Artificial Intelligent Assignment 2

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**Q1 Logicproblem**

a) Express Madame Irma's six statements into First Order Logic (FOL). Note: You are allowed to change the person you are looking for to Robin

- *You have a dog.*
- *The person you are looking for buys carrots by the bushel.*
- *Anyone who owns a rabbit hates anything that chases any rabbit.*
- *Every dog chases some rabbit.*
- *Anyone who buys carrots by the bushel owns either a rabbit or a grocery store.*
- *Someone who hates something owned by another person will not date that person.*

*Statement:*

$$\exists\, x\left(Owns(Me,x)\bigwedge Dog(x)\right)$$

$$BuyCarrotsByBushel(Robin)$$

$$\forall x,\forall y\left(Owns(x,y)\bigwedge Rabbit(y)\longrightarrow \forall \mathrm{z},\forall \mathrm{w}\left(\mathrm{Rabbit(w)}\bigwedge Chase(z,w)\longrightarrow Hates(x,z)\right)\right)$$

$$\forall x\left(Dog(x)\longrightarrow \exists y\left(Chase(x,y)\bigwedge Rabbit(y)\right)\right)$$

$$\forall x\left(BuyCarrotsByBushel(x)\longrightarrow \exists y\left(Owns(x,y)\bigwedge\left(Rabbit(y)\bigvee Grocey(y)\right)\right)\right)$$

$$\forall x,\forall y,\forall z\left(Hates(x,y)\bigwedge Owns(z,y)\longrightarrow \neg Date(x,z)\right)$$

b) Translate the obtained expressions to Conjunctive Normal Forms (CNFs)
CNF:

1. $Owns(Me,A)$
2. $Dog(A)$
3. $BuyCarrotsByBushel(Robin)$
4. $\neg Owns(x,y)\vee\neg Rabbit(y)\vee\neg Rabbit(w)\vee\neg Chase(z,w)\vee Hates(x,z)$
5. $\neg Dog(x)\vee Chase(x,A)\vee Rabbit(A)$
6. $\neg BuyCarrotsByBushel(x)\vee Owns(x,A)\vee Rabbit(A)$
7. $\neg BuyCarrotsByBushel(x)\vee Owns(x,A)\vee Grocey(A)$
8. $\neg Hates(x,y)\vee\neg Owns(z,y)\vee\neg Date(x,z)$

c) Transform Madame Irma's conclusion into FOL, negate it and convert it to a CNF.

Conclusion:

$$( \neg\exists x\ (Owns(Robin, x) \land Grocey(x))) \ \longrightarrow\ \neg Date(Robin, Me)$$

Negation:

$$\neg[( \neg\exists x\ (Owns(Robin, x) \land Grocey(x))) \ \longrightarrow\ \neg Date(Robin, Me)]$$

CNF:

(a) $\neg Owns(Robin, A) \lor \neg Grocey(A)$

(b) $Date(Robin, Me)$

d) Based on all the previously created CNF (you should have at least 7 de- pending on how you split them), prove that Madame Irma is right and that you should go to see Robin to declare to her your (logic) love.

Proof:

[3, 6] 9. $Owns(Robbin, A) \lor Rabbit(A)$

[3, 7] 10. $Owns(Robbin, A) \lor Grocey(A)$

[2, 5] 11. $Chase(A, B) \lor Rabbit(B)$

[11, 4] 12. $\neg Owns(x, y) \lor \neg Rabbit(y) \lor Hates(x, A)$

[9, 12] 13. $Hates(Robbin, A)$

[13, 8] 14. $\neg Owns(z, A) \lor \neg Date(Robbin, z)$

[1, 14] 15. $\neg Date(Robbin, Me)$

[10, a] 16. $\phi$

[15, b] 17. $\phi$

Because the final result is an empty set, the conclusion is true

**Q2 Classification**

a) For multi-classifier, the loss function should be selected as cross-entropy which minimizes the distance between two probability distributions-predicted and actual.

b)
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Epoch 50: loss: 26.274193275843402, train accuracy: 98.65166666666667, valid accuracy:90.66
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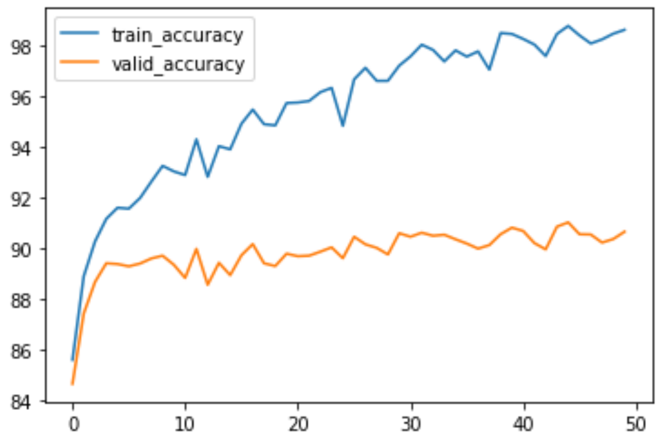


Figure 1 CNN with ReLu activation function and lr in 0.1

In the early stages of training, the value of the loss is very large, but it also drops quickly. As can be seen from Figure 1, the accuracy of the first 10 epochs has improved very quickly. In the subsequent training, the loss decreased and the train accuracy increased, but the valid accuracy fluctuated around 90.3. Overfitting may have occurred.

c) Table 1 Accuracy with different activation function

| Activation function | Train accuracy | Test accuracy | Loss (Final) |
|---|---|---|---|
| ReLu | 98.65 | 90.66 | 26.27 |
| Tanh | 100 | 91.61 | 0.42 |
| Sigmoid | 87.98 | 86.66 | 624.96 |
| ELU | 98.34 | 90.0 | 83.60 |

Keeping ReLU, use 5 different learning rates: 0.001, 0.1, 0.5, 1, 10. From Figure 2, where lr=0.001, it can be seen that the training accuracy and valid accuracy have been improved very smoothly, with less fluctuation. Both reached about 86% in the 50th epoch with a high loss of 730. From the results, the model may be underfitting or reach a local optimum, which is caused by the small learning rate.

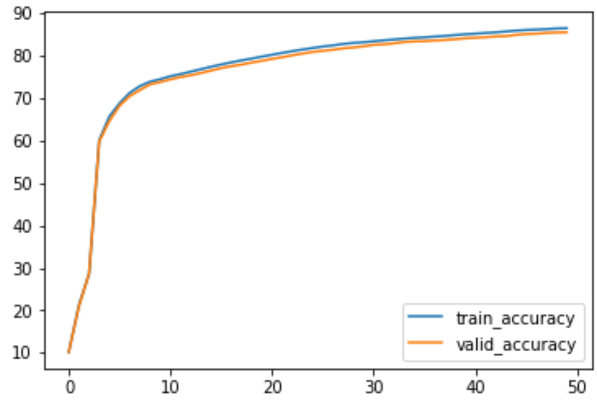


Figure 2 CNN with ReLU activation function and lr in 0.001

From Figure 3, when lr is greater than 0.5, the trained models all perform the same. The training accuracy and verification accuracy are both 10%, and the loss is around 4330. As lr increases, loss also increases accordingly. This is caused by the excessive learning rate. An appropriate learning rate should be as shown in question b) where the lr = 0.1.

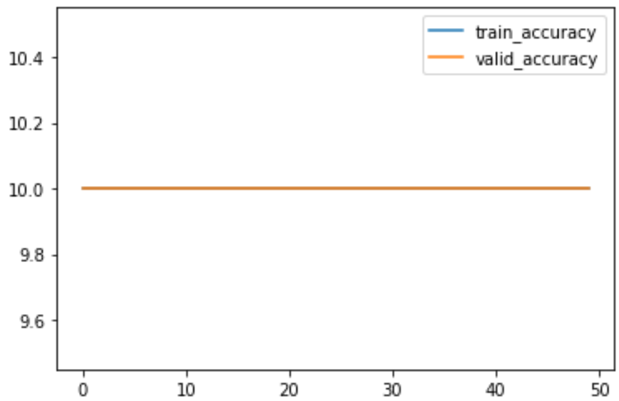


Figure 3 CNN with ReLU activation function and lr over 0.5 (0.5, 1, 10)

d) As shown in Figure 4, after adding 0.3 dropout, the accuracy rate becomes smoother, and the test accuracy rate is reduced while the valid accuracy rate remains unchanged.

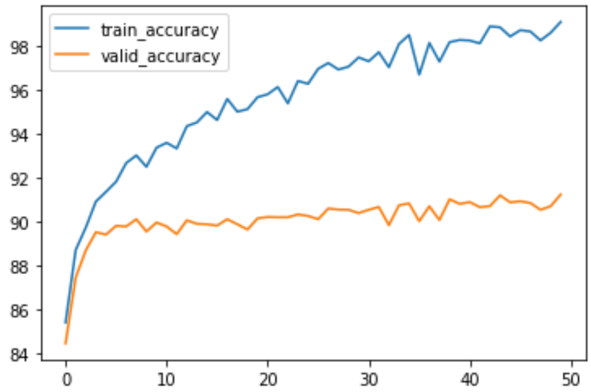


Figure 4 CNN with a dropout rate 0.3

As the dropout rate increases shown in Figure 5, the gap between training accuracy and valid accuracy is getting smaller and smaller. Although the model's performance in training accuracy has been reduced, dropout has effectively improved overfitting.

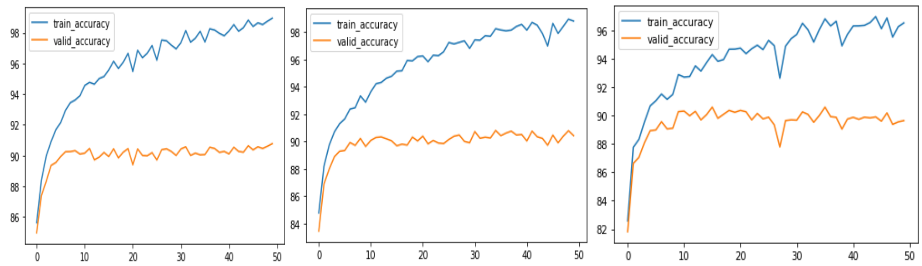


Figure 5 Dropout are 0.1, 0.5, 0.9 respectively