BEHAVIORAL URBAN INFORMATICS, LOGISTICS, & TRANSPORT LAB (BUILT@NYU)
Center for Urban Intelligent Transportation Systems

--- 2016 Research Brief ---

Greetings, and Happy Holidays! It is that time of the year to reflect on what we've done and look forward to what we plan to accomplish. 2016 was the first full year at NYU, and also my last year supervising graduate researchers at Ryerson. Things are proceeding well with several exciting new research funding opportunities. First and foremost, our research consortium led by Prof. Kaan Ozbay was awarded a Tier 1 University Transportation Center from the U.S. DOT, entitled "Connected Cities for Smart Mobility towards Accessible and Resilient Transportation" (C^2SMART). It is the only UTC awarded this round that deals with **smart and connected cities**, with $1.4M funding for the first year (up to $7M over five years from U.S. DOT, plus additional cost sharing). Unlike other recent smart cities research funding, this center will involve universities from several diverse cities (NYC; Seattle, WA; El Paso, TX) to also study scalability and interoperability of smart mobility solutions across cities.

In addition to the center grant, my lab was awarded a 3-year grant from the National Science Foundation to study shared mobility systems and other types of multimodal transport services, as well as inter-agency strategic planning.

BUILT continues to work with collaborators in Toronto and Luxembourg, and we have initiated research projects with colleagues at University of Maryland and several private companies and public agencies. We invited Prof. Jayakrishnan's graduate student (Roger Lloret-Batlle) from UC Irvine to visit us during the summer as a Junior Research Scientist, and currently we have a Visiting Scholar (Dr. Bin Zheng) from Southwest Jiaotong University working at our lab for the next few months. During the fall, we also hosted Prof. Catrin Lammgard from University of Gothenburg to co-teach a graduate course with me in sustainable logistics and freight.

BUILT participated in two summer research programs for the first time: the Summer Undergraduate Research Program at NYU, and the ARISE program, which supports high school students interested in STEM research.

Research Highlights

Our research agenda this year continued our mission of finding innovative solutions to make use of data and information in managing urban transport systems, divided into three thrust areas: learning/inference, systems evaluation, and dynamic optimization. All our products are open source. Prototypes of our algorithms can be found either online at https://nyu.academia.edu/JosephChow or by request. A recap of our research products in 2015 is available here.

Transport system learning and informatics

Work in this area is primarily related to algorithms for transport system operators to monitor their systems. We made three significant products this year in this area. The first is a part of Hamid Sayarshad's dissertation. Using taxi pickup data from NYC, we compared several prediction models and found the best fitting online arrival prediction model to be a discrete variable time series model called FM-IntGARCH developed originally for supporting ambulance deployment. Guidelines are provided so that city agencies can use this model to identify sudden changes in arrivals over time, which is invaluable for event management, surge pricing, or for disaster evacuation.

In a collaboration with Dr. Tai-Yu Ma from LISER in Luxembourg, we developed and tested a new Bayesian network methodology to untangle and learn the dependencies between different variables associated with commuter mode choice behavior. The method simultaneously estimates the parameters as well as the structure of dependencies. This model was applied to commuter data from Luxembourg City, where up to 40% of the employees have to cross international borders each day to get to work, leading to very complex factors relating to this behavior. The work was presented at the International Conference on Operations Research of the German Operations Research Society in Hamburg.

A third product is a new inference framework that shows how to use data obtained from individual traveler decisions (such as route GPS data) to infer spatial-temporal preferences of the population or to infer parameters of the network that they traverse. This work was in collaboration with Mehdi Nourinejad from University of Toronto. Transportation modelers can use this approach to estimate a travelers' behavior or network characteristics that might be difficult to estimate otherwise. These are important for city monitoring and for dynamic operations where real time network route choice data coming from multiple agents is available. Furthermore, the framework expresses the learning using the same language as network optimization, which is crucial for any automated dynamic transport service. We presented results from preliminary computational experiments at the TRISTAN IX triennial international conference held in Aruba, and at INFORMS in Nashville.

Multimodal flexible transit service evaluation

Work in this area is primarily systems analysis for policy-makers. Our contributions in this area in 2016 include analysis of three systems, with some more theoretical efforts underway with the ongoing NSF project. We ask whether the Brooklyn-Queens Connector might be better served by an autonomous vehicle fleet instead of a conventional light rail or streetcar technology. Our simulation analysis, the first to directly compare an autonomous vehicle fleet operation to a transit technology, found that a fleet of 150 or more EZ10s would be needed along this 17-mile corridor to provide the same or better total travel time for passengers. This study will be presented at the 96th Annual Meeting of the TRB.

We also examined the shared taxi operational policy, particularly for trips to JFK Airport. Using discrete choice models fitted to survey data provided by the Port Authority, we quantified the social welfare impacts of the use of shared taxi service to the airport. The results suggest that the use of shared taxis improves the social welfare of airport access travelers overall, but this benefit is not uniformly applied to everyone. A portion of travelers has a reduction in social welfare due to increased wait time or detours that outweigh their benefits from reduced fares.

In a third effort, we collaborated with Prof. Mahdieh Allahviranloo from City College of NY to study "fractional ownership" of autonomous vehicle fleets, or driverless car clubs. In this scenario, a community would share ownership of time slots for a fleet of vehicles, and people can choose to trade those time slots with one another. The pricing of these systems depend on the underlying activity schedules of the population; for example, a community that primarily goes to work at 7am in the morning and returns home at 6pm in the evening will have very different needs than a 24/7 active community like NYC. We developed an algorithm to determine an appropriate fleet size and time slot pricing mechanism for such a system. Results from preliminary computational experiments were presented at the TRISTAN IX triennial international conference held in Aruba.

Anticipatory network optimization

The third major thrust area from our lab is in the area of anticipatory network optimization, using real time data to anticipate future conditions for a system to operate. Two major research products emerged from this area in 2016. The first is a new algorithm for deploying commercial drones or UAVs to monitor traffic conditions in a road network. Simulation experiments indicate positive results with the algorithm. Traffic management centers can use this algorithm to manage drone equipment alongside other data collection sources like loop detectors, video cameras, and mobile devices.

In a collaboration with Prof. Paul Schonfeld and Dr. Qianwen Guo at University of Maryland, we developed a data-driven analytical model to determine when best to switch operations for a transit service. The model is derived from corporate finance theory of real options, and can be used by a transit operator to determine, for example, when to switch from peak fixed route service to off-peak flexible service, or to switch vehicle size, among others. This work will be crucial to autonomous vehicle fleet operators.

Dissemination

In 2016, our work was presented in TRISTAN IX in Aruba, INFORMS Annual Meeting in Nashville, TRB Annual Meeting in Washington DC, UTRC 5th Connected/Autonomous Vehicle Symposium in NYC, Annual International Conference of the German OR Society in Hamburg, and Transportation for Smart Cities Symposium at NYU Abu Dhabi.

Looking Ahead

In 2017, we expect to continue our work in the focus areas above. In particular, we will hopefully have some promising results for some groundbreaking work that we are doing under our NSF project which may alter the practice of transportation planning to accommodate shared mobility services and megaregion integration. We are also turning to more research topics related to optimization, learning, and privacy design, which I will provide further updates in next year's brief.

Lastly, BUILT will be present at the first TRB reception from NYU Tandon School of Engineering, which will be hosted at the Marriott Marquis Independence Salon H on Sunday, January 8th, 5-7PM. We hope to see friends and colleagues there!

Sincerely,

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Research Lab Contributing Members in 2016

Postdoctoral fellows: Xintao Liu (now an Assistant Professor at HK Polytechnic)
PhD student researchers: Hamid R. Sayarshad (now a Postdoc at Cornell), Shadi Djavadian, Susan Jia Xu, Jinkai Zhou, Saeid Rasulkhani, Yueshuai He, Diego Estuardo Correa (co-supervised with Kaan Ozbay)
MS student researchers: Ahmed Amer, Matthew Harvey, Anchor Chin, Maria Alejandra Pardo Baquero, Manel Rivera Bennàssar, Matthew Urbanek, Lior Melnick
Undergraduate researchers: Andy Lai, Lucas Mestres Mendes, Ziyi Ma, Adam Sanghera, Jakub Gil
High school researchers: Kathy Lau, Malaq Alzoubeir

New Research Products in 2016

Journal publications:

Ma, T.Y., **Chow, J.Y.J., Xu, J.**, 2016. Causal structure learning for travel mode choice using structural restrictions and model averaging algorithm. *Transportmetrica A*, in press, doi: 10.1080/23249935.2016.1265019.

Chow, J.Y.J., 2016. Dynamic UAV-based traffic monitoring as a stochastic arc-inventory routing policy, *International Journal of Transportation Science and Technology*, special issue on Unmanned Aerial Vehicles, in press, doi: 10.1016/j.ijtst.2016.11.002.

Amer, A., Chow, J.Y.J., 2016. A downtown on-street parking model with urban truck delivery behavior. *Transportation Research Part A*, special issue on "Freight behavior research", doi: 10.1016/j.tra.2016.08.013.

Djavadian, S., Chow, J.Y.J., 2016. Agent-based day-to-day adjustment process to evaluate dynamic flexible transport service policies. *Transportmetrica B*, in press, doi: 10.1080/21680566.2016.1190674.

Sayarshad, H.R., Chow, J.Y.J., 2016. Survey and empirical evaluation of nonhomogeneous arrival process models with taxi data. *Journal of Advanced Transportation* 50(7), 1275-1294.

Harvey, M.J., Liu, X., Chow, J.Y.J., 2016. A tablet-based surrogate system for "in-situ" evaluation of cyber-physical transport technologies. *IEEE ITS Magazine* 8(4), 79-91.

You, S.I., **Chow, J.Y.J.**, Ritchie, S.G., 2016. Inverse vehicle routing for activity-based urban freight forecast modeling and city logistics. *Transportmetrica A*, special issue on Activity-Travel Behavior Analysis and Multi-State Supernetwork Modeling, 12(7), 650-673.

Chin, A., Lai, A., Chow, J.Y.J., 2016. Non-additive public transit fare pricing under congestion with policy lessons from Toronto case study. *Transportation Research Record*, 2544, 28-37.

Conference proceedings:

Mendes, L.M., Bennàssar, M.R., Chow, J.Y.J., 2017. Simulation experiment to compare light rail streetcar against shared autonomous vehicle fleet for Brooklyn Queens Connector, In: Proc. 96th Annual Meeting of the Transportation Research Board, Washington DC.

Working papers:

Xu, J., Nourinejad, M., **Chow, J.Y.J.**, 2016. Network learning via multi-agent inverse transportation problems. arXiv preprint arXiv:1609.04117, https://arxiv.org/abs/1609.04117.

Theses:

Djavadian, S., 2016. Evaluation methods of dynamic flexible transportation systems. PhD Thesis, Ryerson University.

Sponsored Research Reports:

Development of mobile device-based surrogate systems for connected and autonomous vehicle technologies, 2016. PI: J.Y.J. Chow, Industry partner: Transnomis, Sponsors: Ontario Ministry of Transportation, NSERC; Programs: Ontario Centres of Excellence CV-AV Research Program VIP (#22905), NSERC Engage (EGP 477034-14).

Agent-based Decision Support for a Flexible Transport Service Pilot, 2016. PI: J.Y.J. Chow, Industry Partner: Metrolinx, Sponsored by NSERC Engage Grant EGP 477367-14.

Invited Talks:

"Automated decision-making in last mile transit", 5th Automated & Connected Vehicles Symposium, UTRC, Nov 8, 2016.

"City monitoring with travel demand "momentum" vector fields: theoretical and empirical findings", Transportation for Smart Cities Symposium at NYU Abu Dhabi, March 25, 2016.

Conference Presentations:

"Inverse transportation problems to infer agent interactions in network-driven machine learning", TRISTAN IX, Oranjestad, Aruba, June 12-17, 2016.

"Fleet sizing for fractional ownership of autonomous vehicles", TRISTAN IX, Oranjestad, Aruba, June 12-17, 2016.

"Causal structure learning for travel mode choice using structural restrictions and model averaging algorithm", Annual International Conference of the German Operations Research Society, Hamburg, Aug 30 – Sept 2.

Media coverage:

ITE Met Section TransTalk, Interview Series, November 2016, https://ite-metsection.org/pdf/transtalk/2016/November.pdf