Workshop Urban Physics

Abstracts and Short-bios

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Luis Bettencourt

Santa Fe Institute

Bio

Luís M. A. Bettencourt is a Professor of Complex Systems at the Santa Fe Institute. He was trained as a theoretical physicist and obtained his PhD from Imperial College, University of London, for research in statistical and high-energy physics models of the early universe. Afterwards he followed his passion for better understanding human social life and its transformative potential. He has worked extensively on cities and urbanization with an emphasis on creating new theoretical interdisciplinary synthesis that describe them in quantitative and predictive ways, informed by the growing availability of empirical data worldwide. His research interests also deal with issues of innovation and sustainability in developing human societies, the dynamics of infectious diseases and general mechanisms for information processing in complex systems. His research has brought new perspectives into how we view human social life in cities and the processes of urbanization and human development and has been featured extensively in the scientific literature and by the media.

The Many Uses of Physics in the Study of Cities

The scientific study of cities as systems lies at the intersection of many traditional disciplines, including economics, the social sciences, geography, engineering and more.

Though Cities are also physical systems, the conceptual framework of the physical sciences may be expected of be of only limited use. However, there is a long tradition, going back almost a century, of coopting mathematical models from Physics to successfully describe empirical urban data. This practice is currently growing as more and better empirical evidence about urban phenomena becomes available, and as the need for predictive modeling - as fundamental theory and analytics - gains wider acceptance.

In this talk, I will give several examples of how concepts and methods from Physics are improving our understanding and modeling of urban phenomena.

At the same time, I will emphasize the pitfalls of importing methods from Physics without an appropriate consideration for urban phenomena and the intellectual tradition of other urban sciences. I will finish with some open challenges that can benefit from Physics thinking, but also go beyond current theory.

Constantine Kontokosta

CUSP, New York University

Bio

Prof. Constantine E. Kontokosta, PhD, PE, is the Deputy Director (Academics) at the NYU Center for Urban Science and Progress (CUSP), an Assistant Professor of Urban Informatics jointly at CUSP and the NYU Tandon School of Engineering, and the Principal Investigator and Head of the CUSP Quantified Community Research Lab. Constantine was part of the CUSP founding leadership team, setting the Center's strategic priorities and assisting in the design of the academic and research programs, growing from two to over 50 faculty and staff and 100 graduate students. At CUSP, he also leads Urban Sustainability Informatics research group, which has focused on using energy benchmarking data to drive carbon reductions in cities, and serves as Faculty Engineer in Residence at the NYU Tech Incubators. Constantine's research lies at the intersection or urban policy and planning, data science, and systems engineering, and he has worked on analytics projects with a range of city agencies to support improved city operations and planning. He holds a Ph.D., M.Phil, and M.S. in Urban Planning, specializing in econometrics, from Columbia University, a M.S. in Real Estate Finance & Economics from New York University, and a B.S.E. in Civil Engineering Systems from the University of Pennsylvania.

"The Quantified Community"

Jean-Paul Bailly

thecamp

Bio

Currently Honorary President of LA POSTE.
Former Chairman and CEO of LA POSTE (the French Postal Service / 275,000 employees).
Former Chairman and CEO of la RATP (the public transportation company for Paris and its region / 60,000 employees).
Education: Graduated from École Polytechnique, Master in Sciences from MIT.

thecamp: an innovation ecosystem to transform people, organizations and cities

Humanity is facing enormous challenges at the beginning of the 21st century. This is a century where the ruptures brought about by technology and its use have the potential to offer unprecedented economic and social opportunities, as long as these changes benefit mankind, enabling us to be proactive players in our future world more than ever before. Our future models of society and civilization will be born and evolve out of these transformations. Europe must take a more active role in this crucial transformational dynamic for humanity! Our cities, which will soon be home for three-quarters of the world's population, are set to become the prime location for this reconstruction. Meeting these new challenges, this new complexity, implies the creation of new ecosystems.

Philippe Dumas

Polytech Marseille

Bio

Philippe Dumas is at the head of Polytech Marseille since December 2012. Alumni of Ecole normale supérieure de la rue d'Ulm, Philippe Dumas enters research at the dawn of nano sciences tackling, in his thesis obtained in 1988, the emerging and exciting field of scanning probe microscopies. Hired the same year by the CNRS, he works today in CINaM (Center Interdisciplinaire de Nanoscience de Marseille) where he animates the Nanospectroscopies group. Today, he focuses new charge transport mechanisms at the nanoscale and on ways to take advantage of them.

Expert for several agencies in the field of nano sciences and energies, he authored more than 50 publications. In 2002, he joined Aix-Marseille University (AMU) where he occupies a full professor position. Since 2012 he is also at the head of AMU's Engineers' school: Polytech Marseille (8 specialities, 1300 students).

His growing interest in the field of Energies leads him to contribute to the competitive cluster Capénergies. Since 2010, he is highly involved in its strategic committee where he promotes the efficiency of cross-sectoral works. Within the competitive cluster, he is currently active in the field of smart grids.

Smart grids and urban physics

More than 50% of the world's population lives in cities (~80% in Europe). This proportion increases. Everywhere new urban areas arise. The population of existing ones is growing, their density increases, they spread. Their governments are joining forces in even larger communities which topology and interconnections where not thought at the beginning. Logistics, networks follow.

How can we model these evolutions? How can we understand them? How can we help and suggest inflections for future trends? How to use the growing data at our disposal? How to grasp the relevant, useful (and only useful) facts? How to set the limit between the necessary knowledge of our collective behavior and the access to private data from each of us? We will discuss these aspects through the prism of interconnected transport and distribution networks, which from continents, running through the towns, power our homes. Which soon, with the spreading of bidirectional communicating smart meters, will provide huge amounts of data through individual load curves.

Thomas Kemper

EU Commission

Bio

Thomas Kemper received the Ph.D. degree in geosciences from the University of Trier, Germany, in 2003 and has many years of experience in remote sensing. He is a Scientific Officer at the Joint Research Centre (JRC) of the European Commission, Ispra, Italy. From 2004 to 2007, he worked with the German Aerospace Center (DLR) Germany, where he helped in setting up the Center for Satellite-Based Crisis Information (ZKI), which provides rapid mapping information after natural disasters. Since 2007, he has been working on the analysis of human settlements, in particular informal settlements such as slums and IDP/ refugee dwellings.

Mapping and Monitoring Cities from Space - the Global Human Settlement Layer

Satellite imagery offers unique opportunities to map and monitor cities at different levels of detail. The challenge is to extract the relevant information in an automated and reliable way to allow comparison of results over time and in different locations. The Joint Research Centre, the European Commission's in house science service, has developed a concept and the methodology for a Global Human Settlement Layer (GHSL). The GHSL proposes a new way to map, analyze, and monitor human settlements and the urbanization in the 21st century. GHSL integrates several available sources reporting about the global human settlement phenomena, with new information extracted from available remotely sensed (RS) imagery. So far, the GHSL is the largest and most complete known experiment on automatic image information retrieval using high and very high remotely sensed image data input. The GHSL automatic image information extraction workflow integrates multi-resolution (0.5m-60m) multi-platform, multi-sensor (pan, multispectral), and multi-temporal image data. The presentation will showcase the GHSL concept and illustrate it with a number of examples.

Michael Schreckenberg

University Duisburg-Essen

Bio

Michael Schreckenberg, born 1956 in Düsseldorf, studied theoretical physics at the University of Cologne, where he got his PhD 1985 in statistical physics, Habilitation in 1991 on neural networks. 1994 he changed to the University of Duisburg-Essen where he became in 1997 the first (German) professor for Physics of Transport and Traffic. Since more than 20 years he is working on the analysis, modeling, simulation und optimization of transport systems in large networks, especially road traffic, and the influence of human behavior on it. His current activities include online traffic forecasts, the reaction of drivers on information, individual navigation systems, Car-2-Car communication and the efficiency of road works.

Urban Road Traffic: Data, Models and Management

Humanity is facing enormous challenges at the beginning of the 21st century. This is a century where the ruptures brought about by technology and its use have the potential to offer unprecedented economic and social opportunities, as long as these changes benefit mankind, enabling us to be proactive players in our future world more than ever before. Our future models of society and civilization will be born and evolve out of these transformations. Europe must take a more active role in this crucial transformational dynamic for humanity! Our cities, which will soon be home for three-quarters of the world's population, are set to become the prime location for this reconstruction. Meeting these new challenges, this new complexity, implies the creation of new ecosystems.

Marta Gonzalez

CEE, MIT

Bio

Marta Gonzalez is an associate professor of Civil and Environmental Engineering of the Massachusetts Institute of Technology; she has joint appointments in the Center for Advanced Urbanism and the Operation Research Center. She joined MIT in July of 2009 after a postdoc in the Barabasi Lab and a PhD in Computational Physics from the University of Stuttgart in Germany (2006). Her research interests are focused on the analysis of vast data collections gathered from different human-driven activities and the formulation of models that elucidate the underlying principles of the observed scenarios. Marta has more of 5k citations publishing at the interface of interdisciplinary journals, transportation and physics. She is area editor of the IEEE Big Data journal and organizer of Workshops in Urban Systems both at the NetSci and the ASCE-EMI. She leads various projects with direct impact in cities funded by governments and industry. Marta's work pioneers urban scale models that inform decisions towards better cities, which look for alternative modes of transportation or more sustainable energy usage.

Data Science to tackle Urban Challenges in Transportation and Energy

Data science is finally enabling the opportunity to help cities around the world to become more livable, equitable, and resilient. Good estimates on how populations interact in space and with their urban infrastructures are needed to generate timely and better-informed strategies for mobility and energy planning. In my talk I will focus in methods to analyze sparse data form information and communication technologies. I present a pipeline to obtain a new generation of urban activity models while discovering behavioral insights from the data. Namely, I present a spatiotemporal mapping of raw mobile phone data into survey-less models of trip diaries. I show how this simplifies the study of urban traffic and allows us to generate social aware strategies to decrease congestion. As example of new insights, I present discoveries related to the mobility of social ties and route choice behavior at urban scale. I close, discussing new directions to model energy demand in the urban context and its insights to favor the adoption of efficient alternatives.

Mehdi Akbarian

MIT

Bio

Mehdi Akbarian received his Bachelor of Science in Civil and Environmental Engineering before joining MIT for his Masters and PhD studies. He is currently a postdoctoral fellow at the Concrete Sustainability Hub at MIT and has been researching the effect that pavements have on vehicle fuel consumption. He is now working on network level life-cycle assessment and life-cycle cost assessment models to improve sustainability of pavement management practices.

Carbon Management of Pavement Infrastructure using Data Analytics of pavement Life Cycle Impacts

In addition to surface texture and roughness induced Pavement-Vehicle Interactions (PVI), we recognize that the dissipation of mechanical work due to viscous deformation within the pavement structure contributes to fuel consumption. Through a combination of dimensional analysis, experiments and model-based simulations of energy dissipation in pavement structures, the key drivers of deflection-induced PVI are identified. These models are incorporated into pavement design, maintenance, and asset management decisions through life cycle cost analysis (LCCA) and life cycle assessment (LCA) frameworks. Specifically, we propose a pavement management strategy through network analyses of California and Virginia to minimize excess fuel consumption due to PVI and its associated greenhouse gas and aerosol emissions, given actual design and maintenance strategies of these networks.

Christoph Reinhart

Sustainable Design Lab, MIT

Bio

Christoph Reinhart is an Associate Professor in Building Technology at MIT where he is leading the Sustainable Design Lab, an inter-disciplinary group with a grounding in architecture that develops design workflows, planning tools and metrics to evaluate the environmental performance of buildings and neighborhoods. Products originating from the group – such as DIVA-for-Rhino, Mapdwell, DAYSIM and umi –are used in practice and education in over 90 countries.

Urban energy systems —Towards more sustainable city and neighborhood design

The United Nations estimates that the number of city-dwellers worldwide will grow until 2030 at a net rate of about two million per week. If this unprecedented urban growth continues to be largely ad hoc via informal settlements, sprawl and haphazard densification, global and local consequences for the environment, the economy and the mere quality of life of billions could be severe. Policy measures at the international and national level as well as technical advances can support positive change but the immediate implementation of sustainable infrastructure measures mostly happens at the municipal, neighborhood and campus level. City governments world-wide have adopted ambitious long-term GHG emission reduction targets and are exploring a plethora of measures from building energy audits and retrofits to the accelerated deployment of renewable energy, district heating and cooling, as well as combined heat and power systems. However, to understand the combined effect of such interrelated actions, decision makers require planning tools that provide spatially and temporally resolved energy demands data for all buildings, and that facilitate the evaluation of “what if” scenarios to prioritize alternative interventions. This presentation describes a series of interrelated research projects and case studies by the Sustainable Design Lab at MIT that demonstrate our evolving ability to reliably evaluate multiple dimensions of urban performance from operational and embodied energy to daylighting and walkability.

Masoud Ghandehari

CUSP, NYU

Bio

Masoud Ghandehari is Faculty at the Department of Civil and Urban Engineering at the Polytechnic School of Engineering and Head of the Urban Observatory at NYU's CUSP. Prior to joining NYU, he worked as a research fellow at The National Science Foundation Center for Advanced Cement Based Materials, and The Center for Quality Engineering and Failure Prevention at Northwestern University. Masoud began his career at Columbia University, and then worked with a consulting practice in New York City; where he worked on various large infrastructure renewal projects. Masoud did his graduate work at McGill University and Northwestern University with his doctoral thesis in Full Field Optical Metrology for Imaging Damage Localization.

Persistent and Synoptic Phenomenology — Cities from Rooftops

While there is an abundance of earth scale observational data available through space borne platforms, there is scant data to characterize cities with complete and granular coverage. Even in data-rich cities like New York, we are not able to simultaneously capture the short-term dynamics of phenomena such as building heat exchange, the urban heat island, the heat output from electro-mechanical systems, and gaseous pollutants and greenhouse emissions. Closing those gaps with high spectral, spatial, and temporal resolution is revolutionizing our understanding of the urban environment and sustainability, and the factors that impact the health and well-being of city inhabitants. This presentation will show the blue print of one of the first platforms for synoptic and persistent observation of cities, describing how it enables the analysis of large swaths of urban terrains, and how such data are designed to be interoperable with existing heterogeneous data and mapped against New York's open and other non-public datasets. I begin with the general concept and brief examples of the variety of modalities used. I will follow with detail of a spectroscopic imaging campaign recently carried out in NYC, where a hyperspectral imager was deployed in Hoboken NJ in order to continuously and passively map urban emissions and solid surface temperature variations in Westside of Manhattan.

Brian Vant-Hull

City College of New York

Bio

Brian Vant-Hull received an M.A. in Physics from Johns Hopkins university in 1993 and a PhD in Atmospheric Sciences from the University of Maryland, College Park in 2007. Since then he has been a research scientist at the NOAA-CREST institute in at the City College of New York, exploring topics involving satellite remote sensing such as thunderstorm tracking and lighting climatology. In 2012 he and his students began a series of field campaigns to characterize fine structure in the Urban Heat Island of Manhattan in collaboration with the Consortium for Climate Risk in the Urban Northeast (CCRUN), a NOAA Regional Integrated Science and Application program. This work in collaboration with the New York Department of Health and Mental Hygiene will be presented at the conference.

Validation of a Spatially Fine Scale Statistical Urban Air Temperature Model

Since mortality during heat waves is a sensitive function of temperature, prediction of temperature variations in densely populated areas is crucial. Air temperature can be viewed as part of the local urban climate, affected by local elevation, vegetation and building parameters. In previous conferences we have reported on a fine scale temperature variability model based on a series of street level field campaigns in Manhattan. The model blends fine scale spatial measurements with weather dependent temperature variability estimates to predict the daily amplitude of fixed spatial afternoon temperature patterns in this highly urbanized environment. The model has been running daily since the summer of 2015, and has been tested in hindcast mode against both a set of fixed instruments in Manhattan and against a set of volunteer stations throughout the city. The model shows modest improvement over a uniform temperature forecast when compared to instruments carefully placed in the shade, but shows no improvement when compared to the more randomly placed volunteer stations. Skill is closely related to elevation, and appears to be coupled to wind exposure.

Gregory Dobler

CUSP, NYU

Bio

Gregory Dobler is the Associate Director for Physical Sciences at CUSP and a Research Assistant Professor of Physics at NYU. His expertise is in image analysis, computer vision, time series, statistical analysis, and mathematical modeling of large data sets. Prior to joining CUSP, Greg was a Research Scientist at the Kavli Institute for Theoretical Physics specializing in multi-wavelength, full sky data sets from radio to gamma-ray energies, and led the discovery of one of the largest structures in the Milky Way. As the Chief Scientist of CUSP's "Urban Observatory" (UO), Greg applies data analysis techniques from astronomy and computer vision to images of New York City's skyline to study air quality, energy consumption, lighting technology, public health, and sustainability.

Better Cities through Imaging

I will describe how persistent, synoptic imaging of an urban skyline can be used to better understand a city, in analogy to the way persistent, synoptic imaging of the sky can be used to better understand the heavens. At the newly created Urban Observatory at the Center for Urban Science and Progress (CUSP), we are combining techniques from the domains of astronomy, computer vision, remote sensing, and machine learning to address a myriad of questions related to understanding the physical urban system. I will go through several specific methodological examples including energy consumption and air quality which can lead to improved city functioning and quality of life.

Francis O'Sullivan

Energy Initiative, MIT

Bio

Dr. Francis O'Sullivan is Director of Research for the MIT Energy Initiative, and a Senior lecturer at the MIT Sloan School of Management. He works on topics related to energy technologies, policy and economics including the evolution of power systems and the integration of large-scale renewables, particularly solar power. He is a lead author of the 2015 MIT Future of Solar Energy study.

Dr. O'Sullivan is a member of the U.S. National Academies' Roundtable on Science and Technology for Sustainability, and is a Senior Associate with the Energy and National Security Program at the Center for Strategic and International Studies. Prior to joining MIT, Dr. O'Sullivan was a senior consultant with McKinsey & Company.

Dr. O'Sullivan received his Ph.D., E.E., and S.M. degrees from the Massachusetts Institute of Technology, and his B.E. degree from the National University of Ireland, all in electrical engineering.

The rise of distributed energy and the challenges ahead

The energy sector is in a state of tumult and no more so than in the electric power sector where the very concept of the electric utility is being challenged by the rise of distributed energy systems, and particularly solar PV. The rise of distributed solar is a very exciting development; one that brings with it a range of important opportunities for addressing climate change and empowering individuals in terms of their energy usage. However, growing distributed solar PV penetration also brings challenges. These include the difficulty of integration into existing power system infrastructure, the erosion of traditional utility revenues and asymmetric welfare transfers. This paper will detail this set of benefits and drawback to the rise of distributed solar, focusing on experiences in the US and Europe, and will discuss how a balance can be struck to ensure distributed solar PVs future success.Thomas Kemper

Edith K. Ackermann

MIT Media Lab

Bio

Edith Ackermann is an Honorary Professor of Developmental Psychology, University of Aix-Marseille, France, and former Associate Professor of Media Arts and Sciences, MIT Media Laboratory. She worked as a Senior Research Scientist at Mitsubishi Electric Research Lab, Cambridge MA, and a Scientific Collaborator at the Centre International d'Epistémologie Génétique, under the direction of Jean Piaget, in Geneva, Switzerland. Current appointments and collaborations include: The Responsive Environments Group, Harvard Design School; The Personal Robots group, MIT Media Lab; The Computation Group, MIT Architecture; The Exploratorium, San Francisco, CA.; and The LEGO group, DK.

[Website: http://web.media.mit.edu/~edith/ blog: http://linkedith.kaywa.com/ Academia.Edu (publications) https://mit.academia.edu/EdithAckermann]

Building better cities: Forget smarts! Focus on mood!

The new forms of mobility and the senses of displacement and dematerialization that come from spending much of our lives in-between (on the go, plugged in, out of touch) call at once for stronger physical anchors and more flexible ties, for safe harbors and new destinations, for convivial places to mingle, play, and savor the moment. This presentation addresses some of the pitfalls to avoid as we design for today's city-dwellers, and stresses the importance of "fourth places" (or paths) as living laboratories for exploring alternative forms of dwelling, in situ. I promote the uses of "smart" tools as a means to measure mood, or sense atmosphere, and as an enabler of beneficial surprise encounters: the art of bringing together folks who wouldn't otherwise meet to do things they otherwise couldn't do! I illustrate my case with examples of transformative interventions..

Yaneer Bar-Yam

New England Complex Systems Institute

Bio

Professor Yaneer Bar-Yam is Founding President of the New England Complex Systems Institute. His research focuses on developing complex systems concepts and applying them to diverse areas of scientific inquiry and to major social problems. He has developed quantitative models for a wide variety of complex system behaviors including network dynamics, market instability and the current financial crisis, negotiation, economic development, pandemics and invasive species, ethnic violence, global food crises, and biological cell function and regulation. Professor Bar-Yam received his SB and PhD in physics from MIT in 1978 and 1984 respectively.

Human Urban Dynamics

Describing the dynamics of a city is a crucial step to both understanding the human activity in urban environments and to planning and designing cities accordingly. Here we describe the collective dynamics of New York City and surrounding areas as seen through the lens of Twitter usage. In particular, we observe and quantify the patterns that emerge naturally from the hourly activities in different areas of NYC, and discuss how they can be used to understand the urban areas. We observe the diurnal "heartbeat" of the NYC area. The largest scale dynamics are the waking and sleeping cycle and commuting from residential communities to office areas in Manhattan. Hourly dynamics reflect the interplay of commuting, work and leisure, including whether people are preoccupied with other activities or actively using Twitter. Differences between weekday and weekend dynamics point to changes in when people wake and sleep, and engage in social activities. We also identify locations and times of particularly high Twitter activity. These include early morning high levels of traffic as people arrive and wait at air transportation hubs, and on Sunday at the Meadowlands Sports Complex and Statue of Liberty. Moreover, we generate a sentiment map of NYC. We find that public mood is generally highest in public parks and lowest at transportation hubs, and locate other areas of extreme sentiment such as cemeteries, medical centers, a jail, and a sewage facility. These patterns of sentiment also fluctuate on both a daily and a weekly scale: more positive tweets are posted on weekends than on weekdays, with a daily peak in sentiment around midnight and a nadir in the morning. Our analysis points to the opportunity to develop insight into both geographic social dynamics and attention through social media analysis.