Introduction to the Course

Adaptive and Cooperative Algorithms (ECE 457A)

ECE, MME, and MSCI Departments,
University of Waterloo, ON, Canada

Course Instructor: Benyamin Ghojogh
Fall 2023

Introduction of the Instructor and Students

Let us know each other by introducing ourselves briefly!

Feel free to let us know (if you would like):

- Your name
- Your major
- Which year are you studying in?
- What is your goal for taking this course? What are your expectations from this course?

Introduction of the Course

- The course covers three (or maybe four) main concepts:
  - Metaheuristic optimization
  - Fundamentals of game theory
  - Fundamentals of reinforcement learning
  - Fundamentals of fuzzy logic (Time allowing)

Introduction of the Course

- Concepts covered in metaheuristic optimization:
  - Preliminaries on optimization
  - Local search (hill climbing)
    - ★ Variants: multi-start local search, iterative local search, guided local search, jitter (noise), smoothing method, variable neighborhood selection, generalized neighborhood selection
  - Simulated annealing
  - Tabu search
  - Genetic algorithm
    - ★ Variants of cross over and mutation
  - Genetic programming
  - Evolutionary programming
  - Differential evolution
  - Particle swarm optimization
  - Ant colony algorithms
    - ★ Ant colony, Ant colony system, Fast ant, Ant tabu
  - Some bio-inspired optimization algorithms (mostly proposed by Seyedali Mirjalili, Torrens University Australia, Australia)
    - ★ Grey wolf optimizer, Whale optimization algorithm
  - Nelder-Mead simplex algorithm (fminsearch of MATLAB)

Introduction of the Course

- Concepts covered in game theory:
  - Elements of a game: players (agents), actions, payoff (utility), information, equilibrium, strategy, nature
  - Forms of game:
    - ★ normal form
    - ★ extensive form
  - Equilibriums
    - ★ dominant strategy equilibrium (weakly and strongly dominant)
    - ★ Nash equilibrium
  - Some well-known games: the prisoner's dilemma, the battle of sexes, the welfare game, the game of chicken
  - Introduction to cooperative game, non-cooperative game, zero-sum game
  - Sequential-move games, Bayesian games
  - Mixed and continuous strategy
    - ★ First-order condition
    - ★ Payoff-equating method
  - Equilibriums in duoploy (in managment science):
    - ★ Cournot, Stackelberg, Bertrand
  - Dynamic games (with parameters)
  - Repeated games: grim strategy and tit-for-tat strategies, the folk theorem
  - Minimax and maximin strategies

Introduction of the Course

- Concepts covered in reinforcement learning:
  - Elements of RL: environment, action, state, reward, policy
  - Markov decision process
  - Bellman's equation
  - Value iteration
  - Policy iteration
  - Monte Carlo evaluation
  - Temporal difference evaluation
  - Q function, Q-learning, and gradient Q-learning
  - Deep Q-network and Atari games
  - Policy gradient
  - Reinforce algorithm
  - Brief overview of playing game of Go with reinforcement learning

Introduction of the Course

- Concepts covered in fuzzy logic:
  - Elements of fuzzy logic: membership function, symbolic representation, fuzzy union, fuzzy intersection, fuzzy complement
  - T-norm, S-norm
  - Fuzzy relation
  - Compositional rule of inference
    - ★ Max-min and Max-product
  - Fuzzy inference, fuzzy rules
  - Fuzzification
    - ★ Singleton, triangular, Gaussian
  - Defuzzification
    - ★ Centroid, mean of maxima
  - Fuzzy inference system
    - ★ Mamdani fuzzy model
    - ★ Sugeno fuzzy model
    - ★ Tsukomoto fuzzy model

Course Materials

- Lecture notes will be provided to you.
- YouTube channel of the course: [Link], Feel free to subscribe!
- Our tutorial papers: [Link]
- Piazza of the course. Please enroll in the Piazza of the course. [Help]
- LEARN page of the course. Check for notifications.
- Additional books:
  - Metaheuristic optimization:
    - ★ El-Ghazali Talbi, "Metaheuristics: from design to implementation". John Wiley & Sons, 2009, PDF available in ResearchGate.
    - ★ Andries P. Engelbrecht, "Computational intelligence: an introduction". John Wiley & Sons, 2007, PDF available in ResearchGate.
  - Game theory:
    - ★ Eric Rasmusen, "Games and Information: An Introduction to Game Theory", 4th Edition, 2007, [Link]
  - Reinforcement learning:
    - ★ Richard S. Sutton, Andrew G. Barto, "Reinforcement learning: An introduction", MIT press, 2018. [Link]
  - Fuzzy logic:
    - ★ Fakhreddine O. Karray, Clarence W. De Silva, "Soft computing and intelligent systems design: theory, tools, and applications". Pearson Education, 2004. [Link]
- Research articles in the literature

Course's Websites

Introducing the instructor and TA of the course:

- Instructor: Benyamin Ghojogh, email address: bghojogh@uwaterloo.ca
- TAs:
  - Danial Sadrian Zadeh, email address: dsadrian@uwaterloo.ca
  - Xuanrui Zeng, email address: x64zeng@uwaterloo.ca
- Please message us in Piazza and not by email. You can message publicly, privately, or anonymously.

Course info:

- Classes will be in-person.
- Discussion chats and questions will be in Piazza.
- The course's website is:
  `https://bghojogh.github.io/pages/uwaterloo/ece-457a-f23/`
- I will probably upload the videos of the classes to my YouTube channel [Click here].
  I will eliminate personal information of students (such as when they introduce themselves) in the videos.

Course Evaluation

- Assignments (30%): Assignments will be posted on LEARN along with the due dates. They are performed individually. We will probably have several (two to three) assignments.
- Course project (20%)
  - Date: Week 5 - 10
  - More details will be discussed in class. Report will be electronic submission due in LEARN.
  - The number of people in each group will be announced in the class.
  - Pick a topic after 5 weeks.
  - Submit the title and proposal/objectives in LEARN to be checked and approved.
- The final exam (50%): Date will be announced later by the department. Details to be discussed in class.
- Bonus points: participation in class, participation in the discussions, asking questions, and answering questions.

Course's Goal

- Don't worry much about your marks!
- Focus on understanding the materials of the course.
- Our goal is to learn the important practical and theoretical adaptive and cooperative algorithms, so you can use them in both your **industrial projects** and **academic research**.
- About theory and practice:
  - We will learn **some theory** to understand why these methods work.
  - We will also learn how to use the methods **in practice** for practical usage.

Ask Questions!

- Please ask questions whenever you do not understand something.
- Let the class be discussion-based. I do not want to be the sole speaker. We are gonna learn all together.