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# Machine Learning Capstone Project

REVIEW

CODE REVIEW

HISTORY

## Requires Changes

7 SPECIFICATIONS REQUIRE CHANGES

Dear student

Nice start on your final project. I'm one of the study group mentors that answered your question about choosing a dataset. It's definitely exciting to see how well your project has turned out. I've noted some things that you should be sure to add/change in your report, but I think you'll see that these are mostly minor issues and shouldn't take you long at all. Keep going...you're doing great!

Cheers!

## Definition

**Student provides a high-level overview of the project in layman's terms. Background information such as the problem domain, the project origin, and related data sets or input data is given.**

Nice overview of the problem domain! I love the focus on the real-world impact of the application.

Suggested:

- It's a good idea to cite some of the studies where the machine learning techniques that you're using were pioneered. This shows that you really know the field and it gives credit to the inventors.

**The problem which needs to be solved is clearly defined. A strategy for solving the problem, including discussion of the expected solution, has been made.**

You've done a great job restating the problem clearly!

Still Required:

- Please provide a brief outline of what your solution will look like to this problem. You should briefly mention the techniques that you'll use to solve this problem.

Suggested:

- This is a good point to begin to justify why your solution is a good 'fit' for the problem. If you were submitting this to a journal for peer review, you'd want to keep the readers focused on what you want them to think about. If they get distracted, they can ask for random things in subsequent revisions (which can significantly drag out the process and lead to arguments).

**Metrics used to measure performance of a model or result are clearly defined. Metrics are justified based on the characteristics of the problem.**

The performance of the model can be evaluated using accuracy score. This is appropriate since all benchmark models are evaluated using accuracy score as well.

You've done a really nice job identifying the metric for the project. Please be sure to add just a little bit more justification for why you've chosen this particular metric (based on the properties of the dataset). Why would accuracy be a good metric to use for this particular problem (instead of other common classification metrics like log loss, AUC, F-beta etc.)?

## Analysis

**If a dataset is present, features and calculated statistics relevant to the problem have been reported and discussed, along with a sampling of the data. In lieu of a dataset, a thorough**

**description of the input space or input data has been made. Abnormalities or characteristics about the data or input that need to be addressed have been identified.**

You've given an excellent description of the scope and nature of the dataset. Some unusual properties of the dataset are addressed and you've provided a sampling of the raw data for the reader. Perfect!

**A visualization has been provided that summarizes or extracts a relevant characteristic or feature about the dataset or input data with thorough discussion. Visual cues are clearly defined.**

Everything is clearly labeled and discussed. Nicely done!

**Algorithms and techniques used in the project are thoroughly discussed and properly justified based on the characteristics of the problem.**

You've made a great start here! However, I would suggest moving most of this discussion down to the **Implementation** section of your report (where you discuss exactly how the CNN model is implemented).

In **Algorithms and Techniques** section of the report, we're looking for a more basic background description of the methods that you're going to use.

- You should provide an overview for CNN models. What are the general strengths and weaknesses? Why did you choose this approach for this dataset? How does the technique work? You don't need to provide lay person friendly descriptions...you can use mathematical formulas or technical diagrams to help you. For example, you should be sure to explain concepts like convolution, activation layers etc.

**Student clearly defines a benchmark result or threshold for comparing performances of solutions obtained.**

Great job choosing relevant (and challenging) benchmark results from the literature!

## Methodology

All preprocessing steps have been clearly documented. Abnormalities or characteristics about the data or input that needed to be addressed have been corrected. If no data preprocessing is necessary, it has been clearly justified.

Nice job documenting your preprocessing methodology!

I also used image augmentation techniques to increase the number of training data: I randomly rotated the images and cropped them in different manners. This should make the classification more stable. I didn't flip them because obviously, the orientation is characteristic for some traffic signs.

Excellent point about not flipping the images! One thing that I'd suggest is to implement some type of stretching/skewing to the image augmentation process. This can simulate what the image would look like if the sign were turned away from the camera at different angles (and can make the model better at recognizing signs when the focus or orientation of the image isn't optimal).

The process for which metrics, algorithms, and techniques were implemented with the given datasets or input data has been thoroughly documented. Complications that occurred during the coding process are discussed.

In your `Algorithms and Techniques` section, I think that you've give a very clear overview of the way that your model was coded. You've also addressed the specific parameter values that would be needed for a programmer to reproduce your results (using only the report).

Just one more thing:

- Please be sure to note if there were any complications or difficulties that occurred during the coding process.

The process of improving upon the algorithms and techniques used is clearly documented. Both the initial and final solutions are reported, along with intermediate solutions, if necessary.

The approach that you took to refine your model is very clear. One thing that you should also be sure to note:

- Please be sure to document how the model performed before you tuned the learning rate and added additional epochs. Showing that the accuracy improved is important for documenting that this was a refinement to your solution.

## Results

**The final model's qualities — such as parameters — are evaluated in detail. Some type of analysis is used to validate the robustness of the model's solution.**

Please be sure to provide some discussion about the final parameters or characteristics of the model. How do these align with the characteristics of the dataset? Why would these be a robust solution to the problem?

Another way that you might make an argument that the model is robust would be to perform a simple k-fold cross validation with the image data. In this case, you could pick a small value for k, but document that the model's validation score is stable across each individual validation fold. If the model is stable when there are small perturbations in the training/validation data, then you can make a very strong argument that the model is robust.

**The final results are compared to the benchmark result or threshold with some type of statistical analysis. Justification is made as to whether the final model and solution is significant enough to have adequately solved the problem.**

My traffic sign detector classified signs of the test set with an accuracy of 83%. The benchmark publication reports an accuracy between 95% and 99% (<https://btsd.ethz.ch/shareddata/publications/Mathias-IJCNN-2013.pdf>). Therefore, there is still room for improvement. However, I used a very small CNN because I wanted to understand the net's structure and setup rather than get a score as high as possible. The performance could of course be improved using transfer learning instead of building a neural net from scratch. Also, I used a simple architecture with only two convolutional layers, two pooling layers and a linear layer. Using more layers could improve the results as well as using dropout to avoid overfitting.

We certainly don't expect that students will always beat the benchmark model. However, please provide a bit more explanation or justification for why this model would represent an adequate solution to the problem. For example, maybe you might use your own background experience in the field (at Mercedes-Benz) to explain why this accuracy rating would be sufficient for certain types of applications. You could also discuss how this represents an adequate solution given computational constraints for training the model etc.

There's not a specific thing that we're looking for here. Just be sure to justify that your solution would represent a sufficient result.

## Conclusion

**A visualization has been provided that emphasizes an important quality about the project with thorough discussion. Visual cues are clearly defined.**

Excellent visualization here! These images suggest that perhaps adjusting the contrast of the images as a pre-processing step might help the algorithm perform better (or at least it would be more certain about the misclassifications).

**Student adequately summarizes the end-to-end problem solution and discusses one or two particular aspects of the project they found interesting or difficult.**

Nice overview of what you've accomplished here! Keep in mind that this is also a great opportunity to brag a bit about anything exciting in the project implementation.

**Discussion is made as to how one aspect of the implementation could be improved. Potential solutions resulting from these improvements are considered and compared/contrasted to the current solution.**

I think that all of these approaches would be helpful. My guess is that adding more layers in combination with some type of regularization (possibly batch normalization) would definitely give you a nice boost in performance.

## Quality

**Project report follows a well-organized structure and would be readily understood by its intended audience. Each section is written in a clear, concise and specific manner. Few grammatical and spelling mistakes are present. All resources used to complete the project are cited and referenced.**

The report follows the project template and is easy to read (thanks...this makes the reviewing process much faster!).

**Code is formatted neatly with comments that effectively explain complex implementations. Output produces similar results and solutions as to those discussed in the project.**

The code appears to produce the documented output. Additionally, everything is clearly labeled...nice job!

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