Complexity: Theory and Computational Models - Course Outline

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Please note that this is a tentative schedule that might still be subject to change. Nothing of the reading mentioned in the outline is required to understand the lectures, but you should watch the Python introductory video in case you have problems in solving the preparatory exercises.

Moreover, in case you do not have any prior knowledge about the subject, taking a look into the readings beforehand might help you to understand basic ideas more quickly. The main purpose of the readings, however, is to give those of you particularly interested in the topics the change to go deeper into the material. There is also a more extensive and commented list of further readings on the course homepage, which will include advanced material that is less useful for the preparation, but rather for follow-up study.

The labs and lectures on Wednesday and Thursday overlap with the interdisciplinary session. We tried to keep the course as modular as possible so everyone who wishes to attend the interdisciplinary sessions will be able to do so. All those who continue to join us will learn about more advanced techniques to study complex adaptive systems.

Nb.	Date	Type	Content	Reading
1	Sat, 9:00-10:30	Lecture	Introduction of the course outline, getting-to-know each other, and introduction to 'systemism' as the meta-theoretical framework.	Gräbner and Kapeller (2017), Gräbner (2017)
2	Sat, 11:00-12:30	Lecture	The relation between ontology, epistemology, and methodology, and its implications for complexity economics.	Rosser Jr (2004), Arthur (2010)
3	Sat, 14:30-16:00	Lab 1	Lab 1: objects, classes, and namespaces	Script 2 of Claudius' Python lectures (partly)
4	Sun, 9:00-10:30	Lecture	Power laws	Newman (2005), Farmer and Geanakoplos (2008)
5	Sun, 11:00-12:30	Lecture	The structure of complex systems: introduction to network theory	EK ch 1 and 2, vS: ch 2 and 6, Newman (2003) (selective), Network script
6	Sun, 14:30-16:00	Lab 2	Networks in Python	Networks script of Claudius Python lectures, The NetworkX documentation
7	Mon, 9:00-10:30	Lecture	Dynamical system theory, Evol Game Theory and Replicator Dynamics	MCE, chaps. 2, 8 & 11, Intro of Albin and Foley (1998)
8	Mon, 11:00-12:30	Lab 3	Simulating functions, simulating dynamic models	NA
9	Mon, 14:30-16:00	Mix	Agent-based models and OOP	MCE, Chap 9; Tesfatsion (2017)
10	Tue, 9:00-10:30	Lab 4	Agent-based model in Python I	Script 2 of Claudius' Python lectures (partly)
11	Tue, 11:00-12:30	Lab 5	Agent-based model in Python I I	Script 2 of Claudius' Python lectures (partly)
12	Wed, 9:00-10:30	Lecture	Complexity, self-organization and heavy-tailed distributions.	Frank (2009)
13	Wed, 11:00-12:30	Lab 6	Modeling complex adaptive systems I	NA
14	Wed, 14:30-16:00	Lab 7	Modeling complex adaptive systems I I	NA
15	Thu, 9:00-10:30	Group work	Wrapping up and future directions to explore; preparation of presentations	NA
16	Thu, 11:00-12:30	Group work	Preparation of presentations	NA

MCE: Elsner, W., Heinrich, T. & Schwardt, H., 2015. *The Microeconomics of Complex Economies: Evolutionary, Institutional, Neoclassical, and Complexity Perspectives*, Amsterdam et al.: Elsevier/Academic Press.

EK: Easley, D. & Kleinberg, J., 2010. *Networks, Crowds, and Markets*, Cambridge, UK et al.: Cambridge University Press. A free pre-print of the book is available on the web.

vS: van Steen, M., 2010. *Graph Theory and Complex Networks*, Amsterdam: Maarten van Steen. Available online.

The lab sessions will cover topics in the programming language Python and its use for research in complexity economics. While we try to make the lectures as interactive as possible, the labs really focus on group work and collective programming.

Readings for Python

As for most programming languages, textbooks for Python are rare. In fact, we found that most of the online tutorials do a better job, because they are more frequently updated than books. Also, learning a programming language is much learning-by-doing: you try to solve a problem, you look up the pieces you do not know about in an online tutorial or on Stack Overflow (which is *the* place to find answers).

There are, nevertheless, some resources that you might want to have a look at, particularly if you have not prior programming experience:

First, Claudius created a video-based introduction to agent-based modeling in Python. It is available here. As for today the videos are mainly available in German only, yet the scrips are in English. We will somehow follow their content in the beginning, but cover a bit less concepts. Thus, the scripts contain a bit more information than will be covered in the lectures but nevertheless provide for a good orientation.

Second, John Stachurski offers a nice intro to Python in his Lectures in Quantitative Economics.[1]

Third, the official documentation is really good. You might check out the tutorial, or the FAQ on the main page.

Finally, Jeffrey Elkner, Allen B. Downey, and Chris Meyers wrote the book How to Think Like a Computer Scientist. It is free and the introduction might be interesting for people without any background in programming. But keep in mind the book is written for Python 2.X and we will be using Python 3.X in the course!

For those of you who have experience in other programming languages, there are specialized tutorials on the web, such as 'Python for C programmers', which might be worth a look before the course. Make sure to check out the page on moving to Python from other languages page on the official documentary.

References

P. S. Albin and D. K. Foley. *Barriers and bounds to rationality.* Princeton University Press, Princeton, NJ, 1998.

W. B. Arthur. Complexity, the Santa Fe Approach, and Non-Equilibrium Economics. *History of Economic Ideas*, 18(2):149–166, 2010.

D. Easley and J. Kleinberg. *Networks, Crowds, and Markets.* Cambridge University Press, Cambridge, UK et al., 2010.

W. Elsner, T. Heinrich, and H. Schwardt. *The Microeconomics of Complex Economies: Evolutionary, Institutional, Neoclassical, and Complexity Perspectives.* Elsevier/Academic Press, Amsterdam et al., 2015.

[1] The whole course is very mainstream and focused on rational expectations economics. While it is not very critical, it is a good course if you want to learn the techniques as such.

J. D. Farmer and J. Geanakoplos. Power laws in economics and elsewhere, 2008. Working Paper, Santa Fe Institute. Available online: http://tuvalu.santafe.edu/ jdf/papers/powerlaw3.pdf.

S. A. Frank. The common patterns of nature. *Journal of Evolutionary Biology*, 22(8):1563–1585, 2009. doi: 10.1111/j.1420-9101.2009.01775.x.

C. Gräbner. The Complementary Relationship Between Institutional and Complexity Economics: The Example of Deep Mechanismic Explanations. *Journal of Economic Issues*, 51(2):392–400, May 2017.

C. Gräbner and J. Kapeller. The micro-macro link in heterodox economics. In T.-H. Jo, L. Chester, and C. DIppoliti, editors, *The Routledge Handbook of Heterodox Economics*, pages 145–159. Routledge, London and New York, 2017.

M. E. J. Newman. The Structure and Function of Complex Networks. *SIAM Review*, 45(2):167–256, Jan. 2003.

M. E. J. Newman. Power laws, Pareto distributions and Zipf's law. *Contemporary Physics*, 46(5):323–351, 2005.

J. B. Rosser Jr. Epistemological Implications of Economic Complexity. *Annals of the Japan Association for Philosophy of Science*, 13(1):45–57, 2004.

L. Tesfatsion. Modeling economic systems as locally-constructive sequential games. *Journal of Economic Methodology*, 24(4):384–409, 2017.

M. van Steen. *Graph Theory and Complex Networks*. Maarten van Steen, Amsterdam, 2010.