Course Syllabus

Program and Course Code	Media Arts and Sciences MAS.S63
Course Title	**Cooperation Machines**
Credit Hours	12
Instructor	Iyad Rahwan
Course Description	Through various cultural and institutional innovations, humans became the most successful cooperative species on earth. This course explores models and mechanisms of cooperation from a variety of disciplines: from behavioral economics and political science, to mathematical biology and artificial intelligence. Emphasis will be on: (1) the use of mathematical and computational techniques, from evolutionary game theory, to model cooperation mechanisms in nature and society; (2) the use of experiments and data analytics to understand cooperation phenomena using real behavioral data. We will then link the phenomenon of cooperation to design features of social media and artificial intelligence systems. First, students obtain proficiency in the mathematical and computational modeling of cooperation and supporting mechanisms (around 25% of the course). Students will then read recent papers published in this area and present them in class, with topics rotating in each offering. Students will also be required to complete a major project, which involves substantial use of mathematical modeling combined with computational simulation or data analysis (e.g. from simulation or lab experiments), and writing up the results in a short article.
Enrollment	Enrollment in this course will be limited to **15 students**, to facilitate seminar-style discussion of papers. Preference will be given to students with a strong technical background.
Pre-requisites	Students are assumed to have a strong foundation in introductory statistics and probability, computer programming, and mathematical modeling. This will be required to read the papers at a sufficiently technical level.
Co-requisites	None
Course Objectives (Learning Outcomes of the Course)	1. Use mathematical techniques to model cooperative behavior. 2. Conduct in-depth discussion of the latest literature on cooperation from various fields. 3. Identify the fundamental mechanisms behind cooperative phenomena, along with their underlying assumptions. 4. Implement and apply simulation and/or data analysis methods and algorithms to investigate a particular cooperation phenomenon. 5. Communicate scientific and technical issues.
Classes	Class meets once per week, for 3 hours (with a break in the middle)
Laboratory	In the first few weeks, some sessions will be hands-on, giving students hands-on practice in simulation and data analysis tools.
Teaching and learning	This is a high-involvement seminar-style course, with most time dedicated to reading and discussing research papers. However, the first few classes will

methodologies	include lectures on some important background material on mathematics and some analysis tools. Subsequently, students are expected to participate in class discussion, present papers, and write a final course paper based on a substantial project. Students must read the papers in advance, submit short summaries and questions before class, participate in class discussion, and present and lead discussion on some papers.

Course Grading In addition to attendance and participation the course will be graded as follows:	
Homework 1	10% Covers data analysis exercise Out: week 3, Due: week 6
Homework 2	10% Covers a simulation exercise Out: week 6, Due: week 8
Class participation	10% for answering pre-class questions
Final Exam	30% Covers lectures + all papers discussed (open book, open notes, 24 hours)
Project + Report	40% Projects are individual-based, and must include substantial independent work and literature review.

Course Materials	
Textbooks	There is no prescribed textbook for the course. However, here are some good overview books: • Tomasello, M. (2009). *Why we cooperate*. MIT press. • Nowak, M., & Highfield, R. (2011). *SuperCooperators: Altruism, evolution, and why we need each other to succeed*. Simon & Schuster. • Skyrms, B. (2014). *Evolution of the social contract*. Cambridge University Press. • Axelrod, R. M. (2006). The evolution of cooperation. Basic books. • Turchin, P. (2015). Ultrasociety: How 10,000 Years of War Made Humans the Greatest Cooperators on Earth.
Sample Reading Collection	Course readings will be composed of research articles from leading journals, conferences and edited volumes. The list below provides a sample, and actual reading list will likely differ. Overviews: • Rand, D. G., & Nowak, M. A. (2013). Human cooperation. *Trends in cognitive sciences*, *17*(8), 413-425. • Raihani, N. J., Thornton, A., & Bshary, R. (2012). Punishment and cooperation in nature. *Trends in Ecology & Evolution*, *27*(5), 288-295. Fundamental mechanisms: • Nowak, M. A. (2006). Five rules for the evolution of cooperation. *Science*, *314*(5805), 1560-1563. • Norenzayan, Ara, and Azim F. Shariff. "The origin and evolution of religious prosociality." *science* 322.5898 (2008): 58-62.

- Mathew, S., & Boyd, R. (2011). Punishment sustains large-scale cooperation in prestate warfare. *Proceedings of the National Academy of Sciences*, *108*(28), 11375-11380.
- Fudenberg, D., Rand, D. G., & Dreber, A. (2010). Slow to anger and fast to forgive: cooperation in an uncertain world. *American Economic Review*

Institutions:

- Gürerk, Ö., Irlenbusch, B., & Rockenbach, B. (2006). The competitive advantage of sanctioning institutions. *Science*, *312*(5770), 108-111.
- Traulsen, A., Röhl, T., & Milinski, M. (2012). An economic experiment reveals that humans prefer pool punishment to maintain the commons. *Proceedings of the Royal Society of London B: Biological Sciences*, rspb20120937.
- Sigmund, K., De Silva, H., Traulsen, A., & Hauert, C. (2010). Social learning promotes institutions for governing the commons. *Nature*, *466*(7308), 861-863.
- Roithmayr, D., Isakov, A., & Rand, D. (2015). Should Law Keep Pace with Society? Relative Update Rates Determine the Co-Evolution of Institutional Punishment and Citizen Contributions to Public Goods. *Games*, 6(2), 124-149.
- Abdallah, S., Sayed, R., Rahwan, I., LeVeck, B. L., Cebrian, M., Rutherford, A., & Fowler, J. H. (2014). Corruption drives the emergence of civil society. *Journal of The Royal Society Interface*, *11*(93), 20131044.
- Skyrms, B. (2001). The stag hunt. In *Proceedings and Addresses of the American Philosophical Association* (Vol. 75, No. 2, pp. 31-41). American Philosophical Association.

Leaders:

- Baldassarri, D., & Grossman, G. (2011). Centralized sanctioning and legitimate authority promote cooperation in humans. *Proceedings of the National Academy of Sciences*, *108*(27), 11023-11027.
- Henrich, J., Chudek, M., & Boyd, R. (2015). The Big Man Mechanism: how prestige fosters cooperation and creates prosocial leaders. *Phil. Trans. R. Soc. B*, *370*(1683), 20150013.
- Hooper, P. L., Kaplan, H. S., & Boone, J. L. (2010). A theory of leadership in human cooperative groups. *Journal of Theoretical Biology*, *265*(4), 633-646.

Reasoning and cooperation:

- Rand, D. G. (2016). Cooperation, fast and slow: Meta-analytic evidence for a theory of social heuristics and self-interested deliberation. *Psychological Science*, Forthcoming.
- Rand, D. G., Greene, J. D., & Nowak, M. A. (2012). Spontaneous giving and calculated greed. *Nature*, *489*(7416), 427-430.
- D. G. Rand, A. Peysakhovich, G. T. Kraft-Todd, G. E. Newman, O. Wurzbacher, M. A. Nowak, and J. D. Greene. Social heuristics shape intuitive cooperation. *Nature Communications*, 5, 2014.
- Evans, A. M., Dillon, K. D., & Rand, D. G. (2015). Fast but not intuitive, slow but not reflective: Decision conflict drives reaction times in

social dilemmas. *Journal of Experimental Psychology: General*, 144(5), 951.

Cultural differences:

- Henrich, J., et al (2006). Costly punishment across human societies. *Science*,*312*(5781), 1767-1770.
- Herrmann, B., Thöni, C., & Gächter, S. (2008). Antisocial punishment across societies. *Science*, *319*(5868), 1362-1367.
- Henrich, J., Heine, S. J., & Norenzayan, A. (2010). The weirdest people in the world?. *Behavioral and brain sciences*, *33*(2-3), 61-83.

Signaling:

- Hoffman, M., Yoeli, E., & Nowak, M. A. (2015). Cooperate without looking: Why we care what people think and not just what they do. Proceedings of the National Academy of Sciences, 112(6), 1727-1732.
- Jordan, J. J., Hoffman, M., Nowak, M. A., & Rand, D. G. (2016). Uncalculating Cooperation as a Signal of Trustworthiness. Available at SSRN.

Policies for promoting cooperation:

- Kraft-Todd, G., Yoeli, E., Bhanot, S., & Rand, D. (2015). Promoting cooperation in the field. *Current Opinion in Behavioral Sciences*, *3*, 96-101.
- Yoeli, E., Hoffman, M., Rand, D. G., & Nowak, M. A. (2013). Powering up with indirect reciprocity in a large-scale field experiment. *Proceedings of the National Academy of Sciences*, *110*(2), 10424-10429.
- Mani, A., Rahwan, I., & Pentland, A. (2013). Inducing peer pressure to promote cooperation. *Scientific reports*, *3*.

Cooperation through machines:

- Bonnefon, J. F., Shariff, A., & Rahwan, I. (2016). The social dilemma of autonomous vehicles. Science, 352(6293), 1573-1576.
- Greene, J. D. (2016). Our driverless dilemma. *Science*, 352(6293)
- Tennenholtz, M. (2004). Program equilibrium. Games and Economic Behavior, 49(2), 363-373.
- Monderer, D., & Tennenholtz, M. (2009). Strong mediated equilibrium. Artificial Intelligence, 173(1), 180-195.

Cooperation Algorithms in AI:

- Littman, M. L. (1994). Markov games as a framework for multi-agent reinforcement learning. In *Proceedings of the eleventh international conference on machine learning* (Vol. 157, pp. 157-163).
- Crandall, J. W. (2015, June). Robust learning for repeated stochastic games via meta-gaming. In *Proceedings of the 24th International Conference on Artificial Intelligence* (pp. 3416-3422). AAAI Press.
- Krieger, M. J., Billeter, J. B., & Keller, L. (2000). Ant-like task allocation and recruitment in cooperative robots. Nature, 406(6799), 992-995.
- Werfel, J., Petersen, K., & Nagpal, R. (2014). Designing collective behavior in a termite-inspired robot construction

	team. *Science*, *343*(6172), 754-758. Human-Machine Cooperation: • Arlette van Wissen, Ya'akov Gal, Bart Kamphorst, Virginia Dignum. Human-Agent Team Formation in Dynamic Environments. Computers in Human Behavior 28:23-33, 2012 • Kamar, E., Gal, Y. K., & Grosz, B. J. (2013). Modeling information exchange opportunities for effective human–computer teamwork. *Artificial Intelligence*,*195*, 528-550. • F. Ishowo-Oloko, J. Crandall, M. Cebrian, S. Abdallah, I. Rahwan. Learning in Repeated Games: Human Versus Machine. arXiv:1404.4985 [cs.CY] Networks and Cooperation: • Rand, D. G., Arbesman, S., & Christakis, N. A. (2011). Dynamic social networks promote cooperation in experiments with humans. Proceedings of the National Academy of Sciences, 108(48) • Wang, J., Suri, S., & Watts, D. J. (2012). Cooperation and assortativity with dynamic partner updating. *Proceedings of the National Academy of Sciences*,*109*(36), 14363-14368. • Rand, D. G., Nowak, M. A., Fowler, J. H., & Christakis, N. A. (2014). Static network structure can stabilize human cooperation. *Proceedings of the National Academy of Sciences*, *111*(48), 17093-17098. Collective intelligence: • DeDeo, S. (2014). Group Minds and the Case of Wikipedia. *arXiv preprint arXiv:1407.2210*. • Woolley, A. W., Chabris, C. F., Pentland, A., Hashmi, N., & Malone, T. W. (2010). Evidence for a collective intelligence factor in the performance of human groups. science, 330(6004), 686-688. • Mason, W., & Watts, D. J. (2012). Collaborative learning in networks. Proceedings of the National Academy of Sciences, 109(3), 764-769. • Krafft, P. M., Zheng, J., Pan, W., Della Penna, N., Altshuler, Y., Shmueli, E., ... & Pentland, A. (2016). Human collective intelligence as distributed Bayesian inference. arXiv preprint arXiv:1608.01987. Consensus: • Couzin, Iain D., et al. "Uninformed individuals promote democratic consensus in animal groups." science 334.6062 (2011): 1578-1580. • Gallup, A. C., Hale, J. J., Sumpter, D. J., Garnier, S., Kacelnik, A., Krebs, J. R., & Couzin, I. D. (2012). Visual attention and the acquisition of information in human crowds. Proceedings of the National Academy of Sciences, 109(19), 7245-7250. • Judd, S., Kearns, M., & Vorobeychik, Y. (2010). Behavioral dynamics and influence in networked coloring and consensus. Proceedings of the National Academy of Sciences, 107(34), 14978-14982. • Kearns, M., Judd, S., Tan, J., & Wortman, J. (2009). Behavioral experiments on biased voting in networks. Proceedings of the National Academy of Sciences, 106(5), 1347-1352.