ISE 662 – Advanced Decision Theory
Units: 3
Term: Spring 2021

Location: VKC 201

Instructor: Ali E. Abbas
Office: OHE 310R
Office Hours: TBD
Contact Info: aliabbas@usc.edu

Teaching Assistant:
Office: TBD
Office Hours: TBD
Contact Info: TBD
Course Description
Rational decision making; value and utility functions; distribution theory; invariance relations; copulas; value of information and control; multiattribute utility; decision and game theory; behavioral research.

Learning Objectives
- Understanding the foundations of decision theory and its evolution to date
- Understanding of the rationality principles of decision making
- Ability to develop prescriptive models of choices under uncertainty
- Ability to construct complex probability distributions and Bayesian revision algorithms, including conjugate distributions
- Ability to test decomposition forms of multiattribute utility models and to construct multiattribute value and utility models
- Understanding of the interplay between decision theory and game theory
- Understanding the relation between descriptive and normative modeling
- Awareness of the possible impact of biases and heuristics for decision analysis
- Prepare students for research in decision theory at the Ph.D. thesis level

Prerequisite(s): The requirements for admission to the ISE Ph.D. program

Recommended preparation: Multivariate calculus; mathematical statistics; some knowledge of real analysis, measurement theory and functional equations preferred

Required Readings and Supplementary Materials

Text(s):

Supplementary Materials
Due to the research nature of the course, a selection of classic research and journal papers will also be distributed. A comprehensive reading list is included below for instructors to choose.

Description and Assessment of Assignments
The class will be primarily in lecture format. Every other class will have an individual homework assignment. The assignments involve computations and derivations. For example an assignment may calculate the value-of-information for a complex decision or derive a multiattribute utility function that corresponds to certain axiomatic criteria. In addition, students will choose an advanced research topic and write a research paper in the form of a literature review or a research project proposal.

Grades
Grades will be assigned on the basis of class participation (10%), assignments (35%), project presentations (20%), and the final research proposal (35%).

Tentative Course Outline:
<table>
<thead>
<tr>
<th>Class #</th>
<th>Topics</th>
<th>Readings</th>
<th>Assignments Due</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>Class overview; history of decision theory from Bayes and Bernoulli to today; relationship to risk analysis and game theory; descriptive vs. prescriptive decision theory</td>
<td>RH2007, HR2007, vW&amp;E1986 (Ch. 14), S&amp;vW2004</td>
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<td>2</td>
<td>Rationality assumptions and axiomatic base of decision theory; decisions under uncertainty; decisions with multiple objectives; simplistic and flawed methods</td>
<td>AA2018 (Ch. 1-3), RH&amp;AA2015 (Chapters TBD), vN&amp;M1947 (Appendix), TS2012</td>
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<td>3</td>
<td>Uncertainty and risk analysis in decision theory: decision trees; expected value; prior and preposterior analysis, conjugate distributions, modeling joint distributions with copulas</td>
<td>C&amp;R2013 (Chapters TBD), W&amp;D2012, C&amp;R1999, SH2007</td>
<td>Brief essay: Do you agree or disagree with the axioms of rationality and why?</td>
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<td>4</td>
<td>Value of information, value of control, value of experimentation, Bayesian networks; discretization methods, analytical vs. simulation approaches</td>
<td>RH&amp;AA2015 (Chapters TBD), C&amp;R2013 (Chapters TBD)</td>
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<td>5</td>
<td>Single attribute utility theory 1; measurement theoretic foundation of utility and value functions; relationship between utility and value functions</td>
<td>KLS&amp;T1971 (Chapters 1 and 4), vW&amp;E1986 (Ch. 7), AA2018 (Ch. 4-6, 10)</td>
<td>Analysis of a complex decision problem</td>
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<td>6</td>
<td>Single attribute utility theory 2: Invariance conditions; functional equations; characterizing risk attitudes; implications of risk aversion</td>
<td>AA2018 (Ch. 13-17), D&amp;S1979</td>
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<td>7</td>
<td>Descriptive theories of decision making under uncertainty: Prospect theory; rank and sign dependent utility theories, random utility models</td>
<td>K&amp;T1979, TS&amp;K1982 (Chapters TBD), RDL&amp;vW1998, KET2004</td>
<td>Assessment of a utility function with two different methods</td>
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<td>8</td>
<td>Discussion of research questions in decision theory: Presentations of research questions</td>
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<td>2 research questions to be addressed in a research paper</td>
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<td>9</td>
<td>Multiattribute utility theory 1: ordinal vs. cardinal value functions; conjoint measurement and difference measurement; model forms and functional equations</td>
<td>KLS&amp;T (Ch. 6), vW&amp;E, (Ch. 7), AA (Ch. 11-12), K&amp;vW, 2007</td>
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<td>10</td>
<td>Multiattribute utility theory 2: Single and joint utility independence, additive and multiplicative models; more complex models based on functional equations</td>
<td>K&amp;R1976 (Chapters TBD), AA2018 (Ch. 21-30), KLS&amp;T1971 (Ch. 7)</td>
<td>Assessment of a multiattribute utility function</td>
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Spring Break
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<tr>
<th>Class #</th>
<th>Topics</th>
<th>Readings</th>
<th>Assignments Due</th>
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</thead>
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<tr>
<td>11</td>
<td>Linking decision models to other models; multi-attribute models and optimization; portfolio analysis with resource constraints; simulation and decision models</td>
<td>vW&amp;S1998, DNK2004, AA&amp;DMS2016, S&amp;K2005</td>
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<td>12</td>
<td>Game theory 1: Distinctions and similarities between game theory and decision theory: overview of types of games; cooperative, non-cooperative, and adversarial games</td>
<td>PKD1999 (Chapters TBD), M&amp;P2011</td>
<td>Progress report on research papers, annotated literature review</td>
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<td>14</td>
<td>Behavioral decision research: The prescriptive-descriptive distinction; heuristics and biases in probability and utility judgments that are relevant to decision analysis</td>
<td>T&amp;K1974, K&amp;T1979, TS&amp;K1982 (Chapters TBD), M&amp;vW2015</td>
<td>Solution to a Stackelberg security problem</td>
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<td>15</td>
<td>Presentations of research papers</td>
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<td>Powerpoint version of research papers</td>
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<tr>
<td>Final</td>
<td>Final research papers due</td>
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Selected Supplementary Readings for Advanced Decision Theory
(Instructors will select supplementary readings from this list)

History and Overview of the Class (Session 1)


Classics

Decisions under uncertainty and with multiple objectives (Session 2)


Uncertainty and Risk Analysis in Decision Theory (Session 3)


**Classics**


**Value of Information and Control (Session 4)**


**Single attribute utility (Session 5 and 6)**


**Descriptive Theories of Decision Making Under Uncertainty (Session 7)**


**Multiattribute Utility Theory (Sessions 8 and 9)**


**Linking Decision Models with other Models for Decision Making (Session 11)**


**Game Theory (Sessions 12 and 13)**


**Classics**


**Behavioral decision research (Sessions 14)**


Statement on Academic Conduct and Support Systems

Academic Conduct:
Plagiarism – presenting someone else’s ideas as your own, either verbatim or recast in your own words – is a serious academic offense with serious consequences. Please familiarize yourself with the discussion of plagiarism in Scampus in Part B, Section 11, “Behavior Violating University Standards” policy.usc.edu/scampus-part-b. Other forms of academic dishonesty are equally unacceptable. See additional information in Scampus and university policies on scientific misconduct, http://policy.usc.edu/scientific-misconduct.

Support Systems:
Student Counseling Services (SCS) – (213) 740-7711 – 24/7 on call
Free and confidential mental health treatment for students, including short-term psychotherapy, group counseling, stress fitness workshops, and crisis intervention. engemannshc.usc.edu/counseling

National Suicide Prevention Lifeline – 1 (800) 273-8255
Provides free and confidential emotional support to people in suicidal crisis or emotional distress 24 hours a day, 7 days a week. www.suicidepreventionlifeline.org

Relationship and Sexual Violence Prevention Services (RSVP) – (213) 740-4900 – 24/7 on call
Free and confidential therapy services, workshops, and training for situations related to gender-based harm. engemannshc.usc.edu/rsvp

Sexual Assault Resource Center
For more information about how to get help or help a survivor, rights, reporting options, and additional resources, visit the website: sarc.usc.edu

Office of Equity and Diversity (OED)/Title IX Compliance – (213) 740-5086
Works with faculty, staff, visitors, applicants, and students around issues of protected class. equity.usc.edu

Bias Assessment Response and Support
Incidents of bias, hate crimes and microaggressions need to be reported allowing for appropriate investigation and response. studentaffairs.usc.edu/bias-assessment-response-support

The Office of Disability Services and Programs
Provides certification for students with disabilities and helps arrange relevant accommodations. dsp.usc.edu

Student Support and Advocacy – (213) 821-4710
Assists students and families in resolving complex issues adversely affecting their success as a student EX: personal, financial, and academic. studentaffairs.usc.edu/ssa

Diversity at USC
Information on events, programs and training, the Diversity Task Force (including representatives for each school), chronology, participation, and various resources for students. diversity.usc.edu

USC Emergency Information
Provides safety and other updates, including ways in which instruction will be continued if an officially declared emergency makes travel to campus infeasible. emergency.usc.edu

USC Department of Public Safety – UPC: (213) 740-4321 – HSC: (323) 442-1000 – 24-hour emergency or to report a crime.
Provides overall safety to USC community. dps.usc.edu