URBAN SYNERGETICS LAB

About

The Urban Synergetics Lab at UNC Charlotte, directed by Prof. Dr. Dimitris Papanikolaou, conducts research at the intersection of design, computing, informatics, and social behavior with a mission to explore new models of urban intelligence, analyze their possibilities, and devise novel strategies for implementing them. We envision a future in which ambient intelligence emerges naturally from how humans interact with data with and through the physical environment. Towards this goal: we develop data-driven modeling tools to predict dynamics of urban cyberhuman systems; we prototype enabling technologies to connect humans, objects and places across scales; and we design social mechanisms to link information to decision and action. The Urban Synergetics Lab, located in Storrs Hall, is a collaboration between the School of Architecture and the College of Computing and Informatics. .

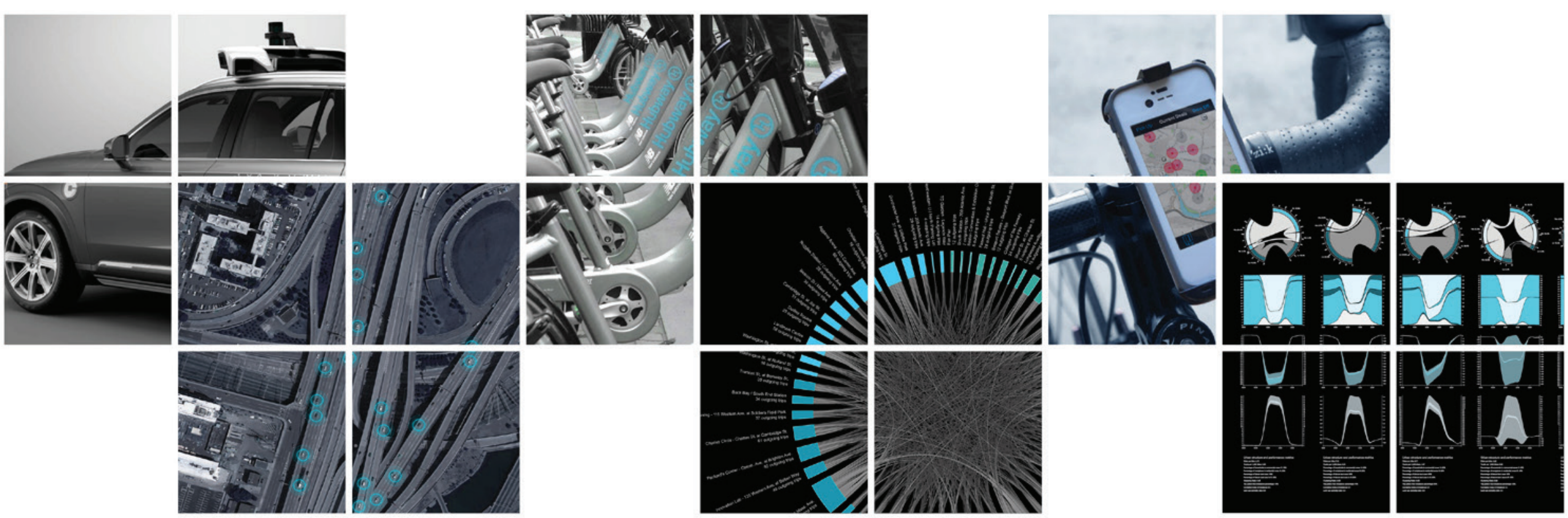


Image credit: Smart Cities, MIT Media Lab

Mobility on Demand (MoD) Systems

Tags: Smart Cities, Intelligent Transportation, Vehicle Sharing
Smart Cities & Changing Places groups, MIT Media Lab, 2008 - 2011

Mobility on Demand (MoD) systems utilize lightweight electric foldable vehicles, networks of rapid charging stations, and intelligent fleet management systems providing personal point-to-point mobility while solving the public parking problem. We developed three vehicles: the City Car (now HIRIKO), the RoboScooter, and the GreenWheel bicycle. All vehicles deploy drive-by-wire technology and plug-n-play in-wheel, electric motors that integrate suspension, steering control, and breaking within the wheel's hub-space. This allows the main chassis to fold to minimize urban footprint. MoD systems incorporate: smart grid technologies, smart fleet management, and vehicle-to-grid (V2G) technology. MoD started as collaboration with General Motors and Schneider Electric and continued with Denokinn. (**best invention of year 2007 , TIME magazine; $100K Buckminster Fuller Award, 2009** - with Prof William J. Mitchell, and Kent Larson, MIT Media Lab).

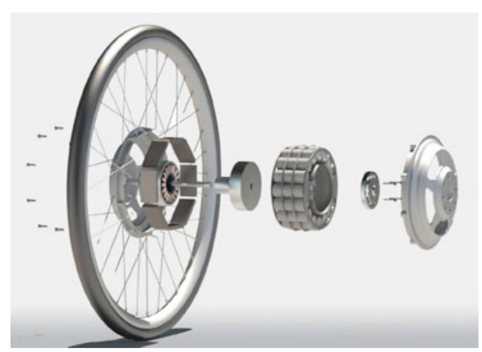


Image credit: Smart Cities, MIT Media Lab

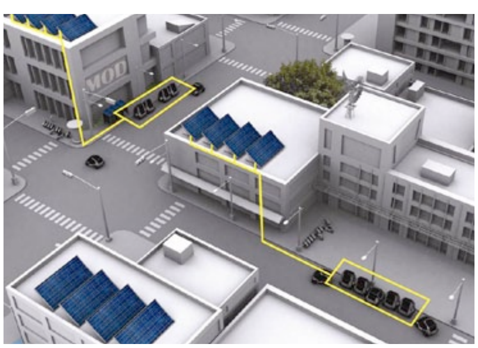
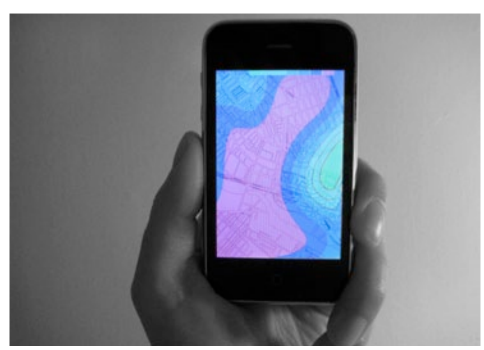
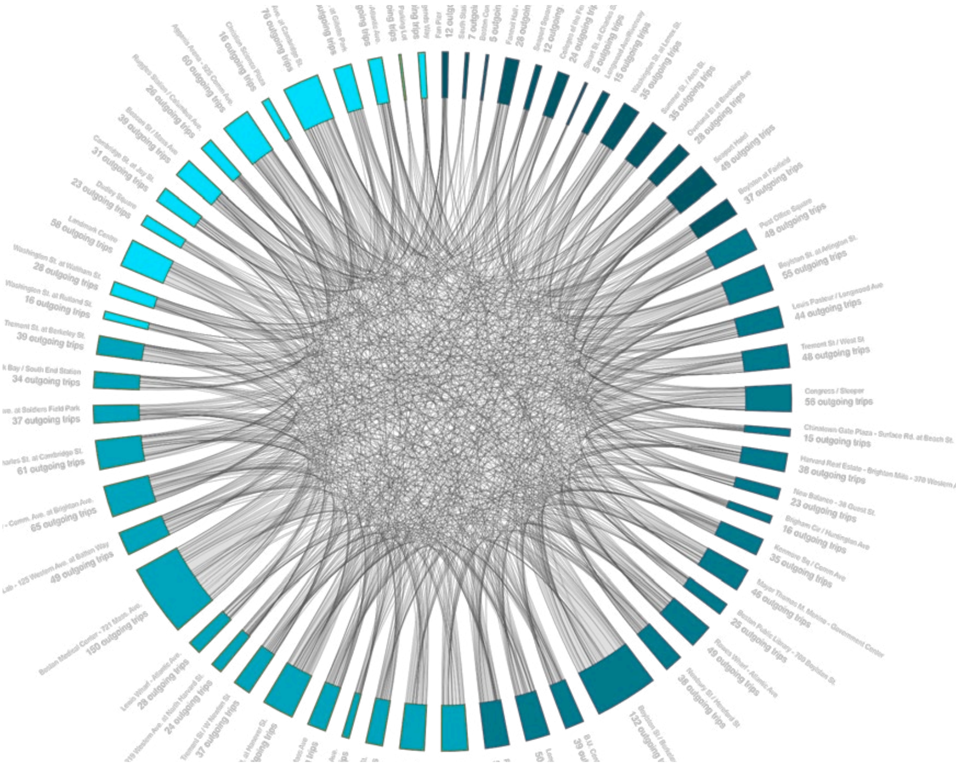
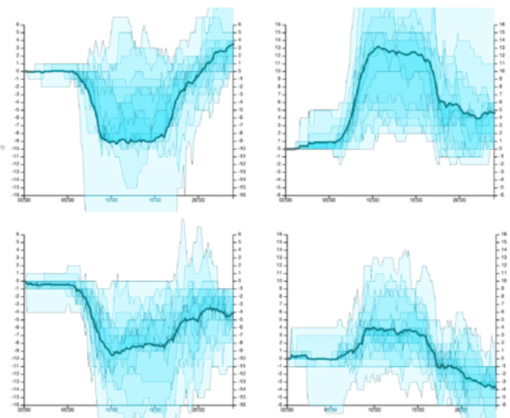


Image credit: Smart Cities, MIT Media Lab

Original image: Smart Cities, MIT Media Lab



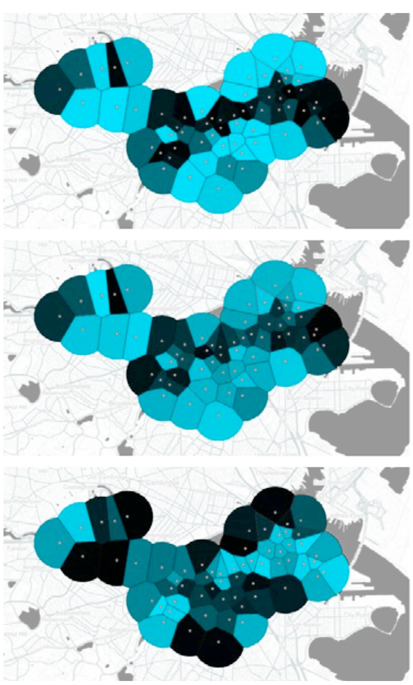


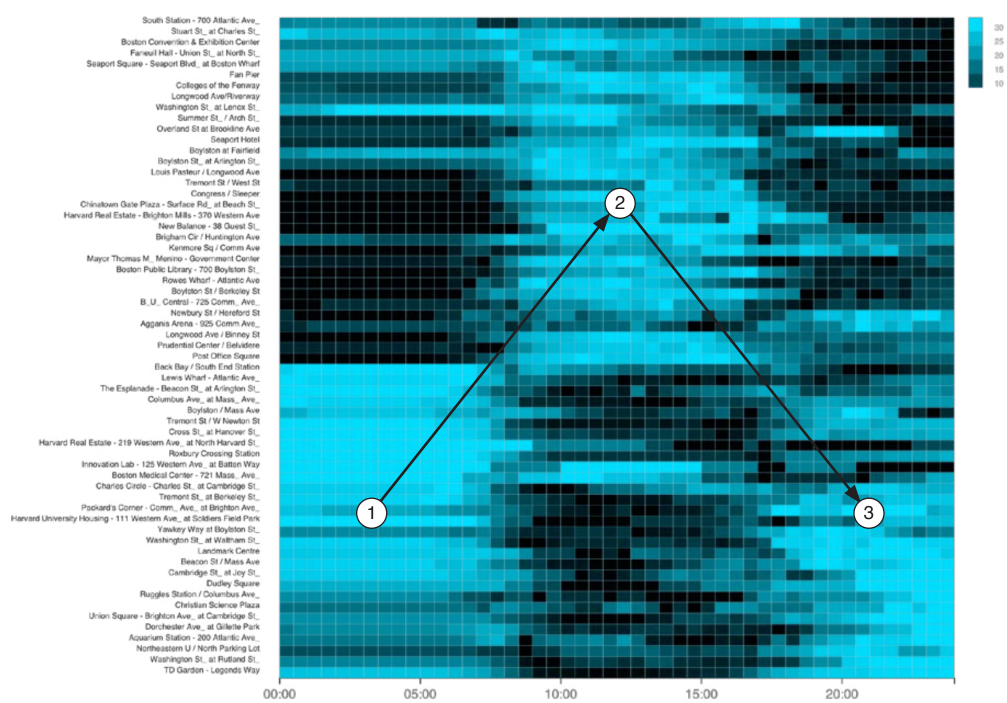


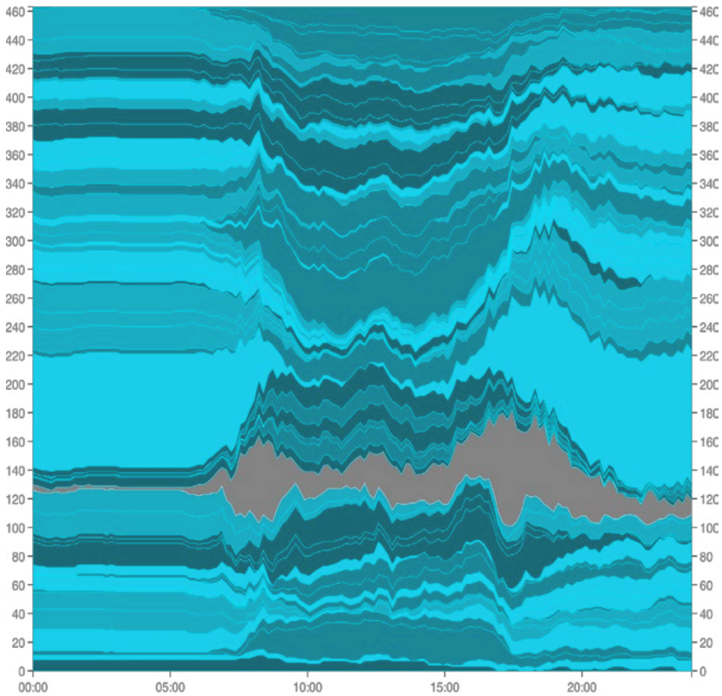
Tidal Patterns of Human Mobility in Bike Sharing Systems

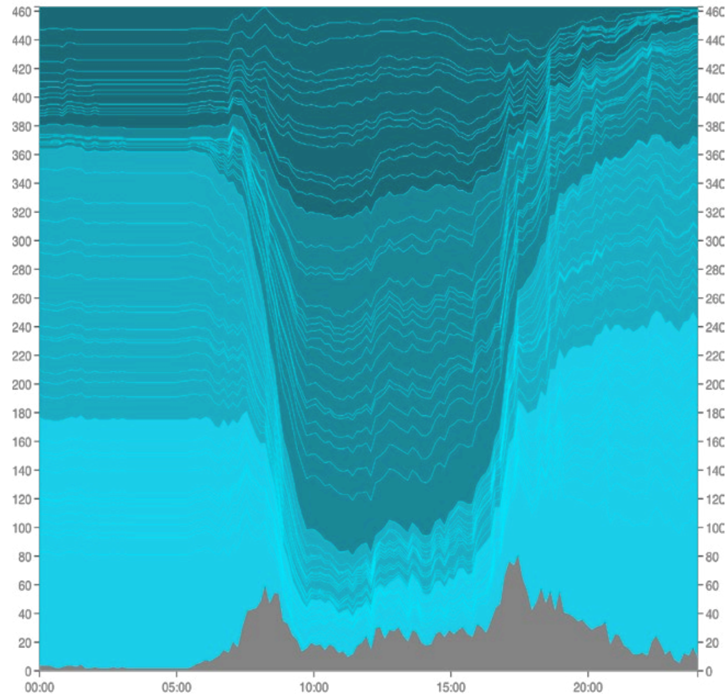
Tags: systems, data visualization, big data, urban mobility, dissertation, MoD
Part of Doctoral dissertation, Harvard GSD

The fundamental design question in MoD systems is the determination of the vehicles, parking spaces, and rebalancing force that collectively minimize the cost of serving a given pattern of trips. With truck routing being computationally intractable even for medium-sized networks, there is no practical approach to study this problem. By analyzing the palindromic commuting patterns in Boston, I present a novel clustering technique that reduces the sizing and rebalancing problem of a network of N stations to a network of 4 lumped regions: residential, commercial, surplus and shortage areas. Clustering is based on comparing the centers and volumes of the masses of inflow and outflow temporal distributions of stations. In residential stations, the center of mass of departures is before that of arrivals. In commercial stations it is the other way around. Likewise, in surplus stations the mass of departures is smaller than the mass of arrivals while in shortage stations it is the other way around. By ordering stations based on their ”residential” and “surplus” scores and by finding the tipping point of their accumulations, I define quantitatively the boundaries between the 4 groups. The technique allows data-driven modeling, simulation, and optimization of arbitrarily large MoD networks by a simple cyclic stock-flow model.





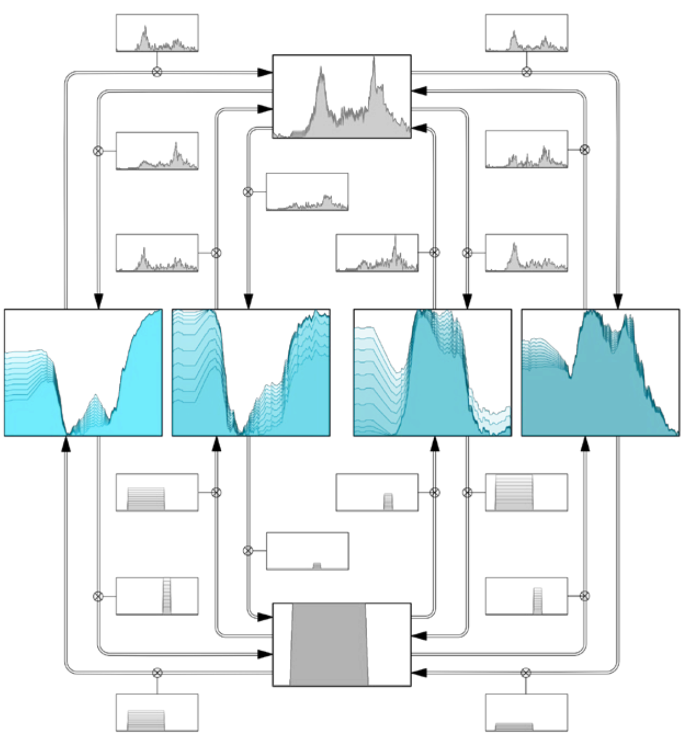


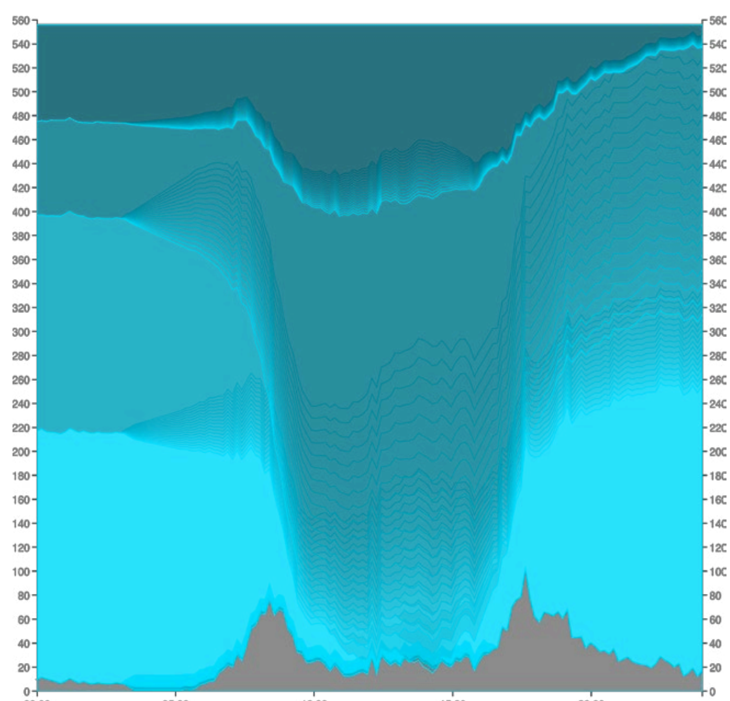


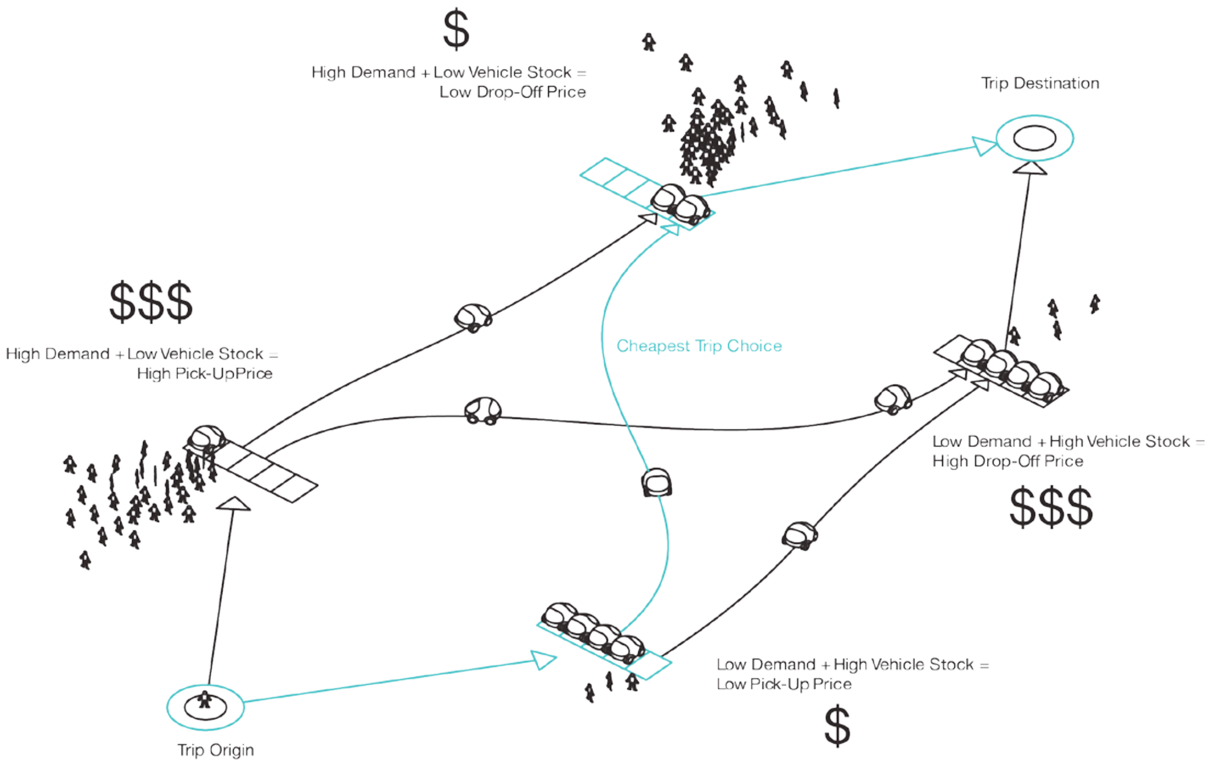
Data-driven System Dynamics Analysis of MoD Systems

Tags: complex systems, system dynamics, modeling, simulation, data visualization, big data, urban mobility, dissertation, MoD
Part of Doctoral dissertation, Harvard GSD

I developed a data-driven system dynamics simulation model that allows designers, planners, and researchers to interactively explore how fleet sizing and rebalancing decisions jointly affect costs, revenues, and environmental impact for mobilizing a pattern of trips as a result of a dynamic equilibrium. The model uses a trips dataset as input and numerically integrates the dynamic transition of the system, allowing a user to directly manipulate 11 controlling parameters. Four parameters control the sizing of each cluster while seven parameters control the rebalancing policy. The method is applicable to any system and can be used to address questions such as: how would ridership, cost, or carbon emissions, change for a marginal change in the fleet size or rebalancing policy? Using Boston's bike sharing system as a case, and working with interviews and a dataset covering over a year of operations (62K trips and 32M inventory entries), I perform a sensitivity analysis assessing a range of sizing and rebalancing options.



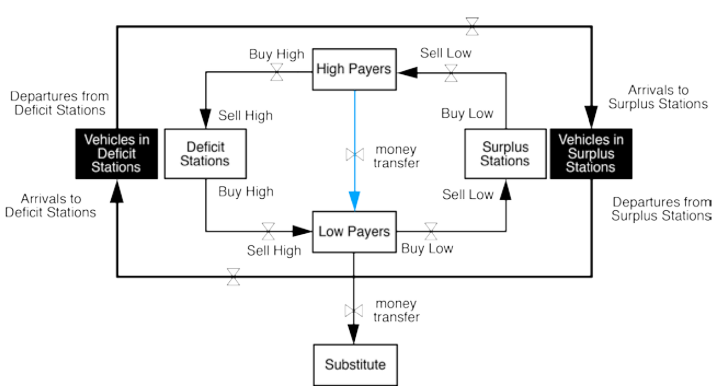




MET: A Self-governed Operation Model for MoD Systems

Tags: Systems, Social Computing, Mechanism Design, Urban Mobility, MoD, Markets, Interactive Telecommunications, MIT Media Lab

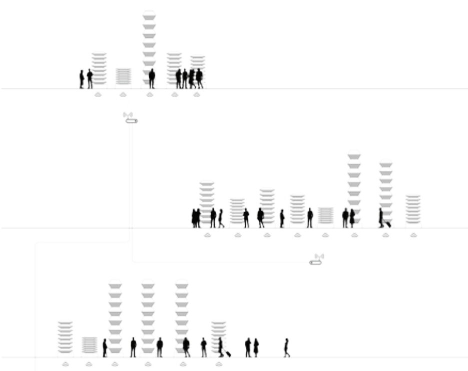
The Market Economy of Trips (MET) is a self-regulating operation model for MoD systems. MET uses dynamic pricing to incentivize users to rebalance the fleet, causing some trips to cost more while others to pay back. MET is based on a two-sided competitive market in which trip values derive as transactional differences between “buying” vehicles from origins and “selling” them back to destinations. In the ‘pickup’ side of the market, stations sell vehicles to departing users. In the ‘drop-off’ side of the market, stations buy vehicles from arriving users. Mutual competition of “station traders” brings the system in equilibrium by redirecting funds from users willing to pay to save time to users willing to profit from spare time. Pricescapes, a map-based visualization interface for MET, associates trading prices to colors. Stations with high trading prices are colored red while stations with low trading prices are colored green. Moving vehicles from red to green areas is rewarding while the opposite is costly. Moving vehicles between areas with same colors is free.

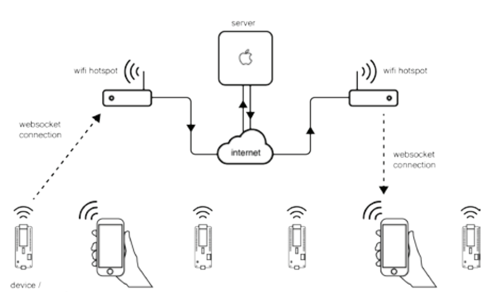


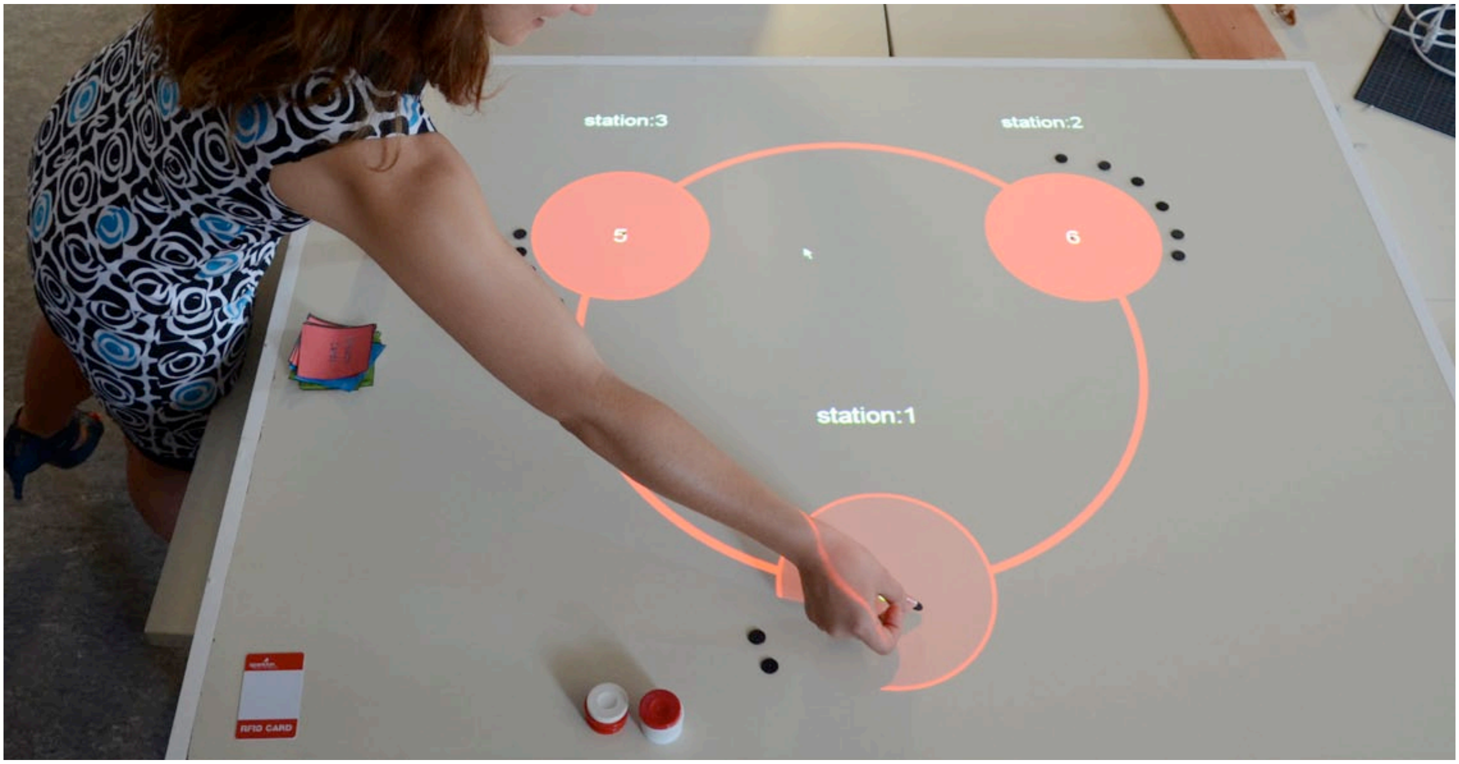
Pneuxels

Tags: tangible media, interaction design, human factors, networked environments
University of North Carolina at Charlotte, 2019
Team: Manoj Deshpande, Saquib Sarwar, Atefeh Mahdavi Goloujeh, Dimitris Papanikolaou

We often perceive other peoples' presence implicitly, through the traces of their interactions with physical objects. What if our urban environments could mediate these traces allowing remotely located people perceive each other's presence collectively? We extend the classic human-machine paradigm with one in which the "system" stands between two or more humans, mediating their interactions implicitly while remaining invisible to them, as ambient environment. Pneuxels are wirelessly networked programmable inflatables, placed at remote sites that allow visitors in one site to perceive the presence of visitors in other sites, promoting public participation and place-making. Pneuxels, change their physical state based on input from other Pneuxels, from the environment, or from users. We have developed a software/hardware platform that allows humans, objects and places to connect, similarly to how a chat application allows multiple online participants to converse.



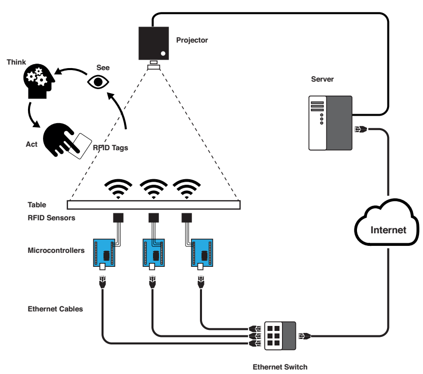


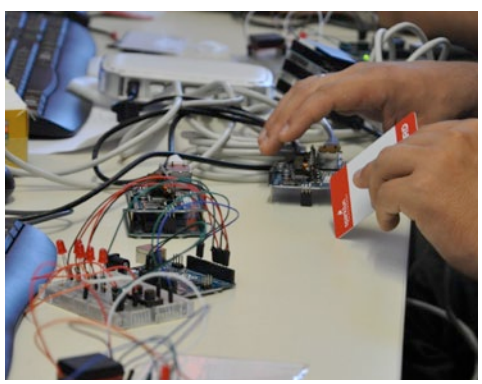


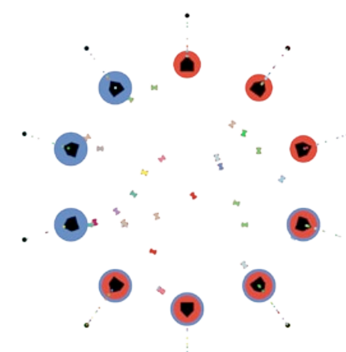
Cloudcommuting Game

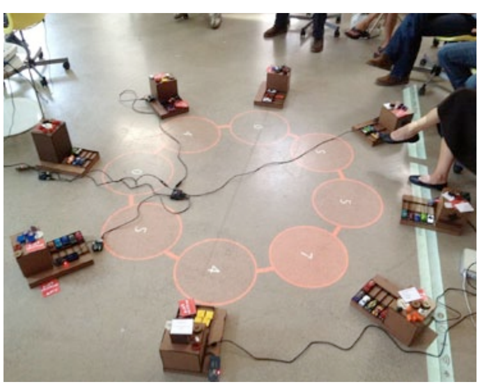
Tags: interaction design,education, strategic games, electronics
MIT Media Lab & Harvard GSD, 2012

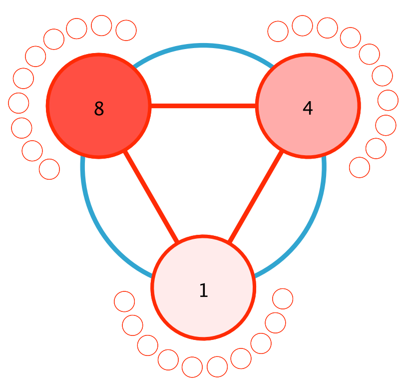
An interactive strategic board game and educational tool that explores decision making and self-organization in dynamically priced resource allocation networks. Two players complete origin-destination missions by relocating their pawns between stations. Players can choose between a fixed-priced and a variably-priced transportation option. A third player (the computer) controls the pricing of picking up and dropping off at the stations based on demand and supply. Players have limited time and money resources, therefore they must choose the optimum combinations to win. The game uses an array of RFID sensors to track pick-ups and drop-offs. Sensors send messages to a central computer through the Internet each time a player picks up or drops. The computer updates a pricing visualization scheme, which is then projected back to the surface of the game, influencing the decisions of the players.

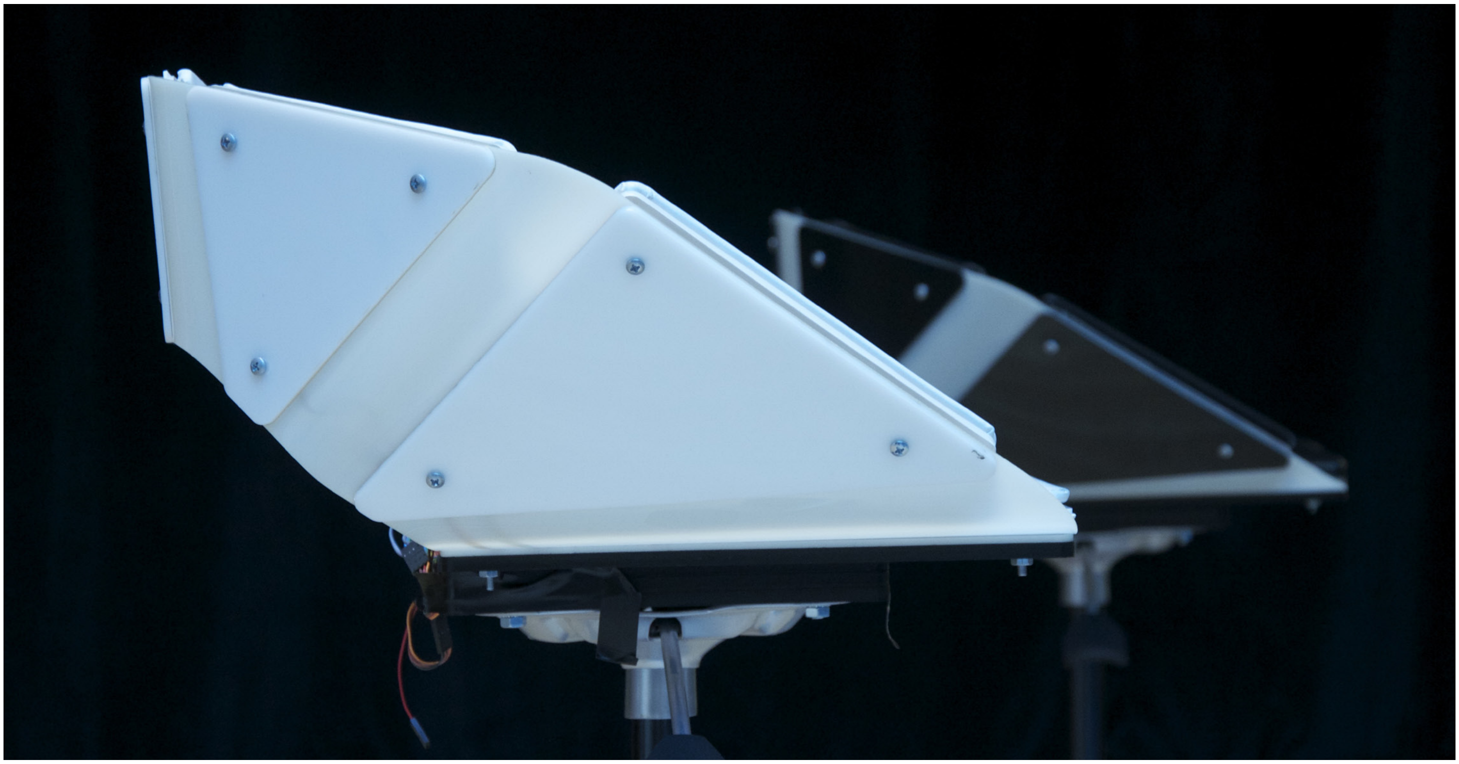








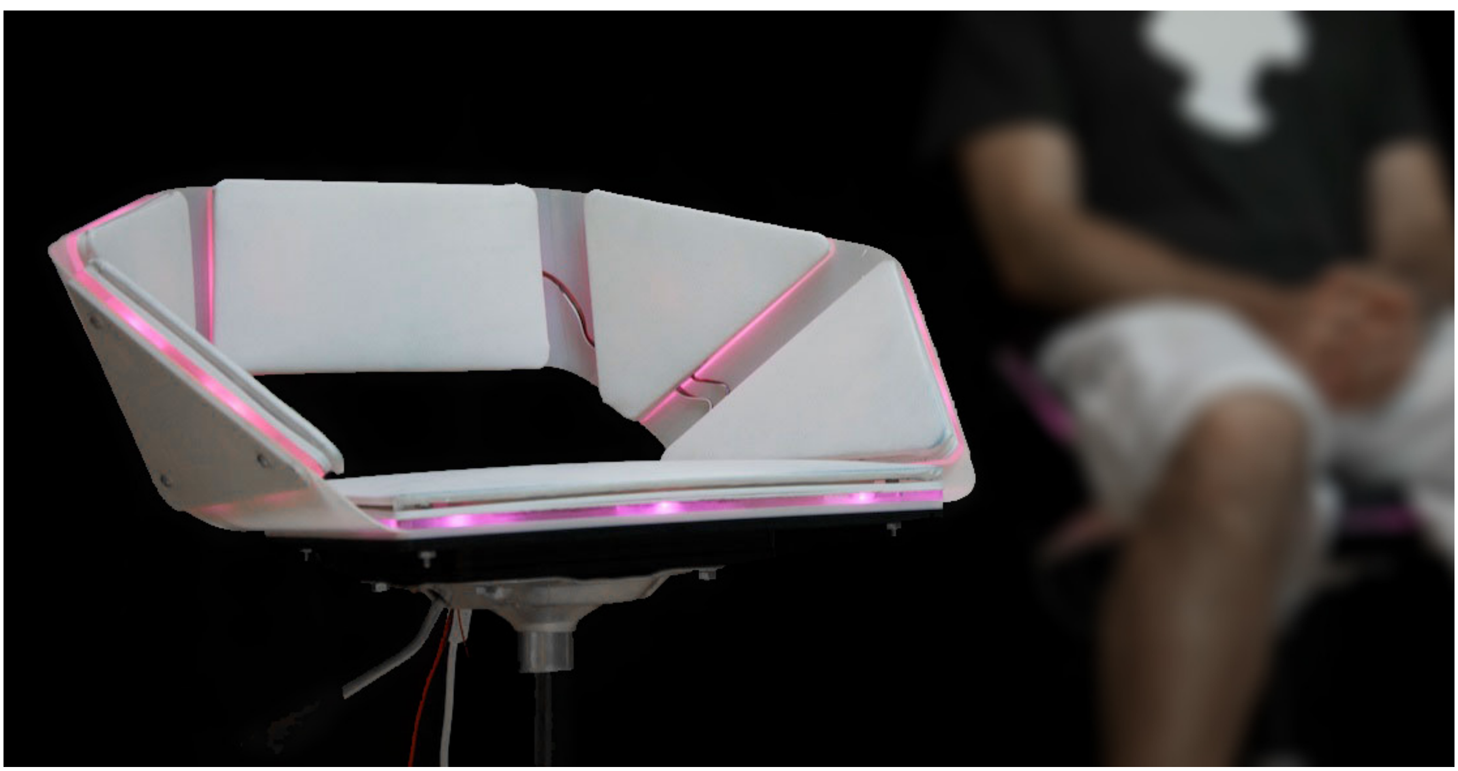


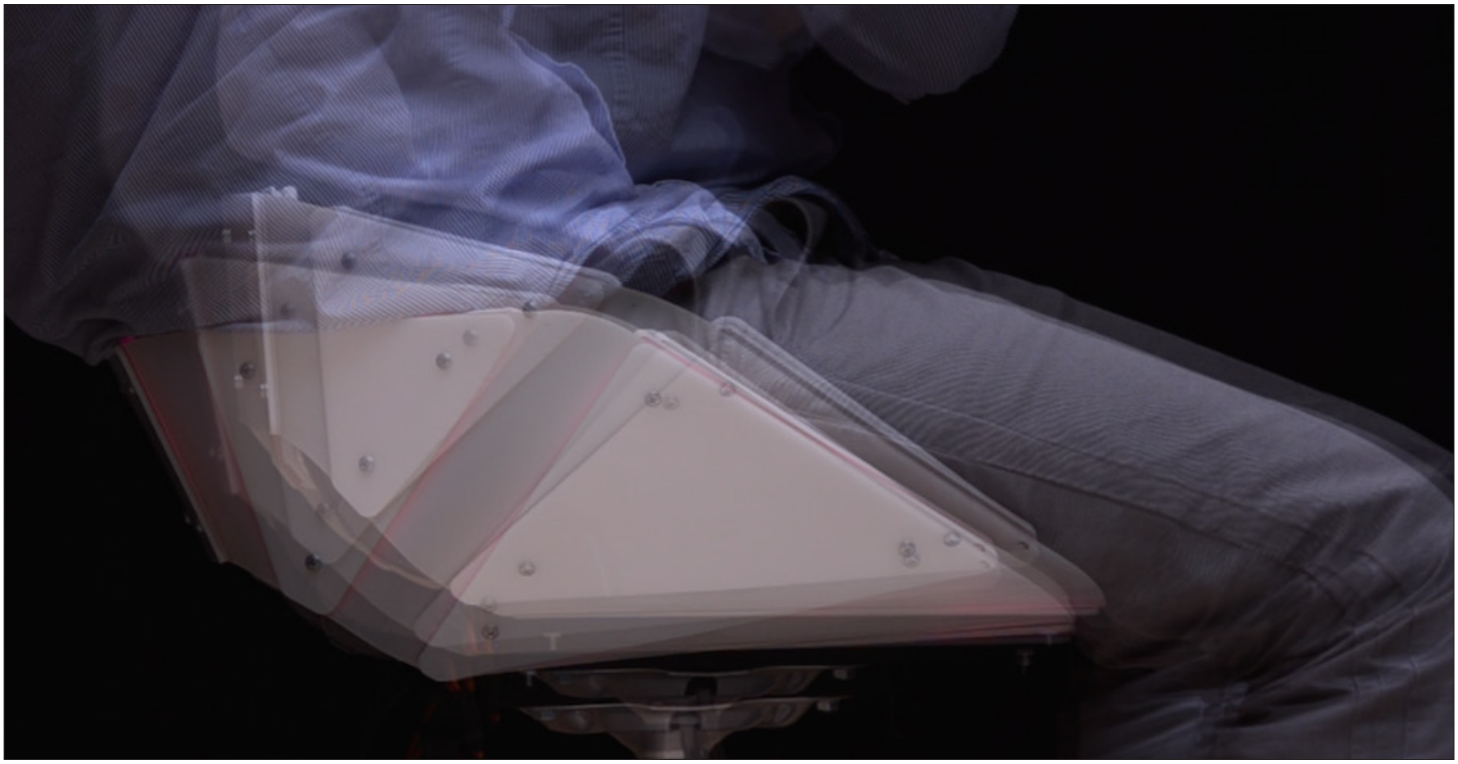


BodyPods

Tags: tangible media, interaction design, human factors, furniture design
Video: https://vimeo.com/102900472
Microsoft Research, Computational User Experiences group, Redmond, MA, 2014

BodyPods inquire the capacity of architecture to mediate human presence through digital information. BodyPods are multisensory seats that allow humans to perceive each other's presence by remotely exchanging their bodyprints through the internet. Analogous to a fingerprint, a bodyprint manifests a person's sitting posture as a distribution of their body pressure on the seat. When a person sits on one BodyPod, their bodyprint is visuallly manifested on the surface of the other BodyPod. If the person leaves, their bodyprint fades away with time. Prior related works in the field retrofitted furniture with technology that were never designed for, resulting in technological complexity (often hundreds of sensors), awkward functionality, poor usability, and bad design aesthetics. (With A.J. Bernheim Brush and Asta Roseway, Microsoft Research).





Interaction & Control

BodyPods recognize 8 sitting postures using only 6 pressure sensors through a novel design that adjust its shape to body anatomy. Each BodyPod is made of a flexible substrate (thermoformed Nylon) with 6 rigid panels (Delrin) mounted on it. The synergy of the two materials allows the seat to flex and maintain contact with sensors during posture transitions. This allow sensors to be placed close to body parts that are used as reference points, minimizing the number of required sensors and simplifying their signal analysis. Each interactive pad contains a pressure sensor (force sensitive resistor) and an array of RGB LED lights. The pads connect to a microcontroller, which sends the data to a server. Paired BodyPods share data through the internet by mapping the sensors of one seat to the corresponding light-emitting pads of the other seat. Results from a 10-person user study showed that BodyPods recognize 8 sitting postures and 2 torso rotations. Potential application areas include tangible or bodily gestural interfaces, musical instruments, game controllers, medical devices, and social experiments.