CS89/189: Deep Learning Generalization and Robustness - Winter 2024 Homework#1

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Explain why sometimes the margin can be negative.

The margin in the context of machine learning classification can indeed be negative. The margin, defined as `μ(f(x), y) = f(x)[y] − max_{i ≠ y} f(x)[i]`, measures the difference between the correct class's prediction score and the highest prediction score of the incorrect classes. A negative margin occurs when the highest score among the incorrect classes exceeds the score of the correct class. This indicates that the model has a higher confidence in an incorrect classification than the true class, which reflects on the model's current inability to correctly distinguish between classes for that particular instance.

Your proof of the CNN output volume formula

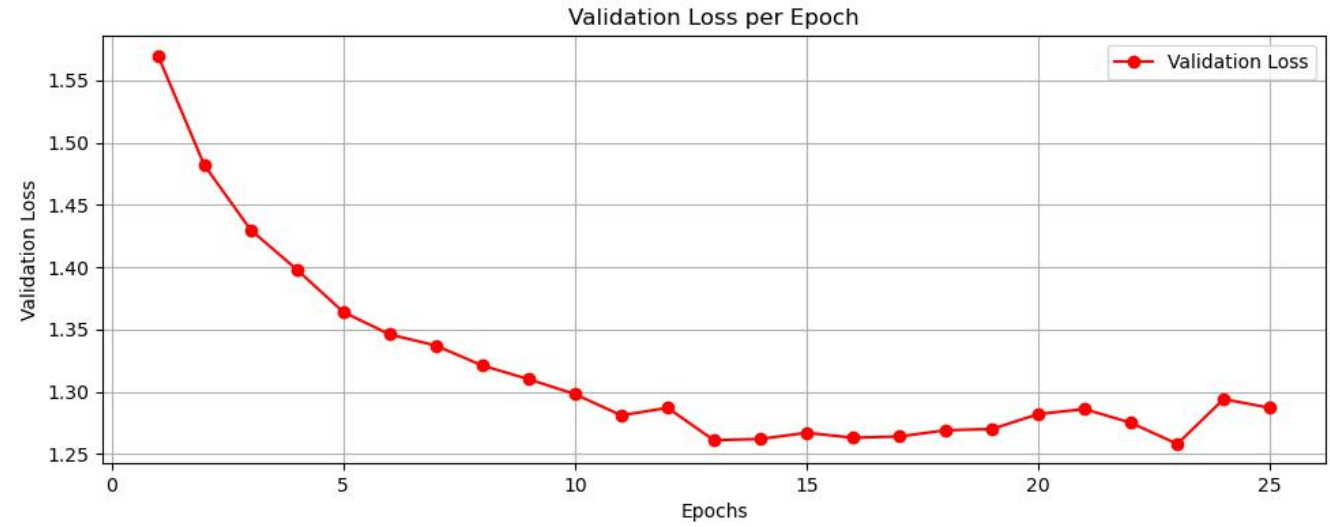
1. When you apply `n*n` filter on a `N*N` input, the output will be `N - n + 1`
2. If you add the `Z` padding (on all sides of edges) the input to expand the size of the out put, the output will be `N - n + 2*Z +1`
3. If we add `S` stride to the filtering process, the output will be `(N - n + 2*z)/S + 1`
4. Having the same filtering process with `V'` filters, we have the final output of `M * M * V'` where M = `(N - n + 2*z)/S + 1`

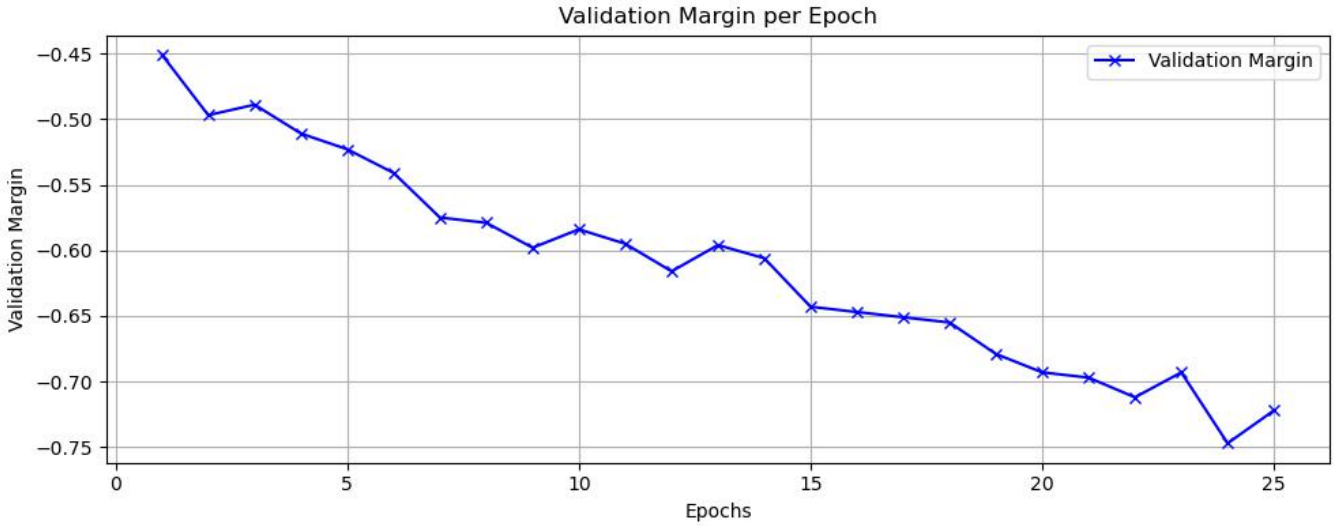
Report your

Model 1

```
=================== Model 1 ===================
Training loss: 0.820   Training margin -0.505    Training accuracy: 0.726
Validation accuracy: 0.564

Frobenius1:      20.7
Frobenius2:      6.73
Distance1:       8.99
Distance2:       5.45
Spectral1:       1.91
Spectral2:       3.14
Fro_Fro:         1.4e+02
L1max_L1max:     2.28e+03
Spec_Dist:       32.9
Dist_Spec:       9.02e+02
Spec_Dist_sum:   9.35e+02
Spec_L1max:      32.7
L1max_Spec:      8.79e+02
Spec_L1max_sum:  9.12e+02
Dist_Fro:        60.5
#parameter:      3.16e+06
VC bound:        9.19e+09
L1max bound:     4.59e+11
Your bound:      1.87e+11
```



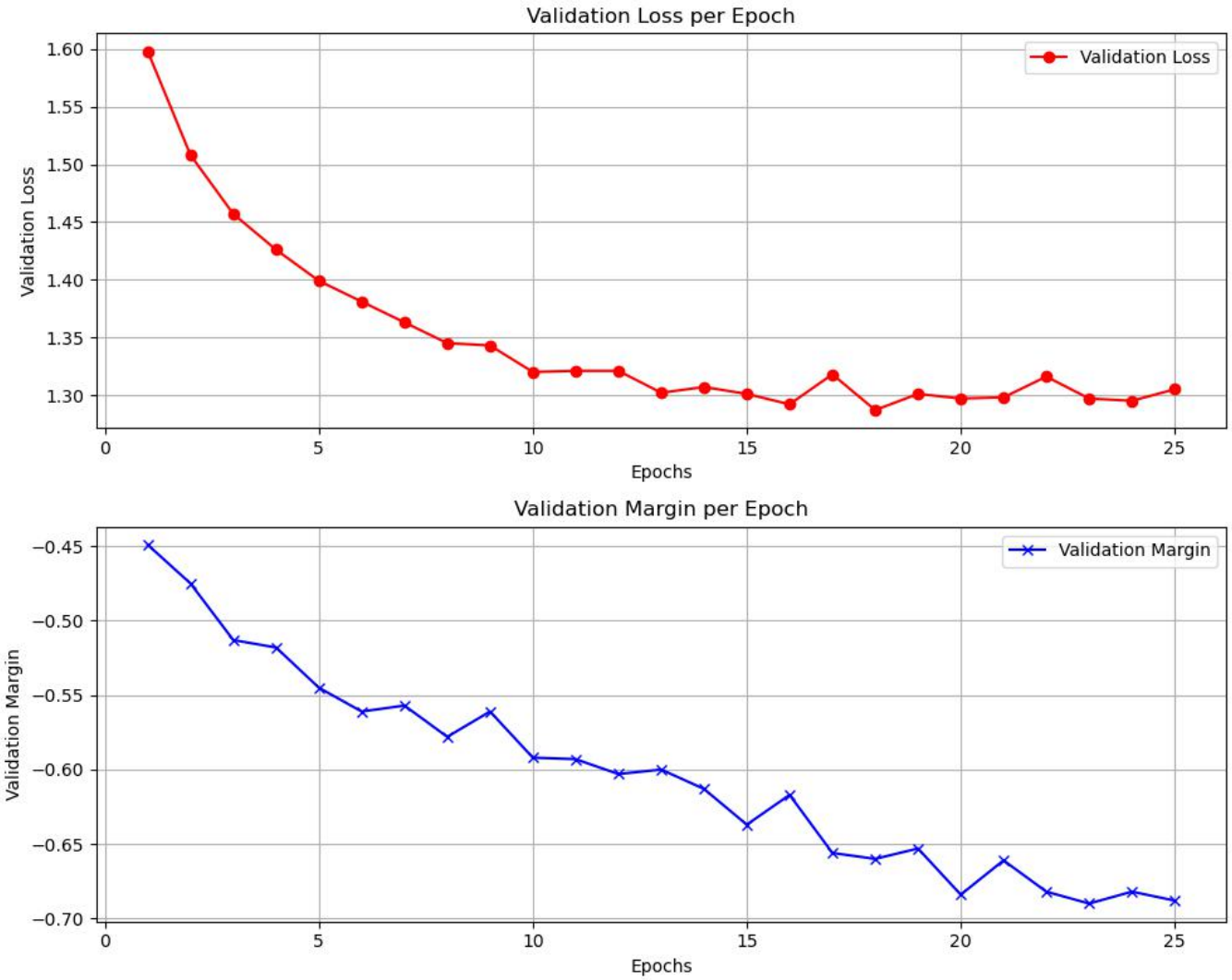


Model2

```
=================== Model 2 ===================
Training loss: 0.967   Training margin -0.539    Training accuracy: 0.672
Validation accuracy: 0.554

Frobenius1:      12.3
Frobenius2:      5.49
Distance1:       8.15
Distance2:       4.2
Spectral1:       1.87
Spectral2:       2.76
Fro_Fro:         67.4
L1max_L1max:     1.25e+03
Spec_Dist:       24.9
Dist_Spec:       3.59e+02
Spec_Dist_sum:   3.84e+02
Spec_L1max:      24.7
L1max_Spec:      3.53e+02
Spec_L1max_sum:  3.78e+02
Dist_Fro:        44.7
#parameter:      7.89e+05
```

```
VC bound:         2.03e+09
L1max bound:      1.2e+11
Your bound:       3.84e+10
```



In general, `model1` has more hidden units which make the model to learn more information from the input hence why the margin and bound greater than `model2`. If we want to minimize the the difference between the two models, we can use regularization to increase the margin of `model2`.