First-Year Seminar Title: Problem Solving

Name and Contact Information of Instructor:

Prof. Dennis Shasha  
Department of Computer Science  
Courant Institute of Mathematical Sciences  
New York University  
251 Mercer Street  
New York, N.Y. 10012-1110  
U.S.A.  
Email: shasha@cs.nyu.edu  
Web: [http://cs.nyu.edu/cs/faculty/shasha/index.html](http://cs.nyu.edu/cs/faculty/shasha/index.html)  
Website for the class:  
[http://cs.nyu.edu/cs/faculty/shasha/papers/problemsolve.html](http://cs.nyu.edu/cs/faculty/shasha/papers/problemsolve.html)

Brief Course Description:

Many problems in science, business, and politics require heuristics -- problem solving techniques that often work well but give imperfect guarantees. This course teaches heuristics as they apply to the design of scientific experiments, the resolution of economic or political negotiations, and in the construction of engineering devices in hostile environments. Students will work in small teams that will solve puzzles, conduct experiments, and build strategies for a competitive auction game. Students will use and learn computational tools, building on some programming experience in Python or other languages. The intent is to make you better able to face complex problems in any field you choose.

The writing center offers the support of writing tutors. You will be seeing a lot of them. They will help you with drafts, but will not grade you. The writing mentor leader is Leah Souffrant [ljs17@nyu.edu](mailto:ljs17@nyu.edu). The writing tutors are ???. You will get to know them well.

Learning Outcomes:
Design approaches to problems that are quantitative, procedural, and adaptive, even when the problems suffer from incomplete information or are only approximately described.

Understand heuristic techniques from computer science, biology, and human history.

Design social, physical, or computational experiments that apply heuristic techniques.

Teaching and Learning Methodologies:

Lectures, readings, programming, and social/cultural experiments.

Methods and Dates of Assessments:

Class participation 5%, presentations 10%, and quiz work 15% (participation evaluated based on interaction with other presenters, responses to questions from the professor, and quality of student’s own presentation), three projects worth 20%, 20% and 30%. Each presentation of a book chapter (you’ll be presenting just one book chapter) should be accompanied by a two to three page writeup explaining some element that goes beyond what you find in the chapter you are discussing. Presentations of projects may be longer. Your writeup should go to the writing tutors within two days of the presentation and is due two weeks later. The experimental project (project 2 below) should be accompanied by an eight 10 page paper explaining the goals, the theoretical background, the results, and the conclusions along with a statistical analysis. There will be four or so short quizzes that may or may not be announced in advance.

Project 1: master one puzzle-based game, design a strategy that is likely to win and be prepared to take on challengers. (due on week 4, with draft to the writing tutors two days later and final to me by week 6). Suggested games include Superply, Corner Chess, Adversarial Shortest Path, DigThat, Evasion, Geo Wars, Gravity, Multiplayer Snake, Safe Roving from http://cims.nyu.edu/drecco2016, or Voronoi from here: http://interstices.info/jeu-voronoi, or NoTippingGameV2, Dating Game V3, Gravitational Voronoi, Sudokill from http://cims.nyu.edu/drecco (note that you have to sign in as guest).
Project 2: design and demonstrate an experiment to test problem-solving techniques and write a description of the goals, techniques, and conclusions (due on week 9). Draft to the writing tutors a few days later and paper due on week 11.

Project 3: compete in the design of methods for a competitive auction (due on week 13). Presentation but no writeup.

Course texts:

1. *Thinking, Fast and Slow*  
   by Daniel Kahneman  
   Farrar, Straus and Giroux; Reprint edition (April 2, 2013)  
   Language: English  
   ISBN-10: 0374533555

2. *Puzzles for Programmers and Pros*  
   Dennis Shasha  
   Publisher: Wrox; 1 edition (May 7, 2007)  
   Language: English  
   ISBN-10: 0470121688  

3. *Natural Computing*  
   Dennis Shasha and Cathy Lazere  
   Paperback: 288 pages  
   Publisher: W. W. Norton & Company (May 17, 2010)  
   Language: English  
   ISBN-10: 0393336832  

4. *Statistics is Easy*, second edition  
   Dennis Shasha and Manda Wilson  
   Publisher: Morgan & Claypool [can be obtained online]  
   Language: English
Course topics and Contents:

Section 1: Thinking quantitatively -- estimation in the natural and human-constructed world (e.g. how many MacDonalds in country X). Heuristic inference of causes in fast and slow styles of human thought. Thinking heuristically -- use of puzzles to approach difficult-to-solve and possibly adversarial problems systematically even under incomplete information. Start learning python through graduated examples.


Project 1 due week 4: Be able to be the expert on some puzzle game and see if someone else can beat you at it. Four page writeup on your strategy. Please submit your draft for the writeup two days after the competition to the writing tutors with final writeup due at week 6.

Week 1 (September 10, 2018): Motivation: when do we need heuristics? For unknowable information, incomplete information, situations where improvisation is inevitable. Estimation and adaptation examples. Students group themselves into pairs.
Introduction to puzzle games on drecco site. Discussion of recognition heuristic. Groups decide which puzzles to be expert at. Install python, introduction to the shell, types and hello world.

Week 3 (September 24, 2018) Part II of Thinking book. Notions of probability: Monte Hall Puzzle, Lucky roulette, Students state which game they expect to master. Python arithmetic and conditionals and loops.

Week 4 (October 1, 2018): Appendix of Thinking Book. First contest. Strategic thinking puzzles: social games, optimizing the worst case, check amounts. Squash club membership. Coach’s dilemma. Python functions along with recursion. Ten questions problem. Python file treatment and parsing. Submit 4 page writeup of your strategy for project 1 to the writing tutors (each of you is responsible for two pages) by October 4. Final writeup due to me on October 15.

Section 2: Approaches to the design of experiments. How does one construct a model of some target question well enough so that carrying out the experiment is fairly simple (e.g. that priming exists)? In parallel, we will teach more elements of the Python programming language including elements of interprocess communication. You will also design your experiment. You will see which statistically valid conclusions you can draw and provide a eight page writeup. In addition you will as groups make a presentation about a chapter in the Natural Computing book. The presentation should be accompanied by a two page writeup jointly authored.

Primary readings: 1. Natural Computing 2. Statistics is Easy

Project 2 to be presented on week 9: Students will construct their own experiment and demonstrate in class.

Week 5 (October 15, 2018): Basic notions of statistics using a resampling approach. Appendix of Thinking Book (if not done). Student presentation of one chapter of Natural Computing. Merge evens only. Chapters 1 and 2 of Statistics is Easy Medical Test problem

Week 6 (October 22, 2018): Student presentations of two chapters in Natural Computing. Students decide on their own experiment and discuss with me. Python interprocess communication.
Week 7 (October 29, 2018): Presentation of Milgram experiments. Computational game-playing techniques. Python interprocess communication.

Week 8 (November 5, 2018): Student presentations from two chapters of Natural Computing. Python interactive website

Week 9 (November 12, 2018) Student presentations of their own experiment with videos in class. Game-playing techniques. Python interactive wordsnake game given common list of words. Presentation of work of pioneers of computer science. A draft of student report on experiment (objectives, design, first videos and discussion of statistical approach that will be used and two sets of conclusions – one if the null hypothesis is reject and one if it isn’t) to the writing tutors by November 15, 2018 with a final writeup to me on November 27.

Section 3: Approaches to the design of engineered devices that must face unpredictable hazards. Biological notions of feedback and evolution can contribute to a new form of adaptive and robust design. The discussion will center on non-examples like the Bhopal chemical plant as well as examples like marketplaces like the date and nut center near campus. The final project is an auction game in which items of different types will appear in an unknown order and your job is to obtain three of the same type. We will conduct several auctions of this type. You will describe your strategy in a presentation, but without a writeup.

Primary reading: Natural Computing

Project 3 due on week 13: Student teams will build a program to “win” a series of auctions by being the first team to acquire three items of the same type.

Week 10 (November 19, 2018): Student presentations of two chapters of Natural Computing. Python work on final project, basic algorithm and plumbing and random algorithm.

Week 12 (December 3, 2018): Student presentations of two chapters of Natural Computing. Student presentations of whichever other chapter you like. Python final project preparation.

Week 13 (December 10, 2018): Project 3: Auction Game. Students compete and then present their strategies using presentation software, but no formal writeup and no need to go to the writing tutors.

Week 14 (December 11, 2018): Wrap-up of any unfinished business.

Relationship of this course to others: useful to students in the social, natural, computational or engineering sciences. Not specifically redundant to any other course.

Undergraduate Writing Tutors Program:

In this class, we are fortunate to have help from the Undergraduate Writing Tutors Program. Writing tutors are curious, well-trained peers who provide feedback to students on drafts of writing assignments. Their role is to encourage and challenge students to strengthen their writing and clarify their ideas. Writing tutors are trained to support the aims of the class, learning about the expectations for writing in the class and listening and responding carefully to individual student writers. While writing tutors are not Teaching Assistants and will not assess papers, they will focus writing conferences on questions that generate clearer writing and stronger thinking about the content. Writing tutors will also look for patterns of grammatical error in student papers, explaining how students can learn to correct these errors. The writing tutors’ main goals are to help students develop their writing and thinking in response to particular assignments and to become better writers over the long term.

Writing tutors take a semester-long practicum to learn to think more deeply about writing and to develop practices for working with peers on writing during individualized conferences. Tutors audit several classes or recitations and read some course materials in the classes where they tutor. Their primary aim is, however, to work with students through a practice-based approach to writing and revising. That is, they will ask questions and work to prompt students to reread, rethink, revise, and craft new writing during conferences.

Students are required to participate in the program for each designated paper assignment, submitting a draft of their paper on time for written feedback and attending a scheduled, 30-
minute long, one-on-one conference. Writing tutors should receive complete drafts from students, not outlines or rough notes. Late submission of drafts to tutors and missed conferences are reported to the Professor, who may reduce a student’s final grade as a consequence.