# CIS 730 Artificial Intelligence
# CIS 530 Introduction to Artificial Intelligence
Fall 2018

## Homework 9 of 10: Machine Problem
Perception and Understanding, Part I:
Artificial Neural Networks (ANNs) and
Genetic and Evolutionary Computation (GEC)

Assigned: Mon 05 Nov 2018
Due: ~~Fri 09 Nov 2018~~ Fri 16 Nov 2018

The purpose of this machine problem is to exercise your knowledge of artificial neural network (ANN) learning and genetic programming (GP). You will apply ANN and GP to a wall-following task for a simple mobile robot.

This homework assignment is worth a total of 100%.

Each problem is worth 25% for CIS 530 students and 20% for 730 students.

**References**

**UCI MLDBR Wall Following Task data**: http://bit.ly/uci-mldbr-wallfollowing
**ARFF documentation:** https://www.cs.waikato.ac.nz/ml/weka/arff.html

**NeuroDimension *NeuroSolutions*:** http://www.neurosolutions.com/neurosolutions/
***NeuroSolutions* overview:** https://youtu.be/KVe27KZcCCA

***Evolutionary Computation in Java (ECJ)*:** https://cs.gmu.edu/~eclab/projects/ecj/
**ECJ documentation and tutorials:** https://cs.gmu.edu/~eclab/projects/ecj/docs/

**Robotis Turtlebot 3 documentation:** http://bit.ly/turtlebot3-docs

1. **(530/730) Preparing ARFF data for the UCI MLDBR Wall-Following Robot Task.** Download the wall following task data compiled by Ananda Freire, Marcus Veloso, and Guilherme Barreto of the Department of Teleinformatics Engineering at the Federal University of Ceará in Brazil, and hosted at the University of California Irvine Machine Learning Database Repository (UCI MLDBR):

   http://bit.ly/uci-mldbr-wallfollowing

   Turn this in to an ARFF file by following the ARFF documentation and using Attributes 1-24 as inputs and Attribute 25, *Class*, as the target. Note that this is a control action in the set `{Move-Forward, Slight-Right-Turn, Sharp-Right-Turn, Slight-Left-Turn}`.

   Turn in `MP9-1.arff` and the code you used to produce this data.

2. **(530/730) Building a Multi-Layer Preceptron for the UCI MLDBR Wall-Following Robot Task.** Train the MLP in WEKA and report the precision, recall, and accuracy, along with the confusion matrix, for the above task.

Turn in `MP9-2.pdf` or incorporate your results into an overall `MP9.pdf`. You may find it convenient to copy and paste your results from WEKA Explorer into `MP9-2.txt`.

3. **(530/730) Downloading, Installing, and Running *NeuroSolutions*.** Download and install the free trial version of *NeuroSolutions 7.1.1.1* for Windows (if you use MacOS 10.x or Linux, I strongly recommend using VMWare or VirtualBox with Windows 10 for this assignment, rather than NeuroSolutions v6 for Mac users under Microsoft Virtual PC for Mac).

   Go through the demo tutorial for building a multi-layer perceptron and step through it. Take a screenshot of your mean-squared error loss function graph after training the network. Name this `MP9-3a.jpg` and embed it in `MP9-3.pdf` along with the actual MSE value or incorporate your results into an overall `MP9.pdf`.

   Now import the ARFF data and run NeuroSolutions' Multilayer Perceptron wizard (with default settings) to train an MLP for the wall-following task in MP9-1 and MP9-2. You will need to consult the documentation to convert ARFF to NeuroSolutions data. **Hint**: for the small robot control data set you are working with, this can be done by hand using a simple text editor or spreadsheet.

   Take a screenshot of your mean-squared error loss function graph after training the network. Name this `MP9-3b.jpg` and embed it in `MP9-3.pdf` or incorporate your results into an overall `MP9.pdf`.

   How would you compare your results from MP9-2 and MP9-3 with one another? **(<u>Hint</u>:** Can you find a way to count classification errors in NeuroSolutions the way WEKA does?**)**

4. **(530/730) Using ECJ.** Download Evolutionary Computation in Java (ECJ) **v26** from Sean Luke's ECLab at George Mason University. Follow Tutorial 4:

   https://cs.gmu.edu/~eclab/projects/ecj/docs/tutorials/tutorial4/

   to build a symbolic regressor using five functions – two variables and three operators (X, Y, +, -, *) for the target function

   $$f((x, y)) = x(y + xy) + y = x^2y + xy + y$$

   Print out the output of

   ```
   java ec.Evolve -file tutorial4.params -p
   stat=ec.gp.koza.KozaShortStatistics -p stat.do-size=true -p
   stat.do-time-true
   ```

   and turn this in as `MP9-4.pdf` or incorporate your results into an overall `MP9.pdf`. Include your Java sources as `MP9-4.zip`.

5. **(730 only) Building and Using A Real-World Robotics Data Set using Machine Learning.** Read and watch:

   http://www.pirobot.org/blog/0007/

   and refer to the documentation of an extant robot kit such as the Robotis TurtleBot 3 Burger:

   http://bit.ly/turtlebot3-docs

Describe in your own words how you would log and prepare data such as that specified in the Pi Robot blog to make a training data set, train an MLP or GP-based symbolic regressor for the tasks in MP9-1 through 3 and MP9-4. Specify whether you are training a classifier or regressor. How would the ROS platform differ for a TurtleBot? How would you use the *NeuroSolutions* or *ECJ* output to drive the robot as shown in the Pi Robot blog entry?

**Class Participation (required)**

Also post to the MP9 thread any questions about any part of this assignment, about probabilistic reasoning and machine learning, or about your term project.

**Extra Credit (10%)**

**(MP9-EC)** Following up on MP9-3, play with the NeuralExpert and NeuralBuilder to try out one more neural network type besides MLP. Which one did you try? Did you get better results than for MLP? Turn in `MP9-EC.pdf` or incorporate your results into an overall `MP9.pdf`.

**Coming Up Next**

**Problem Set 10** (due Fri 30 Nov 2018) – Perception and Understanding, Part II: Natural Language Processing (NLP), and Vision. You will solve problems and answer some discussion questions about perception and understanding. (This will include some practice final exam questions.)