AnthroPOLIS HUMAN CENTERED MOBILITY | SystemX

CentraleSupélec

北航中法工程师学院 CENTRALE PEKIN

SEMINAR SERIES ANTHROPOLIS CHAIR AND FUTURES CITIES LAB

ACADEMIC YEAR 2021-2022
JUNE 2022

Seminar Series | Academic Year 2021-2022

JOINT SEMINAR SERIES OF THE ANTHROPOLIS CHAIR AND THE FUTURES CITIES LAB

Report | June 2022

After the successful first edition from November 2020 to June 2021, the second joint seminar series of the Anthropolis Chair and the Future Cities Lab followed from September 2021 to June 2022. The series of research seminars aims at exchanging knowledge and ideas on the ongoing projects within the Chair and Lab and its affiliates and collaborators, as well as at communicating the research progress to external stakeholders.

Like last year, the bi-weekly one-hour sessions consisted of short input presentations on chosen topics and interactive discussions in which everyone is invited to actively participate. In total, thirteen speakers from France and China presented their work online.

Partners of the Anthropolis Chair

Partners of the Futures Cities Lab

ANTHROPOLIS CHAIR

Human-Centred Mobility

The Chair is constructing a vision of future mobility integrating the major challenges of urban life, such as reducing carbon emissions and improving the quality of life in cities. Anthropolis develops fundamental methods to design mobility systems and services with a human-centred approach.

Our main research area is the Saclay plateau in the Île-de-France. However, other French and European cities are considered for our investigations. We collaborate with Centrale Casablanca (joint PhD supervision) and Centrale Pékin (Future Cities Lab) to enlarge our vision towards non-European cities. We explore the following three complementary topics: future mobility and urban life, mobility as a service (MaaS), and future infrastructures.

For **urban life and mobility futures**, the Anthropolis Chair is particularly interested in mobility and immobility in tomorrow's society to answer questions on the futures of urban and regional development and management. The creative exploration of possible futures is systematically explored based on individual and collective views compiled through multiple stakeholder workshops.

The implementation of regional **MaaS** systems demands a commitment by political decision-makers and a genuine intention to collaborate by all stakeholders of urban and suburban mobility. The question is how new technologies will influence new forms of MaaS, and what forms of governance and organisational models will emerge? Finally, the impact on regional attractivity and mobility behaviour is modelled and analysed for different MaaS concepts.

For **future infrastructures**, the Chair investigates the interaction between the future evolution of urban infrastructures and mobility, complemented by a socio-technical, human-centred approach. Sensors, charging stations, shared mobility stations, and urban spaces are major areas of investigation. Replicable planning methods for various mobility infrastructures are being developed, taking technological, organisational, and social factors into account.

Finally, the Chair addresses the transversal topic of **sustainability of urban mobility**. This part of the contribution is placed under the umbrella of Sustainable Development Goal 11, Cities and Sustainable Communities. Our ultimate goal is set by the Paris Agreement: Zero carbon emissions by 2050. In our work, we intend to balance and examine the sustainable value creation and negative (environmental and social) impacts generated by mobility solutions.

FUTURE CITIES LAB

E-Mobility & Power Systems of Tomorrow

The Future Cities Lab is a multi-national joint research initiative between **Ecole Centrale Pékin, Beihang University in China, and CentraleSupélec in France**. The Future Cities Lab is co-financed by the Région Île-de-France and the City of Beijing and is co-directed by Prof Hai-Jun Huang and Prof Jakob Puchinger.

The research conducted within the Future Cities Lab addresses the challenges related to planning, operating, and managing increasingly complex future urban systems, particularly the interdependence between critical infrastructure systems, such as the transportation, energy, and healthcare systems.

Through these collaborations, the Future Cities Lab seeks to act as a foundation to advance knowledge related to these complex challenges and a platform for exchange between researchers from China and France.

The Future Cities Lab focuses on investigating the interaction between **future electrified urban mobility and electric power systems** and providing technical management insights to ensure the reliable and economic operation of these interdependent systems. The researchers in the Future Cities Lab are currently developing quantitative state-of-the-art modelling frameworks to try to address the following questions.

What is the technical and economic potential for shared autonomous electric vehicles for providing power grid services when needed while maintaining excellent transportation satisfaction levels?

How to mitigate the risks of disruption for power grid and electric mobility services and ensure—and even improve—the resilience of the interconnected systems?

How to coordinate the SAEV (Shared Autonomous Electric Vehicles) charging schedule considering the uncertainty in transportation flow patterns and transportation demand?

To answer these questions, the researchers depart from techno-economic modelling, mathematical programming, and analysis techniques to evaluate the conditions under which electricity pricing, transportation demand, SAEV fleet size, and the interaction of the system's parametres would enable a successful and scalable implementation of these services.

29.09.2021 | 10-11 AM CET
Tarek Chouaki | PhD Candidate, Anthropolis Chair, IRT SystemX and CentraleSupélec
Implementing and using Reinforcement Learning for empty Shared Vehicle Rebalancing in Multi-Agent Transport Simulation MATSim

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In the first session of this seminar series, Tarek Chouaki presented his work on the usage of Reinforcement Learning based relocation algorithms for Empty shared vehicles in the MATSim simulation framework. This is performed by implementing a software architecture that extends MATSim by providing an external rebalancing server, which offers a set of rebalancing algorithms. This allows to implement complex rebalancing algorithms with minimal changes introduced into MATSim's code base. In this architecture is implemented a simple Q-learning rebalancing algorithm. Initial results show the potential of this approach. Although they are not better than existing rebalancing algorithm in MATSim, this approach enables more developments in this area and the implementation of other more complex algorithms for mobility on-demand operation in MATSim.

13.10.2021 | 10-11 AM CET
Han Wang | PhD Candidate, Beihang University, Beijing
Does the labor competition really matter to urban agglomeration development?

The increasing population density in urban areas and the tendency of single cities to gather in urban agglomerations are indicators of urbanization of modern societies. In China for example, the number of cities between 0.2 to 1 million population declined whereas the number of cities with more than 1 million population increased. This raises the question of whether the small city is doomed to vanish and how will its social welfare be affected. In this seminar session, an approach to tackle these questions by studying a configuration of two cities (one large and one small) independently governed where intercity commuting is performed by High-Speed Train and intracity commuting is performed by car was presented.

10.11.2021 | 10-11 AM CET
Michiel DE BOK | Researcher, TU Delft
Multi-agent simulation of urban freight transport: MASS-GT model development and applications

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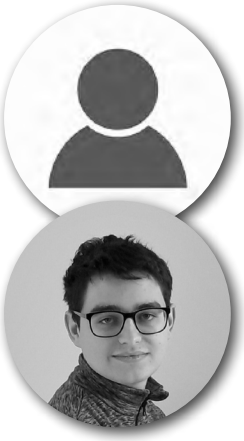
The aim of the MASS-GT project is to develop multi-agent simulation models for urban freight transport. Main motivators were the absence of strategic simulation tool for impact assessment of city logistic developments and policies and the emergence of new sources of large data collections on freight transport. The acronym MASS-GT stands for Multi-Agent Simulation System for Goods Transport and expresses the general specifications of the approach. First of all, the multi-agent approach is adopted to explicitly address the heterogeneity of stakeholders that are involved in urban freight transport (e.g. producers, customers, carriers, local administrators). Second, an extensive dense dataset with freight vehicle trip diary data is used to develop data-based simulation solutions and calibrate logistical choice models.

The MASS-GT model applies an agent- and shipment-based approach. Demand is simulated at the unit of shipments (instead of vehicles) which corresponds better with logistic behavior. Some shipments are transported directly from producer to consumer but many goods are transported via distribution channels with one or more 'logistical nodes'. Therefore distribution centers and transshipment terminals are represented as logistic nodes, to distinguish transportation flows that are part of a multi-tier distribution channel. Figure 1 illustrates how the goods are transported as shipments between producer and consumer, and where which logistical choices are made. It illustrates strategic choices, such as distribution channel choice, shipment size, and tactical choices such as vehicle type and tour formation.

The evolutionary development of the approach is published in a number of publications and is actively evolving. Specific components are redeveloped, or improved releases of the system are being developed in diverse parallel projects, such as H2020 innovation projects, PhD projects, or MSc projects. In this seminar the model has been presented and the development philosophy and some recent model applications were discussed.



24.11.2021 | 10-11 AM CET
Etienne Lu, Researcher, Future Cities Lab, CentraleSupélec
Hadrien Herubel | Research Intern, Future Cities Lab, CentraleSupélec

Shared autonomous electric vehicles transport scheduling with charging considerations: optimization-based planning approaches

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Car-sharing services are becoming increasingly popular as a result of the ubiquitous development of the communication technologies that allow the easy exchange of information required for these systems to work. The adoption of autonomous driving technology for providing car-sharing services is expected to further accelerate the widespread of this transport model. Moreover, as autonomous vehicles are expected to operate with electric power, they have the potential to significantly decrease greenhouse-gas emissions in the transport sector. The increased electrification of the transport system due to the adoption of shared autonomous transportation has significant implications for the electric power systems. In addition to efficient passenger transport, shared autonomous electric vehicles (SAEVs) provide a significant opportunity to act as moving batteries and to add electricity storage to the grid that would counterbalance the intermittence of renewable energy sources, such as wind and solar. If correctly managed, SAEVs can contribute to power grid flexibility, reduction of peak load and in providing ancillary services such as frequency regulation. This would enable major cost savings for both the transportation and energy systems, enable a higher renewable energy integration and production and offer overall more resilient systems capable of withstanding and recovering from disruptions. However, a poor coordination between the two systems may compromise both the grid stability and passenger travel times. In this presentation, we show some of the research work done within the Future Cities Lab regarding the potential interaction between SAEV and the power grid in terms of charging scheduling. We particularly show how a variety of modeling approaches can be used to address this problem, each with a set of advantages and limitations.

08.12.2021 | 10-11 AM CET
Jinxiao DUAN | PhD Candidate, Beihang University, Beijing
Reliability of the public service market against cascading imbalance

In this seminar, the presenter detailed her approach of dealing with cascading imbalances/failures in a public service market, in this case a road network. In this

work, a two-level cascading failure model was used that features convex programming for the socially aware choice problem. The measures of performance that have been used in this study are the reliability, ratio of return to cost and vulnerability. By exploring various topology forms of markets, social good considerations and amount of adjustment on the travelers' side, this research shows that a public service market should not just balance between supply and demand and that a long-term mechanism can be designed to regulate investment behavior of managers and consumption behavior of travelers.

12.01.2022 | 10-11 AM CET
Branch-and-Bound for multiobjective integer linear programming
Sophie PARRAGH | Researcher, Linz University

Many real-world optimization problems involve multiple objectives. When considered concurrently, they give rise to a set of optimal trade-off solutions, also known as efficient solutions. These solutions have the property that neither objective can be improved without deteriorating another objective. In this work, the potential of branch-and-bound techniques for solving multi-objective mixed integer linear problems is explored. To achieve a high-quality approximation of the optimal set of trade-off solutions, various innovative techniques are used in the different components of the branch-and-bound paradigm: lower bound sets computation using the vector linear programming solver Bensolve; enhanced variable fixing; objective space branching; primal heuristics; feasibility pump. First results on bi-objective and tri-objective problems are very promising and consolidate the path towards a generic method for solving multi-objective mixed integer linear problems.

26.01.2022 | 10-11 AM CEST
Mariana REYES | PhD Candidate, Anthropolis Chair,
IRT SystemX and CentraleSupélec
The place of active modes for Sustainable MaaS solutions: Identifying Mechanisms for Sustainable Value Creation, Capture and Reallocation in MaaS

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Mobility as a Service (MaaS) is one of the urban mobility futures' solutions at the border of physical and digital infrastructure. MaaS solutions gather a panoply of stakeholders and institutions around a common goal: proposing users an integrated (inter)mobility service that assembles data, information and mobility offers, permitting to access different transport modes and infrastructures for their journeys in each territory. The (eco)systemic nature of MaaS poses several challenges regarding data sharing, liabilities, responsibilities, and obligations of each actor

within the ecosystem as well as value redistribution among the stakeholders, to name a few. Despite the challenges to be faced, MaaS represents an opportunity to decarbonize mobility and catalyze sustainable mobility policies by implementing strategies that: 1) enable behavior change in mobility practices (persuasive mechanisms) and 2) allow an enhanced use of infrastructure for intermodal travel (Integrative mechanisms). This research aims to highlight the importance of an integration strategy for active modes in MaaS business models from the analysis of existing solutions. This study represents the first stage of our research aiming to appraise the integration of active modes in MaaS solutions deployed in France. To do so, we analyze its context, characteristics, business model, and the current state of integration of pedestrian mobility they propose. A comparative analysis of the information provided for pedestrian itineraries was carried out to identify the type of information provided and the mode hierarchy in each MaaS solution.

09.02.2022 | 10-11 AM CET
Michele Tirico | Researcher, Future Cities Lab Paris
Morphogenesis of urban systems: Modelling the co-evolution of human transport and urban forms

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The transportation network is the backbone of urban systems. It organizes elements of cities (e.g. population, political and socio-economic agents), allowing them to get in relationships, interact and move. The evolution of elements and the structural properties of the network are interrelated, making an overlapping of synchronic and diachronic feedback which drives the systems to unexpected behaviours and emerging forms. In this seminar I will present an approach based on complexity theory to investigate those dynamics and more precisely how street networks form and evolve. The morphogenesis of those spatial networks is studied through a graph generator model. Inspired by the reaction-diffusion theory, I supposed that simple dynamics govern the behaviour of elements of an urban system: they interact each others (react), self-regulate their concentration (auto-catalysis) and move in space (diffuse). Unexpected evolving patterns emerge from those local and decentralized dynamics and constraint the evolution of the street network. A dynamic vector field represents those forces to an evolving geometric graph. In order to validate this approach, I compared simulated networks to the most relevant geometric graphs and street networks of French department cities. Using measures from complexity theory, graph theory and multi-fractality theory, I observed that the robustness, the hierarchies of shortest paths and the self-similarity of obtained networks are similar to empirical networks. I will conclude the seminar with some perspective of the project, and I will describe a general framework which aim to explore how predictable mobility modes will shape urban forms.

09.03.2022 | 10-11 AM CET
Christopher Tchervenkov | Researcher, ETH Zurich
Mobility pricing in Switzerland: The MOBIS Study

The MOBIS study conducted a randomized controlled trial to investigate and analyze the effect of Pigovian transport pricing in Switzerland, i.e., personalized pricing of all external costs in transport. Over 3,700 participants in metropolitan areas in the French and German-speaking parts of Switzerland participated, making it the largest and most comprehensive transport pricing experiment in the transport sector to date. Empirical work was conducted from September 2019 to January 2020, during which the travel of the study participants was tracked using a smartphone app, based on which the associated congestion, climate change, and health-related external costs were computed. After a four-week observation period, participants were randomly divided into three equal groups (pricing, information, and control groups) and subjected to an information or pricing treatment for an additional four weeks. The information group received regular information about the external costs their behaviour had caused, whereas the pricing group additionally received a budget from which the external costs were deducted. As an incentive to reduce the external costs of their transportation behaviour, this group was allowed to keep the unspent portion of the budget. At the end of the study, all participants received an incentive payment of CHF 100. The treatment effect was measured using a difference-in-differences approach. A significant reduction in external costs was observed for participants in the pricing group, who measurably changed their behavior through shifts in route choice, departure time choice, and mode choice. The short-term price elasticity is -0.31. Participants in the information group also showed reductions, but not to a statistically significant extent. The results were tested for robustness in a series of tests and confirmed.

23.03.2022 | 10-11 AM CEST
José Rafael Verduzco Torres | PhD Candidate, Urban Big Data Center, University of Glasgow
Revisiting the value of public transport. An empirical study drawing on big data and open-source modelling software

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Public transport infrastructure requires large expenditures to cover both capital as well as operation and maintenance costs. Land value capture (LVC) mechanisms can support the implementation of these type of projects. The present work aims to advance the discussion related to the assessment of the distribution of the economic benefits generated by public transport infrastructure that capitalize on residential land value by taking advantage of relatively novel methods, tools, and

sources, primarily developed and used under the accessibility umbrella, such as: (1) the growing open, standardized, and detailed information about public transport systems in General Transit Feed Specification (GTFS) format which substantially widens the possibilities to evaluate multiple transport scenarios retrospectively or prospectively; (2) the development of spatial open-data resources (e.g., OpenStreetMap, OSM) and open-code software, and; (3) as well as the associated computational resources made available to researchers outside computer science. Specifically, I seek to re-examine the implicit willingness to pay for accessibility to employment in the housing market considering some of the key issues addressed in the fields of urban and transport geography. For this purpose, this project draws on the case of Greater Mexico City.

06.04.2022 | 10-11 AM CEST
Chenlan WANG | Associate Professor, School of Economics and Management, Beihang University
Network performance measure and importance identification: A case study of private car in Zhengzhou

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Measuring the OD-level and citywide efficiency is helpful for managers to improve transportation planning. It may not realistic to improve the efficiency of all OD pairs of the whole city, while more reasonable to allocate limited budget or resources on selected OD pairs. Optimizing inefficient OD pairs directly may not effectively improve the traffic network efficiency value at the whole city level. Therefore, it is important to identify the vital O–D pairs affecting the system efficiency, when designing transport control measures. This study develops the existing measurements on the basis of the excess commuting (EC) framework to measure the OD-level and citywide travel efficiency and proposes a new importance index to further identify the vital OD pairs for network improvement. We conduct both OD-level and citywide efficiency assessments with the private car data in Zhengzhou, China, with different cost units of travel time, travel distance and the integrated unit of PSWE, respectively. We also quantify the importance level of each OD pair in the city and identify the vital OD pairs which encumber the system. Furthermore, detailed analysis on the vital inefficient OD pairs is also provided, referring to the land use planning of Zhengzhou city.

20.04.2022 | 10-11 AM CEST
Dr Flore Vallet | Senior Researcher, Anthropolis Chair
Tjark Gall | PhD Candidate, Anthropolis Chair\
Integrating today's and tomorrow's users in mobility system design: Potentials of matching personas and\ synthetic populations

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Design is increasingly influenced by digitalisation yet differs largely across domains and remains often disconnected. We present synergies between the works of UX designers and data scientists. Personas are used to represent users and their behaviours. Synthetic populations provide agent groups for agent-based transport simulation. Despite sharing characteristics, their synergies have not been widely explored so far. We propose a workflow and test it in the urban mobility context to link a synthetic population of Paris and the Communauté d'Agglomeration Paris-Saclay with a set of contextual personas. This is extended by (1) Showcasing ongoing work on integrating activity chains of the agents into the persona development and (2) Using the approach to develop possible future populations. The outcomes builds the basis for designing urban mobility across fields by integrating people-centred approaches at different design process stages.

29.06.2022 | 10-11 AM CEST
Yue Su | PhD Candidate, Paris
A Column-generation-based Approach for the Electric Autonomous Dial-a-Ride Problem

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Electric Autonomous Dial-a-Ride Problem (E-ADARP) consists of scheduling a fleet of electric autonomous vehicles (EAVs) to provide ride-sharing services for customers that specify their origins and destinations. E-ADARP differs from typical DARP in two aspects: (i) a weighted-sum objective that minimizes both total travel time and total excess user ride time; (ii) the employment of electric autonomous vehicles and a partial recharging policy. We present a highly efficient column generation (CG) approach to solve E-ADARP, where a customized labeling algorithm is designed to generate feasible routes. To handle (i), we propose a segment-based representation for a partial path that allows us to generalize a sequence of resource extension functions (REFs) to a single REFs. When extending the partial path, a novel schedule optimization method is invoked to generate all the optimal schedules. The partial recharging (ii) is tackled by tailored REFs, and we define strong dominance rules to allow fast computation of the shortest paths with constant time feasibility checking. In the computational experiments, 55 instances out of 104 are solved optimally at the root node, among which 15 solutions are newly identified optimal solutions. The generated lower bounds have quite small deviations (0.31% on average) to the best-found objectives, and we enhance 18 previously reported lower bounds and provide 17 new lower bounds for large-scale instances. Thirty-six new best solutions are generated on previously solved and unsolved instances, and the average computational time decreases by 30.4%. The proposed CG approach is able to handle instances with up to 8 vehicles and 96 requests. The superiority of our CG algorithm over the existing exact method is therefore highlighted by these computational results.

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The Anthropolis Chair, operated by IRT SystemX and CentraleSupélec, brings together the partners EDF, Engie, Groupe Renault, Communauté d'Agglomération Paris-Saclay, and Nokia Bell-Labs to work towards human-centred mobility. The Future Cities Lab is a joint initiative of Centrale Pékin, Beihang University Beijing, and Laboratoire Génie Industriel (LGI), CentraleSupélec, Université Paris-Saclay. To get to know more about ongoing activities, visit the Chair's website and join the mailing list.

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