# Model AI Assignments 2024

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**Abstract**

The Model AI Assignments session seeks to gather and disseminate the best assignment designs of the Artificial Intelligence (AI) Education community. Recognizing that assignments form the core of student learning experience, we here present abstracts of five AI assignments from the 2024 session that are easily adoptable, playfully engaging, and flexible for a variety of instructor needs. Assignment specifications and supporting resources may be found at http://modelai.gettysburg.edu.

## Collective Intelligence from a Synthetic and Biological Perspective - Pia Bideau, David Bierbach, and Wolfgang Hönig

In this project we study collective intelligence from two different aspects: First, we build a system exhibiting collective behavior by scaling single-robot solutions to achieve inter-team collision avoidance. Here, students design synthetic behavior that may be tested on a team of commercially off-the-shelf robots. In a second part we take a closer look into a natural system of collectively behaving fish. In combination with a biomimetric robot the natural system helps us to validate and test hypothesis about natural behavior of animals. For the first part of creating synthetic behavior, students learn about robot dynamics, controllers, motion planning using differential flatness, relative position estimation with a camera, and collision avoidance (Buffered Voronoi Cells). Everything is validated using Python notebooks with few dependencies that are widely available. Optionally, the same code can be executed on a team of real Lego Mindstorm robots. For the second part of analyzing natural behavior, students learn about schools of fish and how these react to artificially controlled robotic team members. Such robot fish mimic appearance and behavior of conspecifics and the resulting observations enable students embody hypotheses regarding agent perception (e.g. distance estimation) and interactions and probe those in real world settings.



## PDDL Assignment - Nir Lipovetzky and Christian Muise

This assignment is dedicated to testing a student's proficiency in implementing a medium-difficulty domain in the Planning Domain Definition Language (PDDL). It guides the students through a series of problems of increasing difficulty and contains ample scaffolding for them to implement the needed actions. The assignment has been piloted across several undergraduate Artificial Intelligence courses and is the perfect companion to a module that teaches students about Automated Planning. Two versions are provided with this submission. The first uses a traditional grading scheme, while the second encourages ungrading for the students. There are also slight differences in the expected mechanics of the domain and the problem descriptions (multiple variations are helpful so that solutions cannot be readily found online).

The assignment and its variations have been given to thousands of students over the last few years, and it is consistently ranked as one of the best (if not the top) among the assignments used in undergraduate AI classes. We are excited to offer this to other AI instructors, hoping it can be used more broadly.

## Using Computer Vision Techniques to Count LEGO Pieces - Lino Coria

This Model Assignment consists of two "sister" lab exercises related to counting LEGO pieces using computer vision techniques.

In the first lab, students are tasked with using traditional computer vision techniques to count and classify LEGO pieces from a small image dataset. All images feature several LEGO pieces against a relatively simple background. Students need to apply three techniques such as image thresholding, edge detection (e.g., Canny), and rg chromaticity to segment, count, and classify the pieces (by color). Students are expected to identify the most suitable technique and provide evidence to support their choice. They should also provide a report containing method descriptions, results, discussion, and conclusion.

For the second lab, students work with a larger and more complex dataset to detect and count LEGO pieces. Students need to train a convolutional neural network to identify and

count LEGO pieces. They can choose any neural network architecture and framework (e.g., Inception/SSD with TensorFlow, Mask R-CNN with PyTorch, YOLO with Darknet). The performance assessment for the object detection task involves using mean average precision (mAP) with an IoU threshold of 0.5. The assignment requires a similar report structure as the first lab.

## An Animal Card Set for Teaching Classification (Unplugged) - Claire Wong and Stephanie Rosenthal

Teaching machine learning can be challenging when students cannot visualize the data that they are modeling. We designed a set of brightly-colored cards that describe features of 36 animals of the classes mammal, bird, and fish drawn from the Kaggle Zoo Animal dataset. We chose a subset of the animals that would be easy for even young students to identify. We additionally provide materials for students to use the cards to build a decision tree.

Using the cards, students can find important features that distinguish one class from another. They can form a model (decision tree or otherwise) based on those distinctive features. Students can also practice computing the model accuracy by determining which animals are classified correctly and which are not. If some cards are left out of the dataset given to students initially, then teachers can also discuss training and testing sets, and potential model errors due to dataset bias. For decision trees in particular, students can test different features at different levels of the tree, and teachers can discuss the depth of the tree and its importance.

Original files are provided so that teachers can modify and add to the dataset as needed.

## Teaching Word Embedding in Natural Language Processing using SNAP- Yu Lu, Ming Gao, and Jingjing Zhang

As an effective and fundamental technique commonly used in natural language processing (NLP), word embedding encodes the meaning of individual words in the form of a real-valued vector. It significantly prompts the advancement of artificial intelligence, and a number of NLP tools have been developed, such as word2vec and BERT. However, it is relatively hard for learners without text-based coding experience, such as high school students and non-computer science students in college, to understand word embedding concept and how it works. By leveraging on a block-based programming environment called SNAP!, we design this assignment to facilitate learning the basic concepts and key ideas of word embedding for the novice NLP learners. The assignment consists of seven specifically designed tasks, where the former one inspires the next one. The key functional blocks and the programming environment can be easily set up in advance, and the learners could accomplish the tasks by drag and drop without additional efforts on programming. Following the simple configuring steps, learners could accomplish all the tasks in the browser. Teachers can also develop new tasks by simply modifying the parameters inside the given blocks of the assignment.