

## Guidelines for CSC4444 (AI) Group Projects

### Group Projects

The main objective of the group projects is to expose students to hands-on experiences of building intelligent agents (systems implementing Artificial Intelligence techniques for solving various problems) so that experimenting with such systems will gain students concrete insight and understanding about various AI ideas. Moreover, because students must form groups and each group works as a team, the project also trains the students' capability for team work, communication and cooperation. The group project presentation session and the written project report also provide the opportunity for training presentation and communication skills. The use of the IBM Bluemix platform would offer students unique experience of exploiting various AI-related software apps for developing their own intelligent systems.

### Required components of the group project:

It is required that each group project must involve an **implementation component** and an **experimentation component**. The group is free to choose any computer hardware platform and the software environment for their project except that the IBM Bluemix platform must be utilized (in addition to other software tools) for project development.

### The implementation component:

The group must develop a computer program that implements an intelligent agent. The group does NOT have to write ALL programs from scratch in implementing an AI system. It is fine for a group to down-load open-source AI programs and to extend/customize/modify the program for various experiments in a particular application domain. For example, for a group project using Genetic Algorithm (GA) to discover game-playing strategies of a particular (board or video) game, the group can incorporate any available open-source codes for GA in their system.

### The experimentation component:

The experiments conducted in the project should be designed toward answering some key questions around a **central theme**. For example, consider a group project that implements an AI-based game-playing program with an  $A^*$ -like search method for finding the best game strategies/actions. Here the key questions to be answered could include: Which heuristic function for guiding the search is better in the sense that it helps generate good game strategies more efficiently - reducing the number of states explored? If a heuristic function is known to be not admissible, how was the quality of the game strategy/actions generated by using such heuristic function in search? Is there a trade-off between admissibility of a heuristic function  $h$  and the efficiency in finding a good game strategy with  $h$ ? Experiments are needed to compare different heuristic functions in terms of efficiency of searching for a strategy and the quality of the strategies generated.

As another example, suppose a group project tries to compare two different approaches of using Neural Networks (NN) for hand-written character recognition: one approach uses the raw (gray-scale) image of the character as inputs to the NN, whereas the other approach uses 10 features (extracted from the raw image) as inputs to the NN. The first approach uses a "deep neural network" (as in "deep learning", a topic actively studied in recent years), and the second approach may use the "traditional" (non-deep) neural networks. The key questions to be answered by the experiments include: Which approach is computationally more efficient? Which approach gives better classification accuracy? Among all the features considered in the second approach, which one (if any) is redundant? To answer such questions, clearly the group needs to design experiments that use varying sizes of training/testing data sets and record the computational time and classification accuracy of the two approaches.

### **Time Lines, Documentation of the group project and presentation:**

The group should identify the topic of the project by **Oct. 10, 2016** and submit an abstract of the proposed project by that date.

The group should submit the written project report by 5pm **December 2, 2016**.

The group presentation is to be conducted on Tuesday **December 6, 2016**

The group presentation should show the design, implementation of the AI system. In addition, the experiment design, experiment results and the interpretation of the results should be presented as well. It is preferred that a system demo is included in the group presentation.

The written report should provide a clear documentation about the project's motivation, the problem addressed by the project, the main technical (AI-related) ideas/concepts behind the project, and the software system design and implementation. The report should describe the experiments performed in the project, and discussions should be included to explain the results of the experiments.

The structure and major components of your project software should be listed. The report should also specify the various software tools/packages utilized for developing the project. The report should include sample screen shots illustrating the functionality of your project. Sample software source code segments should be included (as an appendix) in the report.

In addition, if your project is web-based, a Web-site link should be included in the project so that the TA can test out your project.

### **Evaluation Criteria**

The group project will be evaluated based on several factors:

(1) **The novelty of the project ideas and applications.**

The groups are encouraged to come up with **original** ideas and novel applications for the projects. A project with new ideas (algorithms, methods) on AI or new interesting applications of existing algorithms are scored higher than a project without much new idea/application.

(2) **The extensiveness of the study and experiments.**

A project that produces a more intelligent system by combining several AI techniques together, or a project that involves extensive experiments and thorough analysis of the experimental results are scored higher.

(3) **The quality of the group presentation.**

(4) **The quality of the written project report.**

### **Some sample group projects:**

- (1) Design and simulation of a mobile robot that explores the environment and (possibly achieve given goals) through learning, search, and planning.

The project implements a software simulation of a mobile robot that can move around in a maze (an unknown environment) and learns to detect walls, avoid obstacles, find dead-ends, etc. Moreover the mobile robot could have other goals (such as finding gold, food, water, etc.) instead of trying to explore the environment.

One could implement various reinforcement learning algorithms or reflexive/goal-oriented/utility-based agents and test and compare the performance of these algorithms in several different two-dimensional grid worlds (with different obstacles and different assumptions on whether the sensor readings are noisy).

- (2) Design and implementation of an intelligent game playing system which can play or gradually learns to play some games - board games (checkers, go, Othello, etc.) or interactive video games.

You may use the system to test the usefulness of Alpha-Beta pruning, the use of different evaluation functions for minimax search, the use of "pattern database", and possibly a combination of techniques, etc.

Various learning algorithms (GA, reinforcement learning, polynomial function learning, decision trees, etc.) can be used as appropriate to learn the game-playing strategy.

You could also consider a game with chance (like Backgammon).

- (3) Comparison of various search methods (and/or heuristic functions in  $A^*$ ) for puzzle-solving problems.
- (4) Design and implement a logical agent that maintains a knowledge base, accepts statements in propositional/first-order logic, and can answer queries posed to the knowledge base.

The inference of the agent could be using SAT solver or resolution.

- (5) Design and implementation of an image classification system using Neural Networks. The project uses Neural Networks (backpropagation or some other type of NN) to build a classifier that can classify images into various categories.

You could also consider using neural networks for other kind of applications such as speech recognition - training a neural network to recognize spoken words.

In addition, one could try to use "deep NN" to perform such image classification tasks.

- (6). Design and implementation of a text mining system based on AI/ML techniques.

Various text mining topics can be explored. For example, one can build a text classification program (using Naive Bayes classifier) that can classify textual documents into different categories. Actually there is one such program available at CMU. See <http://www.cs.cmu.edu/afs/cs.cmu.edu/user/mitchell/ftp/ml-examples.html>. You can adapt, customize the code there and perform experiments on various issues of text mining.

One could also combine information retrieval techniques and ML methods (such as decision trees) for concept mining - extracting important key words (concepts) from texts, and for classifying texts into categories based on the extracted concepts.

- (7). Design and implementation of an intelligent control system based on planning, search, and learning techniques.

The control system could be a complex system such as a mobile robot, a chemical plant control system, or a simple controller - for example, just a controller for an air-conditioner with the objective of maintaining certain temperature and humidity level and saving energy at the same time. One may need to identify the sensors (such as temperature and humidity readings) available to the controller, the actuators (actions the controller can perform), the performance objective and the experience/environment available to train the learning system.

- (8). Design and implementation of GA-based systems for various optimization problems/applications.

For example, one could apply and compare several variants of GA for solving the traveling-salesman problem, or for the school class-time scheduling problems.

- (9). Design and implementation of a system for sentiment analysis using social media data (such as Twitter) with various NLP (Natural Language Processing) methods.

- (10). Design and implementation of AI based systems to interesting application problems.