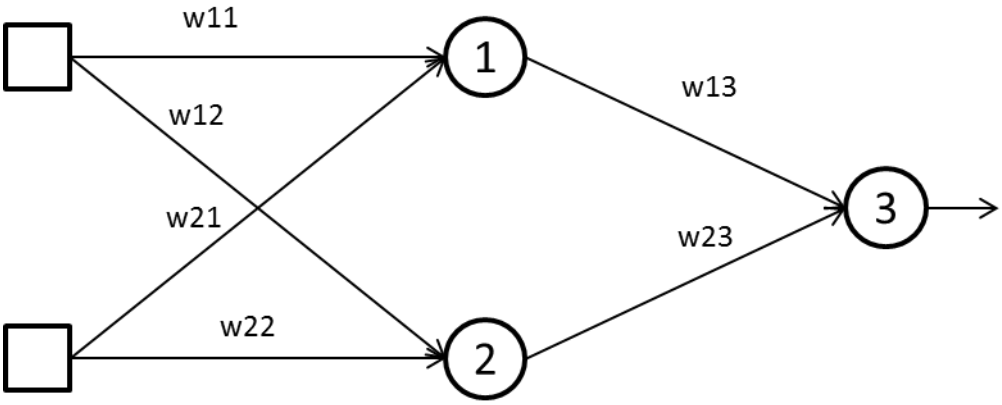
Intelligent Systems Engineering
ECE 449
Final Exam Review Questions

1. Consider the following feedforward network:



In this multilayer perceptron, the first layer is composed of identity neurons, while all the remaining layers are composed of sigmoidal neurons that apply the logistic function

$$y(n) = \frac{1}{1 + \exp(-v(n))}$$

to the induced local field v(n). Assume that the current network weights are given in Table 1. The next input/output pattern to be presented to the network will be: (0.2, 0.7, 1) Using the online backpropagation algorithm with a learning rate of η=0.1 (no momentum term), compute the network outputs for the forward pass of this pattern, as well as the updated weights for the backwards pass.

Table 1: Connection Weights

W10	0.5
W11	0.3
W12	0.2
W20	0.3
W21	0.4
W22	0.5
W30	0.6
W13	0.4
W23	0.3

2. Neurocomputers are a form of computational device that can perform massively parallel operations using artificial neurons. They are normally not designed as adaptive or learning systems, but just perform a fixed forward-pass computation. Design a neurocomputer to compute

an $n \times n$ square matrix where each cell of the matrix is the product of the corresponding cells in two input matrices, each of the same size as the result. Thus, you are computing

$C[i,j] = A[i,j] \cdot B[i,j]$

for $i, j \in (1,2,\ldots,n)$.

3. The fuzzy PD rulebase is the most common form of fuzzy controller you find in the literature. The inputs are the plant state error *e* (versus the current set point of the plant), and its derivative *de*, and the output is the control signal *u* to be sent to the plant to correct the error *e*. For a fice-way partition of each variable, a typical fuzzy PD rulebase would look like this:

		e				
		NL	NS	Z	PS	PL
de	PL	Z	NS	NS	NL	NL
	PS	PS	Z	NS	NS	NL
	Z	PS	PS	Z	NS	NS
	NS	PL	PS	PS	Z	NS
	NL	PL	PL	PS	PS	Z

a) Convert this tabular presentation to the canonical IF – THEN format of the linguistic fuzzy rules.

b) Determine the parameters for, and plot, equal triangular membership functions for each of the linguistic values in each variable. Assume the universes of discourse are [-1,1] for each variable.

c) You probably noticed that the part of the universe of discourse where PL and NL is the strongest membership are half the size of the other membership functions. The s- and z- shaped membership functions let you address this problem. Redo part (b), but this time make sure that each of the five membership functions has an equal-sized partition of the universe of discourse where they are the strongest.

4. The mean filter is a basic convolutional operation in image processing. A small convolution mask (3x3, perhaps 5x5) with uniform weights in all cells summing to 1 is passed over the image; this replaces each pixel with the mean value of the pixels in its immediate neighborhood. The resulting image is a bit blurrier, but a lot of noise (especially salt-and-pepper or Gaussian noise) is removed.

We are going to implement the mean filter in a neurocomputer. The convolution mask to be applied to an image is:

$1/9$	$1/9$	$1/9$
$1/9$	$1/9$	$1/9$
$1/9$	$1/9$	$1/9$

Specify all layers and the filters within them, and the inputs and transfer function for an arbitrary neuron in each filter. You do not need to write code to implement it.

5. Consider two fuzzy sets A and B. Both are triangular fuzzy sets over the universe of discourse [0,3]. Membership μ_A has parameters (0, 1, 2) and μ_B has parameters (1, 2, 3).

a) Plot both of these membership functions on one graph.

b) Indicate the membership function of $A \cap B$ on the same graph.

c) Indicate the membership of $A \cup B$ on the same graph.

6. What is epistasis in genetic algorithms? Give an example of a high-epistasis encoding, and a low-epistasis encoding. Why would they be considered high or low epistasis?

7. Here is a list of ten individuals making up the current population of a genetic algorithm, and their fitnesses. Assuming that the two fittest individuals will be carried forward to the next generation, which individuals should then be selected as parents if we are only interested in exploitation rather than exploration?

ID	Fitness
1	0.5
2	0.75
3	0.3
4	0.8
5	0.2
6	0.1
7	0.45
8	0.9
9	0.4
10	0.32

8. You can find several examples of the Travelling Salesman Problem at https://jlmartin.ku.edu/courses/math105-F14/chapter6-part6.pdf. Write a program in Python using EasyGA to solve the Travelling Salesman Problem, and test it on Examples 1 and 2.