Outline of ECE457A

University of Waterloo, Fall 2023

Instructor: Benyamin Ghojogh

I. OUTLINE

- 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)
- 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)
- Concepts covered in game theory:
 - Elements of a game: players (agents), actions, payoff (utility), information, equilibrium, information, 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
- · 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
- 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

II. 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

III. 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.

IV. 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.