USE – Physics of Social Systems

Physics of Social Systems	
Offered by	Department of Applied Physics and Science education
Language	English
Primarily interesting for	All students from all departments. You will be working in small multidisciplinary student teams therefore students from all departments are very welcome!
Prerequisites	Required courses: - Recommended courses: -
Contact person	Prof. dr. F. Toschi (f.toschi@tue.nl)

Content and composition

Traditionally focusing on the dynamics of matter and energy and their behavior through space-time, in recent years physics intersected many other disciplines such as chemistry, biology and economics making its boundaries much less defined. This USE learning line focuses on the use of quantitative scientific tools to the study of social systems. Students from all departments are welcome to join!

Already two centuries ago it was suggested that social systems could possibly be quantified in terms of laws similar to the ones of physics. Not until recently, however, the quality and quantity of data about social systems could allow considerable progress. Today, thanks to the recent enormous advances in technology and communications, we have potential access to enormous databases that quantify -with very high accuracy- the way humans interact in crowds both virtually (e.g. on social media, in investment strategies, in spending patterns, reading material, etc.) as well as in real-life (e.g. tracking of individuals' location via GPS or via electric travel documents, etc.).

This unprecedented availability of data has already led to a vast number of applications while many more are still beyond our imagination. For such applications to be successful knowledge of physics alone no longer suffices. Instead, interdisciplinary approaches combining physics and the social sciences (e.g., psychology, sociology, and economics) are needed. For one, understanding of human perception, experience, motivation and decision making, as provided by psychological theory and methodology, will improve and speed up interpretation and modeling efforts. At the same time, one needs to be knowledgeable of the ethical and legal restrictions when establishing and processing large datasets; especially now that these are increasingly entering the personal lives of citizens. Similarly, ethical issues associated with crowd monitoring, and with the possibility to influence individuals' behavior need to be carefully considered and addressed before real-world implementations can be successful and admissible.

In this learning line students will be challenged on how to bring together mathematical, physics (model driven) and machine learning (data driven) modeling approaches with ethics and psychology on a concrete and challenging real- case problem.
• How to quantitatively analyze and model social dynamics of human crowds?
• Which psychological aspects play a role in spatial behavior in human crowds and how to incorporate them into quantitative models?
• How to record and process data of human behavior according to the standards of research ethics?
• How to deal with the ethical implications of intensively monitoring and possibly influencing individuals in human crowds?

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Course code	Course name	Level classification	2023-2024	2024-2025 (subject to change)*
3QEUS0	Sociophysics 1: Analysis of human crowd dynamics	1.	Regular education	Re-exam
3QSUS0	Sociophysics 2: Modeling human crowd dynamics	2.	Regular education	Re-exam
3QAUS0	Sociophysics 3: Nudging human crowd dynamics	3.	Regular education	adapted project, last opportunity

Course description

3QEUS0, Sociophysics 1: Analysis of human crowd dynamics
In coordination with stakeholder(s) we will provide inspiration for possible projects. An introductory set of lectures will provide the basic tools and hints on the possible direction where to find additional material. These include an introduction to basic mathematics and physics tools, computer science techniques, basic aspects of psychology as the science of human behavior, and ethical implications of data collection and behavioral nudging. Students will be guided towards the definition of the group projects. In this course projects will focus on describing human crowd behavior through the (statistical) analysis of existing data, and by combining physics-based (statistical) tools, computer science machine learning approaches and psychology. Based on these analyses, and as part of the final deliverable, students will develop informed hypotheses regarding the underlying mechanisms of the observed behavior. At the end of the project each student group will produce a report and a presentation to the relevant stakeholders and involved research groups.

3QSUS0, Sociophysics 2: Modeling human crowd dynamics
This course is an extension of course 1 in the direction of modeling. Students will review and improve the analysis tools developed in course 1 and will extend them in the direction of modeling the social system. Students will work under supervision, and will use insights from the psychological literature and from their own in situ observations of human behavior to improve the models. As part of the final deliverable students will make an informed suggestion, based on the developed model, for an intervention strategy that may succeed in influencing crowd behavior in accordance to the problem of the stakeholder. At the end of the project each student group will produce a report and a presentation to the relevant stakeholders and involved research groups.

3QAUS0, Sociophysics 3: Nudging human crowd dynamics
This course is an extension of course 2 in the direction of influencing social systems, and the influencing (or nudging) of the dynamics of single individuals in particular. Using insights from the psychology of behavior change (e.g., how structural interventions work) the models and nudging protocols developed in course 2 will be further validated, extended and used as a basis to quantify the possibility to influence social systems via nudging. Students will design and conduct a simple experiment that takes into account the ethical aspects of nudging behavior and of conducting experiments on human participants. At the end of the project each student group will produce a report and a presentation to the relevant stakeholders and involved research groups.