CS620 Quiz 2 (Spring 2021)

Max marks: 25 **Due: Mon Feb 22, 5.00pm**

- *Be brief, complete and stick to what has been asked.*
- *Untidy presentation of answers, and random ramblings will be penalized by negative marks.*
- *Unless asked for explicitly, you may cite results/proofs covered in class without reproducing them.*
- ***If you need to make any assumptions, state them clearly.***
- ***Do not copy solutions from others. Penalty for offenders: FR grade.***
- **Expected time to solve:** 1 **hr** 30 **mins.**

1. Consider the DNN shown in Fig. 1 below. Assume that each node in the hidden and output layers uses a ReLU activation function.

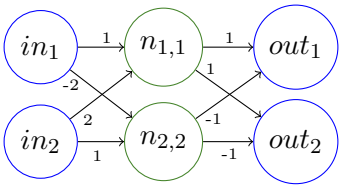

Figure 1: A simple DNN

   (a) *[7.5 marks]* Write all node constraints (for nodes in hidden and output layers) and all edge constraints for this network.

   (b) *[2.5 marks]* Let us call a conjunction of linear (in)equalities a *linear program*. For the DNN in Fig. 1, we wish to write an equivalent (not approximate) system of constraints that is a disjunction of linear programs, i.e. a disjunction of conjunction of linear (in)equalities. How many linear programs need to be reasoned about in general if we were to analyze the DNN in Figure 1being studied in this question. reason about in order to analyze the DNN? Give clear explanation for your answer.

   (c) *[5 marks]* Using ideas discussed in the lectures, write as good a linear program as you can that over-approximates the behaviour of the DNN in Fig. 1.

2. *[10 marks]* Consider the worked out example given in Page 9 of the required reading: *Reluplex: An Efficient SMT Solver for Verifying Deep Neural Networks* by Katz et al. (`https://arxiv.org/pdf/1702.01135.pdf`). This example shows how the ReLUplex calculus can be used to solve constraints arising from a DNN using ReLU activation functions.

   Read the example carefully, and then re-work the example with the following change: $v_{11} \in [1, 2]$ and $v_{31} \in [2, 3]$ (both intervals include the end-points).

   You must show every step, as has been shown in the paper.