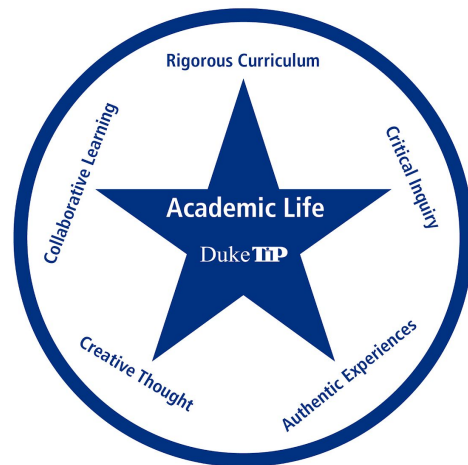**Duke Talent Identification Program**
Summer Studies Program 2018
Artificial Intelligence
Site: Georgia Institute of Technology
Term: 2
Instructor: Muhammad "Osama" Sakhi
TA: Julian Wright

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Course Description:
While science fiction has a long history of intelligent machines, we now live in a world in which these machines are reality—and you can learn the skills to work in this exciting field. We can hold conversations with Siri on our iPhones, watch computers defeat the world's greatest chess players, and might soon ride around in driverless cars. These new technologies require artificial intelligence, which is the study and development of technology that can reason, deduct and, basically, act human. Learn the programming necessary to work in machine intelligence development, and explore the origins of AI as well as modern areas of research, including language processing, perception, motion, and manipulation.

Extended Course Description:
Students will first learn about many applications of Artificial Intelligence in the fields of pathfinding, machine learning, and natural language processing. Next, they'll tackle building an agent that can beat Pacman without any human input. They will then learn how machines can be "taught" to make decisions based on examples using datasets of their choice. In the final week, students will use sentiment analysis to predict whether Amazon reviews are overall positive or negative.

Required Texts: (provided to students by Duke TIP)
None

Course Objectives:
During this course, students will:
Primary
- Learn about AI in the world and its current abilities
- Understand AI's applications in Pathfinding, Machine Learning, and Natural Language Processing

- Develop an intuition for which types of Machine Learning models will fail or succeed in a given environment
- Understand how the complexity of spoken language presents new challenges for machines

Secondary

- Learn how to take an AI algorithm from concept to working prototype
- Gain enough proficiency in a programming language to implement algorithms effectively

Assignments and Evaluation:

This course takes a hands-on approach to Artificial Intelligence through a series of projects. Each week, will consist of learning algorithms that solve wide range of problems, applying it to one specific problem as a class, then tackling new problems in groups. The objective of these projects is to help students see the algorithms in action in various domains. Supplemental topics are presented as needed to give additional understanding.

An important part of this course is the ability to research topics that are unfamiliar to the students, deduce the most important findings, and present them in a way the whole class can understand with a limited background in artificial intelligence.

In this course, teamwork will be vital as most projects and assignments require students to pair up and distribute work evenly among partners. Furthermore, engagement in groups and in class discussions as a whole will factor in heavily into the evaluations.

Ultimately, the skills these students develop by working in teams, applying known solutions to new classes of problems, and deducing the most important findings in research papers will prove to be invaluable regardless of where their interests take them in the future. Artificial Intelligence is bound to arise in brand new domains in the future, and these students will leave this class with an intuition of AI's powers and limitations in those domains going forward.

Day by Day Itinerary:

Course Outline: Week One
Monday: Course Introduction, Python Introduction
Morning:

- Instructor / Student Introduction
- Review of Syllabus
- Student Programming Experience Survey
- Course Overview: AI Topics and Applications
  - Brief History of AI
  - Strong AI vs Weak AI
  - Modern Applications of AI:
    - Pathfinding

- ■ Recommendation systems for Netflix, Amazon
- ■ Translation Systems
- ■ Facial Recognition

Afternoon:
- Setup VirtualBox with Ubuntu on Laptops
- Introduction to Linux and the Terminal
- Introduction to Python:
  - Types, Variables, Operators in Python
  - Conditionals
  - Loops
  - Lists
- Guided Python exercises

Evening Study:
- Discussion: Limitations of Neural Networks in Generating Movies

Tuesday: Data Structures, Research Project

Morning:
- Research Projects:
  - Groups of 2 Pick a Subdomain of AI:
    - ■ Business Intelligence
    - ■ Medical AI
    - ■ Computer Vision
    - ■ Machine Learning
    - ■ Natural Language Processing
    - ■ Robotics
    - ■ Swarm Intelligence
    - ■ Video Games
    - ■ Internet of Things
  - Find Recently Published Papers in Chosen Subdomains, Synthesize Findings
  - Present to Entire Class

Afternoon:
- Continue Learning Python:
  - Built-in Data Structures − Lists, Dictionaries, Sets
  - Stacks, Queues
  - File I/O
- Guided Exercises: Data Structures

Evening Study:
- Introduction to Graph Theory:
  - Graphs
  - Defining graphs in Python

Wednesday: Research Presentations

Morning:

- Jeopardy Game: Artificial Intelligence, Python Essentials
- Recap: Python Data Structures, Indexing
- Python Exercise: Representing US State Map as a Graph

Afternoon:
- Complete Research for Projects
- Research Presentations

Evening Study:
- Complete US State Map Assignment

Thursday: Graph Search Algorithms

Morning:
- Python Warmup Exercises
- Depth-First Search (DFS)

Afternoon:
- Breadth-First Search (BFS)
- Implementing BFS on US Airline graph

Evening Study:
- T-Shirt design

Friday: Uniform Cost Search, Pacman Project

Morning:
- Solution Walkthrough: BFS Assignment
- Begin Pacman Project
- Weighted Graphs
- Uniform Cost Search / Djikstra's Algorithm

Afternoon:
- Continue Pacman Project

Saturday: The Imitation Game

Morning:
- Movie: The Imitation Game
- Discussion: Alan Turing's Role in Computing, Universal Turing Machines
- Discussion: Problems in Cryptography & Combinatorics
- Discussion: Video and Speech Synthesis Using Machine Learning

Course Outline: Week Two
Monday: A* Algorithm

Morning:
- A* Algorithm

Afternoon:
- Complete Pacman Project

Evening Study:
- Introduction to Git and GitHub

Tuesday: Introduction to Probability & Statistics, Machine Learning

Morning:

- Introduction to Probability & Statistics:
    - Independence of Events
        - Gambler's Fallacy
    - Bayes Rule
    - Distributions
    - Sampling
- Card Game Activity: Bluff
- Machine Learning Overview:
    - Supervised Learning
    - Unsupervised Learning
    - Reinforcement Learning

Afternoon:

- Supervised Learning: Classification vs Regression Problems
- Supervised Learning Models:
    - Decision Trees
    - Random Forests
    - KNN — K-Nearest Neighbors
    - Naive Bayes
    - Neural Networks
- Demo: Applying Each Supervised Learning Model
    - Dataset: Handwritten Digits
    - Means of Preventing Overfitting

Evening Study:

- Term Book Page: Student Superlatives, Class Picture Submission
- Guided Exercise: Machine Learning Experiment Walkthrough

Wednesday: Naive Bayes Classifier

Morning:

- Recap Bayes Rule
- Understanding Normal Distributions
- Exercise: Creating a Naive Bayes (NB) Classifier By Hand
- Evaluating Supervised Learning Models:
    - Training Sets vs Test Sets
    - Bias vs Variance
    - Accuracy
    - Overfitting
- Importing Datasets

Afternoon:

- Continue NB Classifier Assignment

Evening Study:

- Continue ML Projects
- Complete NB Classifier

Thursday: Cross-Validation, Begin Machine Learning Projects
Morning:
- Cross-Validation Crash Course
- Cross-Validation Using Scikit-Learn
- Grid-Search Cross-Validation for Parameter Tuning
- Evaluating Regression Models

Afternoon:
- Begin Machine Learning Project:
    - Find Datasets For Classification and Regression Tasks
    - Create Test / Train splits of data
    - Apply Cross-Validation to Discover Best-Performing Models
    - Evaluate Model Performance
    - Present Results to Class

Evening Study:
- Continue ML Project

Friday: ML Project Presentations
Morning:
- Jeopardy Game: Pathfinding, Machine Learning
- Complete ML Projects

Afternoon:
- ML Project Presentations

Saturday: Hidden Figures
Morning:
- Movie: Artificial Intelligence (2001)

Course Outline: Week Three
Monday: Introduction to Natural Language Processing
Morning:
- Introduction to NLP
- Bag-of-Words (BOW) model

Afternoon:
- Sentiment Analysis
- Document Classification
- Using BOW Model for Sentiment Analysis of Amazon Product Reviews

Evening Study:
- Improving BOW Models by Constraining Vocabulary Sizes

Tuesday: Techniques for Improving Classification, Field Trip

Morning:

- Field Trip: Virtual Reality Robot Improv Demonstration

Afternoon:

- Term-Frequency Inverse-Document Frequency (Tf-Idf)
- Applying Tf-Idf to Amazon Sentiment Analysis Task

Evening Study:

- Compare Model Performance of BOW vs Tf-Idf

Wednesday: Perceptron Classifier By Hand

Morning:

- TED talk on Machine Learning Ethics
- Calculus in Action: Derivatives and Approximations
- Perceptron Learning Algorithm:
    - Error Function
    - Minimizing Error Function Using Gradients

Afternoon:

- AI Course-themed Rap Battle
- Exercise: Create a Perceptron Classifier By Hand

Evening Study:

- Complete Perceptron Exercise

Thursday: Begin Final Projects

Morning:

- Begin Final Project:
    - Groups of 2
    - Brainstorm Ideas that Incorporate Pathfinding, Machine Learning, or NLP
    - Present Project, Approach, and Results to Class Upon Completion

Afternoon:

- Continue Final Project Work

Evening Study:

- Staff Evaluations
- Continue Final Projects

Friday: Final Presentations, Robotics Lab

Morning:

- Word2Vec Model: Helping Machines Understand Relationships Between Words
- Continue Final Project Work
- Final Project Presentations (10 - 15 minutes each)

Afternoon:

- Field Trip: Georgia Tech College of Computing's Robotics Lab

Saturday: Parent Conferences