

## Data Mining: Assignment 4

Due date: April 11 (Thursday)

**Problem 1** (5 points for CIS 4930, 3 points for CIS 6930)

(a) Draw a neural network for computing the parity function, with three input units and one output. If an even number of inputs is 1, the output must be 0; otherwise, it must be 1.

(b) Consider a multi-layer feed-forward network with a *linear* activation function; that is, the output of each unit is a linear function of the weighted sum of its inputs. Prove that we can replace this network with a perceptron that gives the same outputs.

**Problem 2** (5 points for CIS 4930, 3 points for CIS 6930)

Implement a neural network for learning basic boolean functions, with three input units and one output. Your network should be able to learn any of the following three functions:

- **Conjunction:** Output 1 if all inputs are 1
- **Disjunction:** Output 1 if at least one input is 1
- **Majority:** Output 1 if at least two inputs are 1

Your program should read a file with training examples and test instances, use the training examples to adjust the weights of the network, and then use the resulting network to classify the test instances. The output of the program should include the training time (seconds) and the classification of the test instances. The input format is as follows:

```
<output> <input-1> <input-2> <input-3>
...
<output> <input-1> <input-2> <input-3>

<input-1> <input-2> <input-3>
...
<input-1> <input-2> <input-3>
```

The training examples are above the blank line, and the tests are below. The `<output>` value is 0 or 1, and each `<input>` is also 0 or 1; successive values are separated by one or more spaces. For instance, the following file includes six training examples and one test for the majority function:

```
1 1 1 0
1 1 0 1
1 0 1 1
0 0 0 1
0 0 1 0
0 1 0 0

0 0 0
```

**Problem 3** (2 bonus points for CIS 4930, 4 regular points for CIS 6930)

*If you are taking CIS 4930, this problem is optional, and it does not affect your grade for the assignment. If you solve it, you get 2 bonus points toward your final grade for the course.*

Extend your neural network to allow learning three additional functions:

- **Negated conjunction:** Output 1 if at least one input is 0
- **Negated disjunction:** Output 1 if all inputs are 0
- **Parity:** Output 1 if an even number of inputs is 1

You should submit *one* neural network for Problems 2 and 3; implementing two separate networks is not an appropriate solution.