.

4. After working on the data for several weeks, your team ends up with the following data: **1 / 1 point**

- 100,000 labeled images taken using the front-facing camera of your car.

- 900,000 labeled images of roads downloaded from the internet.
- Each image's labels precisely indicate the presence of any specific road signs and traffic signals or combinations of them. For example, $y^{(i)} = \begin{bmatrix} 1 \\ 0 \\ 0 \\ 1 \\ 0 \end{bmatrix}$ means the image contains a stop sign and a red traffic light.

When using a non fully labeled image such as $y^{(i)} = \begin{bmatrix} 0 \\ ? \\ 1 \\ ? \\ 1 \end{bmatrix}$, which of the following strategies is most appropriate to calculate the loss function to train as a multi-task learning problem?

- Make the missing entries equal to 1.
- It is not possible to use non fully labeled images if we train as a multi-task learning problem.
- Calculate the loss as $$\sum \mathcal{L}(\hat{y}^{(i)}_j, y^{(i)}_j)$$ where the sum goes over all the know components of $$y^{(i)}$$.
- Make the missing entries equal to 0.

Expand

Correct
Correct. We can't use the components of the labels that are missing but we can use the ones we have to train the model.

5. The distribution of data you care about contains images from your car's front-facing camera, which comes from a different distribution than the images you were able to find and download off the internet. Which of the following are true about the train/dev/test split? **1 / 1 point**

- [ ] The train, dev, and test must come from the same distribution.
- [ ] The dev and test sets must contain some images from the internet.
- [x] The dev and test sets must come from the same distribution.

Correct
Correct. This is required to aim the target where we want to be.

- [x] The dev and test set must come from the front-facing camera.

Correct
Correct. This is the distribution we care about most, thus we should use this as a target.

Expand

Correct
Great, you got all the right answers.

6. Assume you've finally chosen the following split between the data: **1 / 1 point**

Dataset:	Contains:	Error of the algorithm:
Training	940,000 images randomly picked from (900,000 internet images + 60,000 car's front-facing camera images)	12%
Training-Dev	20,000 images randomly picked from (900,000 internet images + 60,000 car's front-facing camera images)	15.1%
Dev	20,000 images from your car's front-facing camera	12.6%
Test	20,000 images from the car's front-facing camera	15.8%

You also know that human-level error on the road sign and traffic signals classification task is around 0.5%. Which of the following is True?

- You have a high bias.
- You have a large data-mismatch problem.
- You have a high variance problem.
- You have a too low avoidable bias.

Expand

Correct
Correct. The avoidable bias is significantly high since the training error is a lot higher than the human-level error.

7. Assume you've finally chosen the following split between the data: **0 / 1 point**

Dataset:	Contains:	Error of the algorithm:
Training	940,000 images randomly picked from (900,000 internet images + 60,000 car's front-facing camera images)	8.8%
Training-Dev	20,000 images randomly picked from (900,000 internet images + 60,000 car's front-facing camera images)	9.1%
Dev	20,000 images from your car's front-facing camera	14.3%
Test	20,000 images from the car's front-facing camera	14.8%

You also know that human-level error on the road sign and traffic signals classification task is around 0.5%. Based on the information given, a friend thinks that the training data distribution is much easier than the dev/test distribution. What do you think?

- ○ Your friend is wrong. (I.e., Bayes error for the training data distribution is probably higher than for the dev/test distribution.)
- ◉ Your friend is right. (I.e., Bayes error for the training data distribution is probably lower than for the dev/test distribution.)
- ○ There's insufficient information to tell if your friend is right or wrong.

Expand

⊗ **Incorrect**

8. You decide to focus on the dev set and check by hand what the errors are due to. Here is a table summarizing your discoveries: **0 / 1 point**

Overall dev set error	15.3%
Errors due to incorrectly labeled data	4.1%
Errors due to foggy pictures	2.0%
Errors due to partially occluded elements.	8.2%
Errors due to other causes	1.0%

In this table, 4.1%, 8.2%, etc. are a fraction of the total dev set (not just examples of your algorithm mislabeled). For example, about 8.2/15.3 = 54% of your errors are due to partially occluded elements in the image.

Which of the following is the correct analysis to determine what to prioritize next?

- ○ You should prioritize getting more foggy pictures since that will be easier to solve.
- ◉ Since 8.2 > 4.1 + 2.0 + 1.0, the priority should be to get more images with partially occluded elements.
- ○ Since there is a high number of incorrectly labeled data in the dev set, you should prioritize fixing the labels on the whole training set.
- ○ You should weigh how costly it would be to get more images with partially occluded elements, to decide if the team should work on it or not.

Expand

⊗ **Incorrect**
The choice should be made taking into consideration other aspects, not just this.

9. You decide to focus on the dev set and check by hand what the errors are due to. Here is a table summarizing your discoveries: **1 / 1 point**

Overall dev set error	15.3%
Errors due to incorrectly labeled data	4.1%
Errors due to foggy pictures	3.0%
Errors due to partially occluded elements.	7.2%
Errors due to other causes	1.0%

In this table, 4.1%, 7.2%, etc. are a fraction of the total dev set (not just examples of your algorithm mislabeled). For example, about 7.2/15.3 = 47% of your errors are due to partially occluded elements in the image.

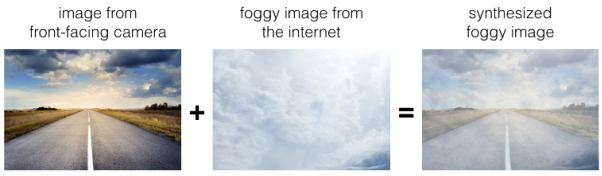
From this table, we can conclude that if we fix the incorrectly labeled data we will reduce the overall dev set error to 11.2%. True/False?

- ◉ False
- ○ True

Expand

✓ **Correct**
Correct. The 4.1 only gives you an estimate of the ceiling of how much the error can be improved by fixing the labels.

10. You decide to use data augmentation to address foggy images. You find 1,000 pictures of fog off the internet, and "add" them to clean images to synthesize foggy days, like this: **1 / 1 point**



Which of the following do you agree with?

- (●) If used, the synthetic data should be added to the training set.
- ( ) It is irrelevant how the resulting foggy images are perceived by the human eye, the most important thing is that they are correctly synthesized.
- ( ) With this technique, we duplicate the size of the training set by synthesizing a new foggy image for each image in the training set.
- ( ) If used, the synthetic data should be added to the training/dev/test sets in equal proportions.

Expand

Correct
Yes. The synthetic data can help to train the model to get better performance at the dev set, but shouldn't be added to the dev or test sets because they don't represent our target in a completely accurate way.

11. After working further on the problem, you've decided to correct the incorrectly labeled data. Your team corrects the labels of the wrongly predicted images on the dev set. **1 / 1 point**

You have to correct the labels of the test so test and dev sets have the same distribution, but you won't change the labels on the train set because most models are robust enough they don't get severely affected by the difference in distributions. True/False?

- ( ) False, the test set shouldn't be changed since we want to know how the model performs in real data.
- (●) True, as pointed out, we must keep dev and test with the same distribution. And the labels at training should be fixed only in case of a systematic error.
- ( ) False, the test set should be changed, but also the train set to keep the same distribution between the train, dev, and test sets.

Expand

Correct
Correct! To successfully train a model, the dev set and test set should come from the same distribution. Also, the deep learning models are robust enough to handle a small change in distributions, but if the errors are systematic they can significantly affect the training of the model.

12. Your client asks you to add the capability to detect dogs that may be crossing the road to the system. He can provide a relatively small set containing dogs. Which of the following do you agree most with? **1 / 1 point**

- ( ) You should train a single new model for the dogs' task, and leave the previous model as it is.
- ( ) You will have to re-train the whole model now including the dogs' data.
- (●) You can use weights pre-trained on the original data, and fine-tune with the data now including the dogs.
- ( ) Using pre-trained weights can severely hinder the ability of the model to detect dogs since they have too many learned features.

Expand

Correct
Correct. Since your model has learned useful low-level features to tackle the new task we can conserve those by using the pre-trained weights.

13. Another colleague wants to use microphones placed outside the car to better hear if there are other vehicles around you. For example, if there is a police vehicle behind you, you would be able to hear their siren. However, they don't have much to train this audio system. How can you help? **1 / 1 point**

- ( ) Multi-task learning from your vision dataset could help your colleague get going faster. Transfer learning seems significantly less promising.
- (●) Neither transfer learning nor multi-task learning seems promising.
- ( ) Either transfer learning or multi-task learning could help our colleague get going faster.
- ( ) Transfer learning from your vision dataset could help your colleague get going faster. Multi-task learning seems significantly less promising.

Expand

Correct
Yes. The problem he is trying to solve is quite different from yours. The different dataset structures make it probably impossible to use transfer learning or multi-task learning.

14. **To recognize a stop sign you use the following approach:** First, you use a neural network to predict bounding box co-ordinates around all traffic signs (if any) within an input image. You then pass the results to a different neural network to determine if the predicted traffic signs (if any) are a stop sign or not. We are using multi-task learning. True/False? **1 / 1 point**

- True
- False

Expand

Correct
Correct. Multi-task learning is about joining several tasks that can benefit from each other. Since there are 2 different neural networks being used here that do not share weights (i.e. structure), this problem has 2 single task learning neural networks and not a multi-task learning setup.

15. Consider the following two approaches, A and B: **1 / 1 point**

- **(A)** Input an image (x) to a neural network and have it directly learn a mapping to make a prediction as to whether there's a red light and/or green light (y).
- **(B)** In this two-step approach, you would first (i) detect the traffic light in the image (if any), then (ii) determine the color of the illuminated lamp in the traffic light.

Approach A tends to be more promising than approach B if you have a _____ (fill in the blank).

- Problem with a high Bayes error.
- Multi-task learning problem.
- Large training set
- Large bias problem.

Expand

Correct
Yes. In many fields, it has been observed that end-to-end learning works better in practice, but requires a large amount of data.