Autonomous Driving (Case Study)

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Autonomous Driving (Case Study)

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Autonomous Driving (Case Study)

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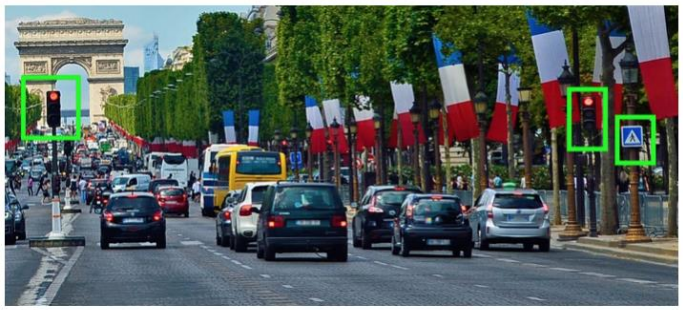
1.

Question 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!

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).

1 / 1 point

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.

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.

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.

Question 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

False

True

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.

Question 3

You are carrying out error analysis and counting up what errors the algorithm makes. Which of these datasets do you think you should manually go through and carefully examine, one image at a time?

1 / 1 point

500 randomly chosen images

10,000 randomly chosen images

500 images on which the algorithm made a mistake

10,000 images on which the algorithm made a mistake

Correct

Focus on images that the algorithm got wrong. Also, 500 is enough to give you a good initial sense of the error statistics. There's probably no need to look at 10,000, which will take a long time.

4.

Question 4

After working on the data for several weeks, your team ends up with the following data:

- 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, $y^{(i)}$ =

$$\begin{bmatrix} 1 \\ 0 \\ 0 \\ 1 \\ 0 \end{bmatrix}$$

$\begin{bmatrix} 1 \\ 0 \\ 0 \\ 1 \\ 0 \end{bmatrix}$ means the image contains a stop sign and a red traffic light.

Because this is a multi-task learning problem, you need to have all your $y^{(i)}$ vectors fully labeled. If one example is equal to

$$\begin{bmatrix} 0 \\ ? \\ 1 \\ 1 \\ ? \end{bmatrix}$$

$\begin{bmatrix} 0 \\ ? \\ 1 \\ 1 \\ ? \end{bmatrix}$ then the learning algorithm will not be able to use that example. True/False?

1 / 1 point

False

True

Correct

As seen in the lecture on multi-task learning, you can compute the cost such that it is not influenced by the fact that some entries haven't been labeled.

5.

Question 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?

0.5 / 1 point

☑ The train, dev, and test must come from the same distribution.

This should not be selected

Most Deep Learning models are robust enough to allow for slightly different distributions between train and dev/test.

☐ The dev and test sets must contain some images from the internet.

☐ The dev and test sets must come from the same distribution.

☑ 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.

6.

Question 6

Assume you've finally chosen the following split between of the data:

Dataset:	Contains:
Training	940,000 images randomly picked from (900,000 internet images + 60,000 car's front-facin images)
Training-Dev	20,000 images randomly picked from (900,000 internet images + 60,000 car's front-facing images)
Dev	20,000 images from your car's front-facing camera
Test	20,000 images from the car's front-facing camera

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

1 / 1 point

☐ Your algorithm overfits the dev set because the error of the dev and test sets are very close.

☐ You have a large variance problem because your training error is quite higher than the human-level error.

☐ You have a large variance problem because your model is not generalizing well to data from the same training distribution but that it has never seen before.

☑ You have a large data-mismatch problem because your model does a lot better on the training-dev set than on the dev set

Correct

☑ You have a large avoidable-bias problem because your training error is quite a bit higher than the human-level error.

Correct

7.

Question 7

Assume you've finally chosen the following split between the data:

Dataset:	Contains:
Training	940,000 images randomly picked from (900,000 internet images + 60,000 car's front-facin images)
Training-Dev	20,000 images randomly picked from (900,000 internet images + 60,000 car's front-facing images)
Dev	20,000 images from your car's front-facing camera
Test	20,000 images from the car's front-facing camera

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?

0 / 1 point

- 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.

Incorrect

8.

Question 8

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

Overall dev set error
Errors due to incorrectly labeled data
Errors due to foggy pictures
Errors due to rain drops stuck on your car's front-facing camera
Errors due to other causes

In this table, 4.1%, 8.0%, etc. are a fraction of the total dev set (not just examples of your algorithm mislabeled). For example, about 8.0/15.3 = 52% of your errors are due to foggy pictures.

The results from this analysis implies that the team's highest priority should be to bring more foggy pictures into the training set so as to address the 8.0% of errors in that category. True/False?

Additional note: there are subtle concepts to consider with this question, and you may find arguments for why some answers are also correct or incorrect. We recommend that you spend time reading the feedback for this quiz, to understand what issues that you will want to consider when you are building your own machine learning project.

1 / 1 point

- (●) False because it depends on how easy it is to add foggy data. If foggy data is very hard and costly to collect, it might not be worth the team's effort.
- ( ) First start with the sources of error that are least costly to fix.
- ( ) True because it is greater than the other error categories added together (8.0 > 4.1+2.2+1.0).
- ( ) True because it is the largest category of errors. We should always prioritize the largest category of errors as this will make the best use of the team's time.

Correct

Correct. This is the correct answer. You should consider the tradeoff between the data accessibility and potential improvement of your model trained on this additional data.

9.

Question 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:

Overall dev set error
Errors due to incorrectly labeled data
Errors due to foggy pictures
Errors due to partially occluded elements.
Errors due to other causes

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?

1 / 1 point

- ( ) True
- (●) False

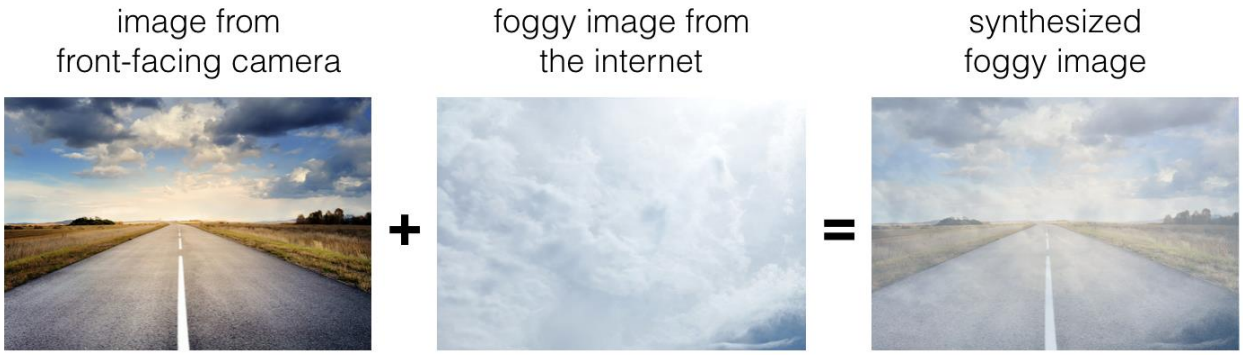
Correct

Correct. The 4.1 only gives us a ceiling of how much the error can be improved by fixing the labels.

10.

Question 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:



Which of the following statements do you agree with?

1 / 1 point

Adding synthesized images that look like real foggy pictures taken from the front-facing camera of your car to the training dataset won't help the model improve because it will introduce avoidable bias.

So long as the synthesized fog looks realistic to the human eye, you can be confident that the synthesized data is accurately capturing the distribution of real foggy images (or a subset of it), since human vision is very accurate for the problem you're solving.

There is little risk of overfitting to the 1,000 pictures of fog so long as you are combining it with a much larger (>>1,000) set of clean/non-foggy images.

Correct

Yes. If the synthesized images look realistic, then the model will just see them as if you had added useful data to identify road signs and traffic signals in foggy weather. I will very likely help.

11.

Question 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. Which of the following is a necessary step to take?

1 / 1 point

Correct the labels of the train set.

Use a correctly labeled version and an incorrectly labeled version to make the model more robust.

Correct the labels of the test set.

Create a train-dev set to estimate how many incorrectly labeled examples are in the train set.

Correct

Correct. Recall that the dev set and the test set must come from the same distribution.

12.

Question 12

One of your colleagues at the startup is starting a project to classify road signs as stop, dangerous curve, construction ahead, dead-end, and speed limit signs. Given how specific the signs are, he has only a small dataset and hasn't been able to create a good model. You offer your help providing the trained weights (parameters) of your model to transfer knowledge.

But your colleague points out that his problem has more specific items than the ones you used to train your model. This makes the transfer of knowledge impossible. True/False?

1 / 1 point

True

False

Correct

Correct. The model can benefit from the pre-trained model since there are many features learned by your model that can be used in the new problem.

13.

Question 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

Neither transfer learning nor multi-task learning seems promising.

Multi-task learning from your vision dataset could help your colleague get going faster. Transfer learning seems significantly less 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.

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.

Question 14

To recognize red and green lights, you have been using this approach:

- **(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).

A teammate proposes a different, two-step approach:

- **(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.

Between these two, Approach B is more of an end-to-end approach because it has distinct steps for the input end and the output end. True/False?

1 / 1 point

True

False

Correct

Yes. (A) is an end-to-end approach as it maps directly the input (x) to the output (y).

15.

Question 15

An end-to-end approach doesn't require that we hand-design useful features, it only requires a large enough model. True/False?

1 / 1 point

True

False

Correct

Correct. This is one of the major characteristics of deep learning models, that we don't need to hand-design the features.