ESRC Strategic Network:
Data and Cities as Complex
Adaptive Systems
(DACAS)

JOINT DACAS ICTP-SAIFR WORKSHOP

ON MODELLING URBAN SYSTEMS

20–24 JUNE 2016
SÃO PAULO, BRAZIL

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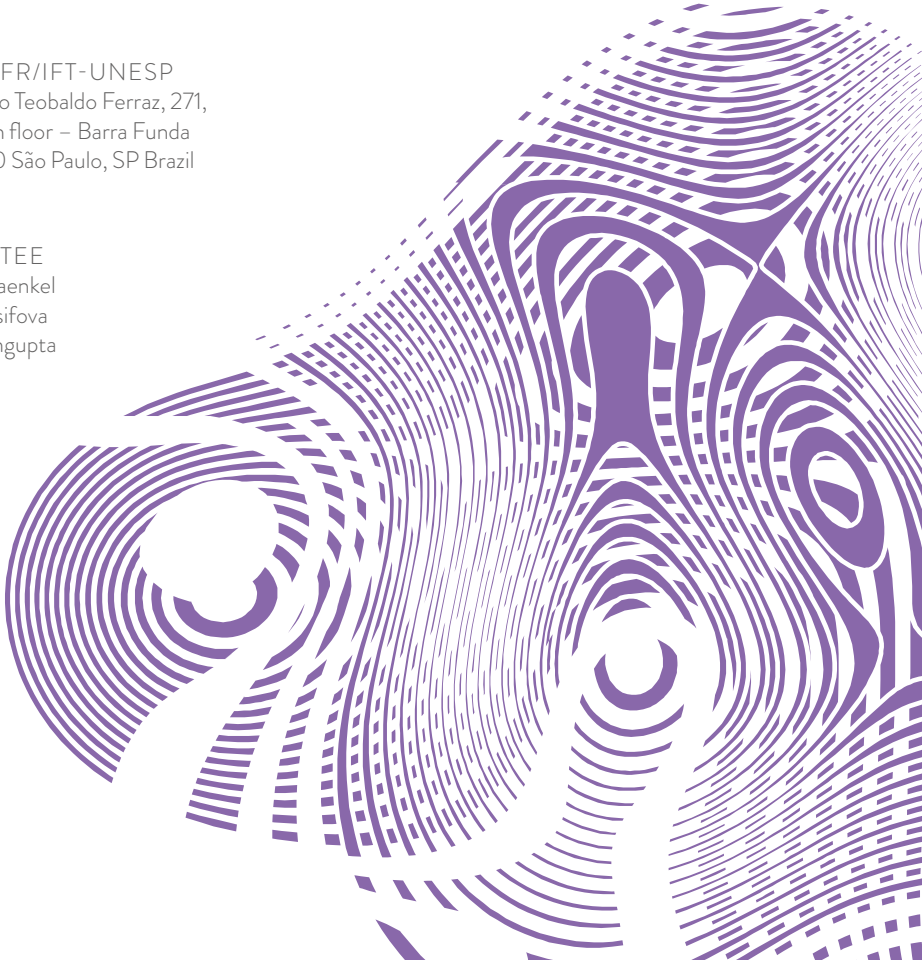

BACKGROUND

The aim of the ESRC Strategic Network Data and Cities as Complex Adaptive Systems (DACAS) is to promote an interdisciplinary complexity science approach to the study of urban data and the links between soft and hard systems as the basis for the development of innovative technological applications.

DACAS connects non-academic stakeholders from the public, private and third sectors and noted academics with backgrounds in various relevant disciplines in China, Brazil and the UK.

The week-long event in São Paulo will include talks, workshops and collaborative sessions with the aim to identify how DACAS activities can help to address the specific challenges of Brazil's urban transformation. These include:

- Changing living conditions (e.g., housing; access to infrastructure; social networks; social norms; etc.)
- Epidemiology (e.g., economic classes; migrant settlements; social movements; etc.)
- Changing movement patterns (e.g., employment; education; recreation; etc.)
- Spatial & infrastructural change (e.g., sanitation; transportation; health care; etc.)
- External factors (e.g., droughts; distribution of amenities; technology shifts; etc.)

The needs of local government, planning departments and NGO representatives will be discussed and incorporated.

The following questions will be addressed:

- What are the most pressing urban issues and how can they be defined as relational, transcalar and emergent?
- Which concepts from the complexity sciences challenge existing discipline-specific research?
- What are appropriate methods to address these issues using a complexity science framework?
- How can existing, discipline-specific methods be updated or transformed to research data and cities as complex adaptive systems?
- Which complexity science models can be applied to the study of data and cities as complex adaptive systems?

PROGRAMME OVERVIEW

<table>
<tr><th></th><th>MON
20/06</th><th>TUE
21/06</th><th>WED
22/06</th><th>THU
23/06</th><th>FRI
24/06</th></tr>
<tr><td>8:30 - 9:30</td><td rowspan="11">Arrival</td><td>Registration</td><td colspan="3"></td></tr>
<tr><td>9:30 – 10:30</td><td rowspan="2">Introduction
&
Stakeholders</td><td>Key Note</td><td>Key Note</td><td rowspan="2">Parallel:

Internal
Meetings</td></tr>
<tr><td>10:30 – 11.45</td><td>PhD/ECR
talks</td><td>PhD/ECR
talks</td></tr>
<tr><td>11:45 – 12:00</td><td colspan="4">Coffee Break</td></tr>
<tr><td>12:00 – 13:30</td><td>Case Studies</td><td>PhD/ECR
talks</td><td>PhD/ECR
talks</td><td>Internal
Meetings</td></tr>
<tr><td>13:30 – 15:00</td><td colspan="4">Lunch</td></tr>
<tr><td>15:00 – 16:30</td><td>Case Studies</td><td>Workshop</td><td>Workshop</td><td rowspan="5">Departure</td></tr>
<tr><td>16:30 – 16:45</td><td colspan="3">Coffee Break</td></tr>
<tr><td>16:45 – 18:15</td><td>Case Studies</td><td>Workshop</td><td>Workshop</td></tr>
<tr><td>18:15 – 18:30</td><td colspan="3">Coffee Break</td></tr>
<tr><td>18:30 – 19:00</td><td>Wrap-up
Day 1</td><td>Wrap-up
Day 2</td><td>Closing</td></tr>
</table>

DAY 1: INTRODUCTION & CASE STUDY PRESENTATIONS

INTRODUCTION:

NEW ICT DIRECTIONS USING URBAN DATA AND COMPLEXITY FRAMEWORKS

Ulysses Sengupta & Eric Cheung, Deljana Iossifova

This presentation examines new ICT tools developed using a complexity science framework to initiate alternative dialogues within East Manchester's planning and development agencies. The aim of the tools are to a) enable greater bottom-up participation and study of existing trends using multiple data mining methods; b) to develop extrapolated future scenarios based on multi-stakeholder input, towards equitable future planning paradigms. The understanding of cities as complex adaptive systems, with both natural and synthetic systems - in constant balancing and reinforcing loops - has relegated the majority of normative spatial planning models to limited testing of isolated phenomena and identifiable infrastructures. Recent digital tools utilising urban data have typically focused on visualisation and information dissemination. However, the integrated use of urban data can open up new research into urban trends through analysis of multiple correlational phenomena. Development and uptake of new methods and tools are dependent on the availability of data, the integrity and granularity of datasets, a trans-disciplinary approach to new model creation and structural change within existing agencies. This paper will expose two new digital tools aimed at informed (environmental, spatial, social, economic) co-production and dialogue around extrapolated and future scenarios.

THE CHALLENGES OF URBAN TRANSFORMATION IN BRAZIL

Tomás Wissenbach

Departamento de Produção e Análise de Informação – Deinfo Secretaria Municipal de Desenvolvimento Urbano – SMDU/ Prefeitura de São Paulo

COFFEE

TOWARD ENGINEERING AND CONTROL OF SELF-ORGANISATION IN SOCIO-TECHNICAL SYSTEMS

Rene Doursat

Self-organised, decentralised and adaptive systems, whether physical, biological or human-caused, are pervasive. (1) First, I will give a brief overview of "canonical" examples of such complex systems across various domains (pattern formation, collective motion, swarm intelligence, spatial communities) and topologies (cellular automata, self-propelled particles, complex networks). While it is generally impossible to characterise in analytical terms the emergence of group behaviour from a large number of elements, agent-based modelling and simulation (ABMS) are often able to reproduce it and make valid predictions. (2) Next, beyond the observation and study of spontaneous systems, I will ask whether it is also possible to influence, steer or even create new forms of self-organisation—in sum, reconcile complex systems with engineering principles. Design and control are not commonly associated with natural phenomena: the latter happen outside planning or intervention, while the former

are about intentionally making structures and reshaping the environment. Yet, by identifying morphogenetically architected complex systems (MACS) to be those large sets of agents that reliably and programmatically give rise to specific architectures and functions from local interactions only (such as multicellular organisms and insect constructions), we can take emergent properties seriously while operationally not give up on (re)inventing systems based on such properties. (3) Toward this goal, I will present Morphogenetic Engineering, a new discipline investigating how to program the bottom-up development and evolution of multi-agent structures toward beneficial outcomes that cannot be directly planned top-down. Potential applications in the socio-technical sphere can be found in a self-configuring internet of things, self-balancing energy grid, self-deploying disaster response, or self-regulating institutions. In each scenario, the system should build its own dynamical connections and activity on the basis of individual rules and peer-to-peer communication—modulated by users and influencing them in turn.

CASE STUDY 01: PROTO-URBAN DEVELOPMENT ON THE PERIPHERY OF A BIOFUEL PLANTATION IN MOZAMBIQUE

Alexandros Gasparatos

Case Overview: Niqel is a biofuel plantation in central Mozambique located in a miombo woodland area. The local rural communities have been historically very poor and overwhelmingly dependent on slash-and-burn subsistence agriculture for their livelihoods.

In 2008, Niqel started producing jatropha (an oilseed crop that can be used for liquid biofuel production). Immediately the operation of Niqel generated employment opportunities in an area where formal jobs were almost non-existent. At the same time Niqel developed a road infrastructure network that connected previously unconnected areas with the main tar roads between the closest large cities (Chimoio and Beira). The better connectivity and income circulating in the community seem to have been major drivers of transformation as witnessed by the expansion of agricultural activities (more and larger farms as farmers now have better access to markets) increasing number of small shops in the area

The question is whether the operation of the plantation is catalyzing a proto-urban transition in a deeply poor rural area, and how tools and concepts from complexity theory can explain the transformations currently observed.

LUNCH

CASE STUDY 02: SUSTAINING THE TRANSITION – A TALE OF TWO CITIES

Christopher Doll

Case Overview: This case contrasts the response to two health crises in India. One of the most recent outbreaks of pneumonic plague occurred in the city of Surat, Gujarat in 1994. A series of changes were made to the structural organisation of the city and improvements in sanitation brought many co-benefits. The city has gone from one of the filthiest cities in India to being recognized as one of the cleanest. By contrast, Delhi struggles to manage ever increasing air pollution despite a raft of measures that have been introduced and constant legislative pressure. Why have measures worked in one case and not the other?

This comparative case takes a systems approach understanding the difference in effectiveness by firstly, considering the fundamental nature of each problem and secondly considering the structurally difference of the required interventions in order to make sustainable impact.

Data sets: A week's worth of footfall data (entry and exit) for every station in the first two phases (current) Delhi metro at an hourly resolution

(from 05:00-23:00, 17 – 23 October 2011, manually geocoded and averaged for the weekday and weekend. The raw data comes in a daily format (Mon-Sun).

CASE STUDY 03: THE MASTER PLANNING AND DESIGN OF LASHA COMPREHENSIVE BONDED ZONE

Jun Luo

Case Overview: In the past 20 years, China experienced rapid urbanization. However, this movement has changed the traditional urban landscape, spatial and social pattern and contexts of many cities and towns, causing the same appearance being of thousands of cities. Various kinds of industrial and economic development zones were constructed, which only contain industrial functions with low building density and plot ratio. This model changed the patterns of people movement and transportation, so-called urban epidemiology, and lost cultural identity.

Our aim is to plan and design a modern industrial zone which integrates industrial functions with urban life – a real city possessing local cultural spirits. To achieve this, one of our main tasks is to determine an appropriate and relational function combination by modelling using a complexity science approach.

CASE STUDY 04: WUHAN TIANDI PROJECT

Shidan Cheng

Case Context: Wuhan Tiandi project is a famous city renovation project in the old city centre of Wuhan. It consists of a high quality residential community and some heritage sites; moreover, it has achieved great business success. This project has turned a declining area into a luxury residential and commercial area. During this process, spatial change, migration, population structure change and business model change have interacted with each other.

Case Overview: The aim is to explore how the new project changed the area, and the process of developing and rebalancing of this change.

Questions:

- What is the change of population structure and population incoming in this area?
- What is the spatial change and infrastructure change in this area?
- How has this project influenced the business models?
- How has this project influenced local people's behaviours?

Expectations of outcome: the new project has changed the physical conditions such as infrastructures, buildings, streets and indoor decoration; the change of physical conditions have changed the population structure which means more rich people settle in this area; the change of population structure has changed the business model and people's behaviours. At the beginning, the new project led to a rapid change, however, as the population structure stabilises, the whole area achieved a new balance.

A complexity theory provides more insights from a simple physical conditions change to the rebalancing and interaction among physical conditions, population structure, business model and people's behaviours.

Data Sets:

- The change of physical conditions during 5 years
- The change of population structure during 5 years
- The change of business model during 5 years
- The change of people's behaviours in some specific area during 5 years

COFFEE

CASE STUDY 05: CAUSALITY IN COMPLEX SYSTEMS AND ITS APPLICATIONS TO URBAN SCIENCE

Murilo da Silva Baptista

In a causal world, the direction of the time arrow dictates how past events in a variable, 'A', cause future events in another variable, 'B'. A natural way to identify causality is by understanding the direction of the flow of information, which points towards the variable being affected ('B'). Identification of causality is both the starting point for modelling a complex system, or the final goal of data-driven modelling designed to identify how different variables of a complex system affect each other.

In this case study, we will understand how the direction of the flow of information from time-series measurements can be accessed, and present a new methodology that can be employed simply and without much computational effort. As a hands-on experiment, we will study how causality can be accessed from coupled nonlinear dynamical systems (dataset 1) and how from a single time-series measurement of the gravitational field (dataset 2) one can determine whether sea tides affect or are affected by oscillatory phenomena of the gravity field produced by the planet Earth (dataset 2). The analysis to be done in dataset 2 has a broad applicability in urban science. For example, it can be used to assess the state of large underwater reservoirs that supply water to a city, e.g. Sao Carlos, where 50% of its water supply comes from the Guarani reservoir.

CASE STUDY 06: UNDERSTANDING THE CO-EVOLUTION OF TRANSPORTATION SYSTEMS

Nir Oren

Case Overview: The movement of goods and people lies at the heart of modern life. Recently, companies such as Uber have disrupted the traditional models of on-demand transportation systems, and are now expanding into the logistics realm. We would like to determine how such companies interact with more traditional ODT(L)S, what equilibria exist when multiple providers are present in an area, and how incentives can be introduced to maximise social welfare.

Data Sets: There are a variety of datasets available which can be used to begin studying these problems, including

- New York taxi data (see http://www.andresmh.com/nyctaxitrips/) and
- Uber data (http://fivethirtyeight.com/tag/uber/).

Analysing such datasets may allow for insights to be obtained regarding changing travel norms, and, together with tools such as AgentPolis (http://agents.felk.cvut.cz/projects/agentpolis), additional synthetic data can be generated for further investigation. Finally, with the imminent arrival of self-driving cars, we may use systems such as AgentPolis to determine how urban infrastructure should be designed in the age of increasing shared transportation choices.

The transportation network is one in which feedback effects (e.g., traffic jams) are rife, and a complexity systems based approach could help better model, understand and optimise such systems.

CASE STUDY 07: RESILIENCE OF INTERDEPENDENT URBAN INFRASTRUCTURE SYSTEMS IN LONDON

Nils Goldbeck

Case Context: London has joined the 100 Resilient Cities network and is developing an urban resilience strategy in order to future proof the city, e.g. against the effects of climate change. A particular resilience challenge is the

protection of critical infrastructure. Like many other cities, London depends on the functioning of a multitude of infrastructure systems, such as transportation networks, energy supply and communication infrastructure. Improving the resilience of such large-scale engineering systems is challenging, especially when the systems are already under pressure from growing demand, ageing infrastructure assets and cuts in public funding. Building resilience is further complicated by the fact that infrastructure systems are interconnected in complex ways. Faults in one network could potentially propagate across system boundaries and lead to cascades of failure with severe consequences for the wellbeing of London's population and the business continuity of many organisations. Current technological trends, such as intelligent transport systems and smart energy, are expected to further intensify the interdependence between different infrastructure sectors in the future.

Case Overview: This case study considers four civil infrastructure systems in London:

- road network
- metro system ("Tube")
- electricity distribution network
- mobile communication network

Interdependencies between these systems arise from various phenomena (e.g. physical, co-location, cyber effects) and affect system operability on various levels (e.g. component reliability, network flows, demand for infrastructure services). The aim of this case study is to use complexity science to improve the understanding of such interdependencies, to develop new approaches for modelling interactions between infrastructure networks and to propose interventions that could enhance the resilience of London's infrastructure.

Data Sets:

- Network topologies are available from various sources (e.g. OpenStreetMap, Transport for London, UK Power Networks, OpenCellID)
- Demand for infrastructure services is available for some infrastructure sectors (e.g. LSOA electricity consumption, rolling origin and destination survey). Census data can be used to estimate demand where actual data is not available
- Interdependency data is available for some specific interdependencies (e.g. the electricity supply for the metro system) but is generally very difficult to obtain for most other systems. Soft datasets that could be used for the analysis include incident reports (e.g. on the 2015 underground fire in Holborn) and generic infrastructure system configurations
- Hazard exposure data is available for specific hazard types (e.g. high resolution flood maps provided by the Environmental Agency).

COFFEE

DISCUSSION & SELECTION OF CASE STUDIES

Three case studies will be selected from those presented on Day 1 and six teams will be formed (two senior researchers and three PhD/ECR per team) to work together during the workshops on Day 2 and 3. Participants will work together with the overall aim to identify data availability and needs and suitable techniques for modelling linked urban systems based on data.

DAY 2: PROBLEM FORMULATION & CONCEPT TRANSFERABILITY

KEYNOTE: URBAN FORM AS AN EVOLVING SYSTEM

Romulo Krafta (Universidade Federal do Rio Grande do Sul) is Professor of Urban Morphology at the Department of Urbanism at the Federal University of Rio Grande do Sul. He received his Bachelors Degree in Architecture at the Federal University of Rio Grande do Sul and obtained a Diploma in Urban Transport Planning – Geipot and a MA in Urban Design at the Oxford Polytechnic (presently Oxford Brookes University). In 1992 he finalised his PhD in Urban Science at the University of Cambridge. After completing his academic qualifications he undertook postdoctoral research at the CASA Centre for Advanced Spatial Analysis at (University College London) and at the Programa de Pos Graduação em Urbanismo (Universidade Federal do Rio de Janeiro). He is actively involved in the Graduate Programme of Urban and Regional Planning (PROPUR) and the CNPq Research Group Urban Configurational Systems.

Abstract: Cities are very large manufactures made up and constantly updated by a very large number of uncoordinated and myopic social agents; each one of those agents has its own particular purposes, values, goals and strategies, and cities show a remarkable degree of spatial organization. Urban form has been traditionally treated as a by-product of social, supposedly higher level, interaction, although more recent research on spatial configuration and allometry has suggested that it would have a nature and dynamics of its own.

Our research group focuses on models that can describe and simulate the evolution of urban form as self-organizing system. Starting from a very disaggregated description of the urban fabric, we develop models designed to describe and measure different spatial attributes of urban space, to assess urban performance, to simulate its evolution through time and to relate it to other variables of the urban system. In part I it is explained the fundamentals of representation and data gathering, in part II the models of state description and evaluation are briefly explored. Part III deals with spatial dynamics and our efforts to reproduce some processes of urban form evolution. Finally a few applications of these models to urban analysis and planning are examined.

PHD AND EARLY CAREER RESEARCHERS

Young researchers will outline how their disciplinary perspective (such as physics, biology, ecology, economics, etc.) on complexity science and theory can be used to study the phenomena of urban transformation with a focus on Brazil.

01 A SYSTEMS-THINKING INFRASTRUCTURE ENGINEER'S PERSPECTIVE ON URBAN TRANSFORMATION COMPLEXITY

Christopher Bouch

I would describe my disciplinary perspective as being that of a systems-thinking infrastructure engineer. My view of complexity aligns with that of Warren Weaver's when he wrote about organised and disorganised complexity. I view many of the designed, complex technical systems found in cities today (transport, waste management etc.) as examples of organised complexity; these have to interface with cities' complex social systems, which it could be argued are examples of disorganised complexity.

I address the organised complexity of designed systems using systems engineering techniques, and have developed a model-based systems engineering methodology to help create models of the existing system, which can be used to identify in advance the potential impact of proposed changes. I approach disorganised complexity from the perspective of Checkland's soft system methodology, and am increasingly interested in human psychology as it applies to the interface between technical and social systems. In particular, I am exploring whether a framework of human behavioural heuristics can be identified, based on the existing psychology literature, to aid designers.

My perspective extends to complex adaptive systems with particular regard to business and the development of business models. I am working on a systems approach to the development of business models for infrastructure in cities that seeks to leverage the complex interdependencies between infrastructures to generate economic, social and environmental value.

These perspectives on complexity offer several ways into studying the phenomena of urban transformation, particularly with regard to the infrastructure that will facilitate, but can also hinder, change. They can shed light on the way infrastructures are linked and what this means for urban resilience; they can help ensure that infrastructures are designed in ways that secure user participation and support; and they can contribute to value capture and realisation of the funding that will be necessary to support transformation.

02 PHYSICS AND THE STUDY OF URBAN TRANSFORMATIONS

Edgardo Brigatti

The contribution of physics to complexity science can generate fecund approaches in the study of urban transformations. Solid theoretical concepts engendered numerous methodologies applicable to the description of urban dynamics which enable quantitative analysis with an attentive interdisciplinary perspective.

Among these methods we can mention scaling laws. They are useful in the identification of general and universal properties produced by different and specific microscopic interactions. For example, they outlined clear relations between socio-economic quantities (gdp, patents, crime, traffic congestions and diseases) and population or system size.

Network theory is a fundamental tool for describing the dynamics of individuals' connections (social networks, event and political outbreaks) and the shape of infrastructural networks (transports, information, resources and energy networks). Phase transitions and non-linear physics are essential for the description and prediction of the transitions between regimes with very different properties (efficient/collapsed infrastructures, different social equilibrium states, etc....). In particular, the prevention of economic or ecological catastrophic transitions and the characterisation of the system resilience to that abrupt shifts are a crucial task.

Pattern formation can describe mechanisms and outputs of different spatio-temporal patterns of hard (urban geometry and morphology) or soft datasets (cultural or socio-economic structures).

Agent based models allow to naturally construct emergent and auto-organised structures from the definition of local microscopic rules. It is probably the most powerful tool for generating possible different scenarios which allow a quantitative probabilistic approach for future urban planning and design, risk management and options evaluation.

These methods should be used linked with data mining techniques for the analysis of the big data sets available from governments and private institutions. Among these techniques, new designed complexity measures should allow the extraction of information and recognition of patterns essential for the description, the hypothesis testing and the predictions in our systems.

03 SCALING LAWS IN CITIES

Fabiano Lemes Ribeiro, Camilo Rodrigues Neto, Fernando Fagundes Ferreira and João Vitor Meirelles

Cities were born to bring together individuals willing to trade surpluses. These individuals, previously separated in space, began to coordinate their production, to specialize and trade surpluses in a more constant and efficient manner. The main function and the essence of the city is to generate interactions in space and time between different individuals. Human settlements leverage interactions by spatially joining its inhabitants.

Theoretically, the probability of encounters and interaction grows as the population and produces reductions in transaction costs and communication society, and other co-location advantages.

Socioeconomic related properties of a city seems to grow faster than a linear relationship with the population, called superlinear scaling. Reversely, the larger a city, the more efficient it is in the use of its infrastructure, leading to a sublinear scaling. To build a quantitative theory of cities we must take into account the city's geometry to calculate aggregate amounts that generate social and infrastructure indexes.

In the present work we address a simple explanation for the scaling law in cities based on fractal properties of the cities and as well as on the behavior of individuals. We follow the statistical mechanics approach and the result was a very simple model, just to obtain the scaling of social and infrastructure indicators. For that, we introduce a measure of social potential energy which capture the influence of social interaction on the economic performance and the benefits of facilities in the case of infrastructure offered by the city. We assume that the population density depends on the fractal dimension and the individual interaction intensity decay with distance. As a result we obtain a power Law scaling for social indexes and for infrastructure. Those scaling are coherent with empirical data. An agent based model is proposed to make computational experiments and test the hypothesis.

04 THE ROLE OF INSTITUTIONS IN THE TRANSITION TO DISTRIBUTED URBAN ENERGY GENERATION

Allison Bridges

Although urban areas in Brazil are not currently major emitters of greenhouse gases (GHGs), metropolitan areas in the country are experiencing rapid growth. Without coherent policy direction at the local level struggles to overcome barriers present in the transformation to the green economy will continue to plague the developing world. Focused in the city of Florianópolis, Brazil, this research maps the movement toward sustainable urban development by analyzing historical changes in local policies and planning practices as they relate to low-carbon energy. Historical analysis of institutional support for local energy innovation, supportive regulation, planning directives, and creative financing, provides a timeline of the emergence of opportunities in support of local level distributed energy resources. There is significant potential in the application of complexity science methods in the energy sector as it allows for a greater understanding of energy systems and their linkages to social and environmental behaviors and processes. As with other systems, energy systems are composed of actors engaging with each other through physical as well as social networks. The interactions of end-users, suppliers, generators and distributors are governed by institutional structures. With policy analysis in the energy sector dominated by traditional economic analysis, complexity science has the capability to better capture interactions between institutions and the actors they influence and govern. As such, soft systems methodology (SSM) will be used to analyze how institutional arrangements and the interactions

between various stakeholders give rise to new patterns of collective behavior that impact urban energy markets. In the analysis of systems in transition, this application has the potential to provide insight into the long-term drivers of the development of local level energy infrastructure.

05 STUDY OF PROPERTIES AND ROBUSTNESS OF THE PUBLIC TRANSPORT NETWORK OF SÃO PAULO

Sandro Sousa

Every complex system has an inherent network that represent the structural relationship between its elements, and a natural way to interpret this interaction is through a graph (Newman; Barabasi; Watts, 2006). In these current research, the urban public transport system of São Paulo is reinterpreted as a coupled (bus and rails) complex network, bypassing operational details and focusing on connectivity. Using GTFS data to empirically generate the graph, a statistical characterisation is made by network metrics where different radius values are used to group nearby stops and stations that were disconnected before. That can be interpreted as a public policy tool, representing the user's willingness to get around the nearest point to access transportation. This process has shown that increasing this willingness generates great reduction in the distance and in the number of jumps between buses, trains and subways lines to achieve all the network destinations. An exploratory model is used to test the robustness of the network by randomly, deterministically and preferentially targeting the nodes and links. According to the grouping radius, aka willingness, different fragmentation values were obtained under attacks. These findings show how Complex Networks can be used to model and investigate infrastructure systems, simplifying to its connectivity but keeping the whole system in mind.

LUNCH

WORKSHOP: PROBLEM FORMULATION & CONCEPT TRANSFERABILITY

Three case studies will be selected from those presented on Day 1 and six teams will be formed (two senior researchers and three PhD/ECR per team). Participants will work together with the overall aim to identify data availability and needs and suitable techniques for modelling linked urban systems based on data. The focus of workshop activities will be

- Problem Formulation: concerned with defining urban systems (scalar, temporal, behavioural and spatial, etc.) and minimum and maximum levels of system definition for soft and hard systems
- Concept Transferability: addresses the identification of appropriate theoretical concepts from the complexity sciences to challenge existing disciplinary research ontologies

COFFEE

DISCUSSION OF FINDINGS AND SUMMARY PRESENTATIONS FROM TEAMS

PhD/ECRs in each team are asked to take notes during discussions and work together to produce coherent summaries of workshop activities , progress and findings. Specific instructions - relating workshop activities to the requested reports – will be provided during the event.

DAY 3: APPROPRIATE METHODS & MODEL TYPOLOGY

KEYNOTE: AGENTS AND MULTIAGENT SYSTEMS IN TRAFFIC AND TRANSPORTATION

Ana Bazzan received her Engineering Degree from the University of São Paulo (USP), and her PhD in 1997 from the University of Karlsruhe (now KIT), Germany. She is an associate professor at UFRGS (Computer ScienceDepartment) in Porto Alegre, Brazil. She is a fellow of the Alexander von Humboldt Foundation. Her professional activities include: associate editor of the journals Autonomous Agents and Multiagent Systems, Advances in Complex Systems, and Journal of Multiagent and Grid Systems; co-general chair of the AAMAS 2014 (the premier conference in the area of autonomous agents and multiagent systems); member of the board of the Int. Foundation for Autonomous Agents and Multiagent Systems (IFAAMAS). Her main research interests are: multiagent systems, multiagent learning, complex systems, machine learning, agent-based simulation, and applications of AI and multiagent techniques in traffic simulation and control.

Abstract: Urban mobility is one of the pillars of smart cities. In this talk I discuss how to make cities smarter, concentrating on mobility. I start by introducing some figures about mobility, and by listing the main challenges. As we see, some of these challenges relates to data. I discuss how participatory sensing is key in smart cities. Indeed, with the wide-spread use of smartphones, now, more than ever, the user has the possibility to influence systems that have been considered very technical (e.g., control of traffic lights), creating a socio-technical system. This kind of system shows that the era of passive users is over; now users also can act as data providers (or sensors) as well, thus changing the paradigm. Following, I discuss four facets of the problem: modelling, information systems (e.g. route guidance to the road user), control, and new technologies applied to urban mobility. The second part of the talk shows how agents and multiagent systems can contribute with solutions. I also make a parallel between multiagent systems and complex systems. In both, there are some issues associated with the complexity of the problem: the number of agents is high; typically agents are highly adaptive; they react to changes in the environment at individual level but cause an unpredictable collective pattern, and act in a highly coupled environment. In the last part of the talk, I present what is being developed in our group at UFRGS.

06 COMPLEX ADAPTIVE SYSTEMS APPROACH TO UNDERSTAND DISASTER RESILIENT CITIES - CASE STUDIES ACROSS 100RC

Eleanor Murtagh

Urban resilience examines cities as complex adaptive systems to understand how multi-dimensional shocks and stresses interact across temporal and spatial scales. Research is being conducted on city resilience strategy design and implementation as part of the Rockefeller 100 Resilient Cities initiative, specifically how interventions across sectors contribute to disaster resilience. As part of the 100RC process, cities identify risks, prioritise key areas and devise actionable strategies, working across complex systems of transportation, infrastructure, environment, economy and society. There is, however, limited empirical evidence of how these systems interact to create urban resilience. Research focuses on how to advance methods to model to predict how small changes as part of city resilience strategies will

affect the behaviour of the city or system and how to measure the impact of projects having co-benefits across sectors. Research hopes to shed light on how interconnected risks and inversely resilience may evolve and affect other systems and to observe networked risks to understand multiple causes and effects. The high level of complexity associated with disaster risk requires new methods to model and understand relationships and assist with decision making, and the application of Bayesian network analysis is being tested. This study is examining what data is consulted and utilised in identifying urban risks, how these sources are integrated and how they are used to prioritise action within the resilience strategy, particularly how to balance quantitative data with qualitative participatory input from citizens. Case studies are being conducted across post-industrial cities involved in the 100RC network.

07 BIG-DATA DRIVEN TRANSPORT PLANNING WITH AGENT-BASED SIMULATIONS

Cuauhtemoc Anda

New Big Data sources such as mobile phone call data records, smart card data and geo-coded social media records allow us to observe and understand mobility behaviour on an unprecedented level of details. But simply observing is not particularly helpful for planning purposes. To allow for prediction in what-if scenarios, we need to understand and contextualise the information contained in such Big Data sources to inform models of travel behaviour and adapt them to be useful in travel demand modelling frameworks.

On the other hand, Multi Agent-based simulations are currently leading the way of travelling demand forecasts. They are based on the concept of evolutionary algorithms and are considered to be a more realistic approach as it allows us to observe flow pattern as a collective consequence of individuals' participation in activities. In addition, they represent a more sensible model, which can predict in response to external policies through complex behavioural adaption patterns.

However, these models are data hungry. A synthetic population that represents a region's population, as well as fully descriptive itineraries for every agent are needed. Commonly, this information is derived from traditional Household Survey Interviews, which are costly, not frequently collected, and represent only a single-day observation period.

To this extent, opportunistic datasets such as mobile phone traces, combined with other available ones (e.g. smart card data, social network data) might be used to lower the barrier-to-entry, and portray a more accurate and updated version of the city mobility patterns. Thus, the challenges to look ahead comprise of suitable data mining algorithms, and an exploration of privacy preserving mechanisms (i.e. differential privacy) to be included in such models. This will ultimately allow us to have better understanding on the evolution of urban mobility patterns, and help us plan for more liveable cities.

COFFEE

08 DEALING WITH RESONANCES IN THE URBAN CONTEXT

Gabriela Depetri, José Carlos Sartorelli, Bóris Marin and Murilo S Baptista

The phenomenon of resonance happens when an external oscillatory signal amplifies the vibration of a system at preferential frequencies. It is at this state that the system optimally extracts energy from the excitation, providing an ideal landscape for the efficient functioning of many natural and technological systems. It is also a common phenomenon in the urban scene, from the construction of cable-stayed bridges to dealing with architectural sound vibration. Even a demolition hammer or other pneumatic demolition machines resonate with the material

to be demolished.

We present a paradigmatic model to describe parametric resonances, that arise from time-dependent modulation of system parameters: a parametrically excited simple pendulum. This system consists of a planar simple pendulum whose pivot oscillates harmonically. We will show how breaking the symmetry of the system, by letting the pivot oscillate along a tilted direction, affects the occurrence of stable periodic oscillations. By applying the Melnikov subharmonic function, we shed light on our observations. We therefore pave the way to understand other more complex systems that rely on optimal resonance factors to extract energy from the external vibrating excitation.

09 DEVELOPMENT OF AN AGENT-BASED MODEL TO INVESTIGATE THE FORMATION AND EVOLUTION LEISURE-TIME PHYSICAL ACTIVITY POPULATION PATTERNS

Leandro Garcias

Purpose: To develop an agent-based model to explore how the interaction between psychological traits and built and social environments leads to the formation and evolution of leisure-time physical activity (LTPA) patterns in adult population.

Methods: The modelling process consisted of three stages: development of a conceptual map, based on literature review (psychological, social and built environment aspects) and expert-based consultation; creation and verification of the model's algorithm; and parameterisation, consistency, and sensitivity analyses. The model's algorithm has been created following a verification protocol to ensure that the algorithm has been implemented accurately.

Results: The elements of the conceptual map are the person's intention; the behaviour of the person's social network and the community at large; and the perception of quality, access and available activities of places where LTPA is practiced. The agent-based model represents a hypothetical community containing two types of agents: people and places where LTPA is practiced. People interact with each other and with the built environment over time, generating population temporal trends of LTPA and intention. Sensitivity analysis indicated that the temporal trends of LTPA and intention were highly sensitive to the influence of the person's current behaviour on her future intention, the person's access to information about her environment, and the proportion of places where LTPA is practiced.

Conclusions: The conceptual map and the agent-based model are suitable to investigate the formation and evolution of LTPA patterns in adult population. The influence of the person's behaviour on her intention, the person's access to information about her environment, and the proportion of places where LTPA is practiced are important determinants of the formation and evolution of population patterns of LTPA in this model.

10 SUPER-LINEAR SCALING FOR INNOVATION IN CITIES AND POTENTIAL GENERATIVE MECHANISMS

Ludmila D. Ribeiro

Since cities are central to human civilization, it is important to understand their dynamics in a predictable, quantitative way. Many diverse properties of cities from Gross Domestic Product (GDP) to urban electric cables length are shown to be power law functions of population size with exponents values varying from 0.8 to 1.35.

In the one hand, doubling the population of any city requires only about an 85% increase in infrastructure (road surface, length of electrical cables or water pipes), which means that they scale sublinearly with exponents values clustered around 0.85. On the other hand, there's strong statistical evidence that quantities reflecting wealth creation and innovation of cities (personal income, GDP, number of new patents, and number of educational and research institutions

all increase by approximately 15% more than the expected linear growth which means that they scale superlinearly with exponents values clustered around 1.15).

The most striking feature of the data is the many urban indicators that scale superlinearly with city size, over different years and nations. These indicators show that larger cities are associated with higher levels of productivity.

In this paper we attempt to explain the superlinear scaling behaviour exploring two potential generative mechanisms: preferential attachment and the general random graph method (GRG).

In preferential attachment, a network formation model, at each step, the probability of a new node receives a new edge is proportional to its current degree. In the general random graph model, edges are inserted probabilistically, according to a probability proportional to the product of the degrees of the two endpoints (nodes).

These network formation models have been applied to a large number of complex systems, including social networks. In fact, many authors have shown that some functions of cities can be determined by network principles that capture its long-term dynamics.

LUNCH

WORKSHOP: APPROPRIATE METHODS & MODEL TYPOLOGY

Three case studies will be selected from those presented on Day 1 and six teams will be formed (two senior researchers and three PhD/ECR per team). Participants will work together with the overall aim to identify data availability and needs and suitable techniques for modelling linked urban systems based on data. The focus of workshop activities will be

- Appropriate Methods: addresses the identification of data availability and needs and, subsequently, appropriate, inadequate or incompatible methods for the collection and analysis of qualitative and quantitative data in the study of urban transformation and cities as complex adaptive systems
- Model Typology: concerned with the development of a model typology based on suitable model types from the various complexity sciences when applied to a study of data and cities as complex adaptive systems

COFFEE

DISCUSSION OF FINDINGS AND SUMMARY PRESENTATIONS FROM TEAMS

PhD/ECRs in each team are asked to take notes during discussions and work together to produce coherent summaries of workshop activities , progress and findings. Specific instructions - relating workshop activities to the requested reports – will be provided during the event.

CLOSING

DAY 4: TEAM REPORT PREPARATION & INTERNAL DACAS MEETING

The following activities will take place in parallel:

TEAM REPORT PREPARATION

PhD/ECR will meet to discuss and prepare work for the requested workshop reports. Specific instructions will be provided during the event.

INTERNAL DACAS MEETING

DACAS members and invited guests will meet to discuss the outcomes (and outputs) from the workshop. Ideas for the forthcoming Summer School in Manchester will be exchanged and a strategy for preparation activities will be decided.

LUNCH & DEPARTURE

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PRACTICALITIES

GROUND TRANSPORTATION FROM GUARULHOS INTERNATIONAL AIRPORT TO PANAMBY HOTEL

There are three options to reach Panamby Hotel from the airport:

Option 1:

See map on next page.

Line 257 – Aeroporto de Guarulhos / Metrô Tatuapé. This is the cheapest option, which costs R$ 4,30+ metro R$3,80 (around 2.00USD total). The destination you have to take is Metro Tatuapé, and get off at the final station (which is Metro Tatuapé). From Metro Tatuapé follow the steps below:

- Take the metro towards "**Palmeiras Barra-Funda**"
- Get off at **Palmeiras Barra-Funda** (which is the ninth stop)
- Follow the signs to the exit which is called **Av. Marques de Sao Vicente**. After passing through the turnstiles, turn left and walk until the end of the station. At the end of the station, go down the stairs and you will see immediately a large white and blue building across the street in front of you. The white and blue building is the Instituto de Artes, and next to it is a large white and **green building** which is the Instituto de Fisica Teorica.

Option 2:

By bus - Airport Bus Service, as you walk outside the terminal you will see immediately a line of buses, the Airport Bus Service. The bus fare is R$45,50 (approximately 12USD), and near the buses there is a ticket office. Each bus has its destination noted on the front or side. The destination you have to take is "**Praça da República**" and get off at San Gabriel Hotel (it takes about 1 hour).

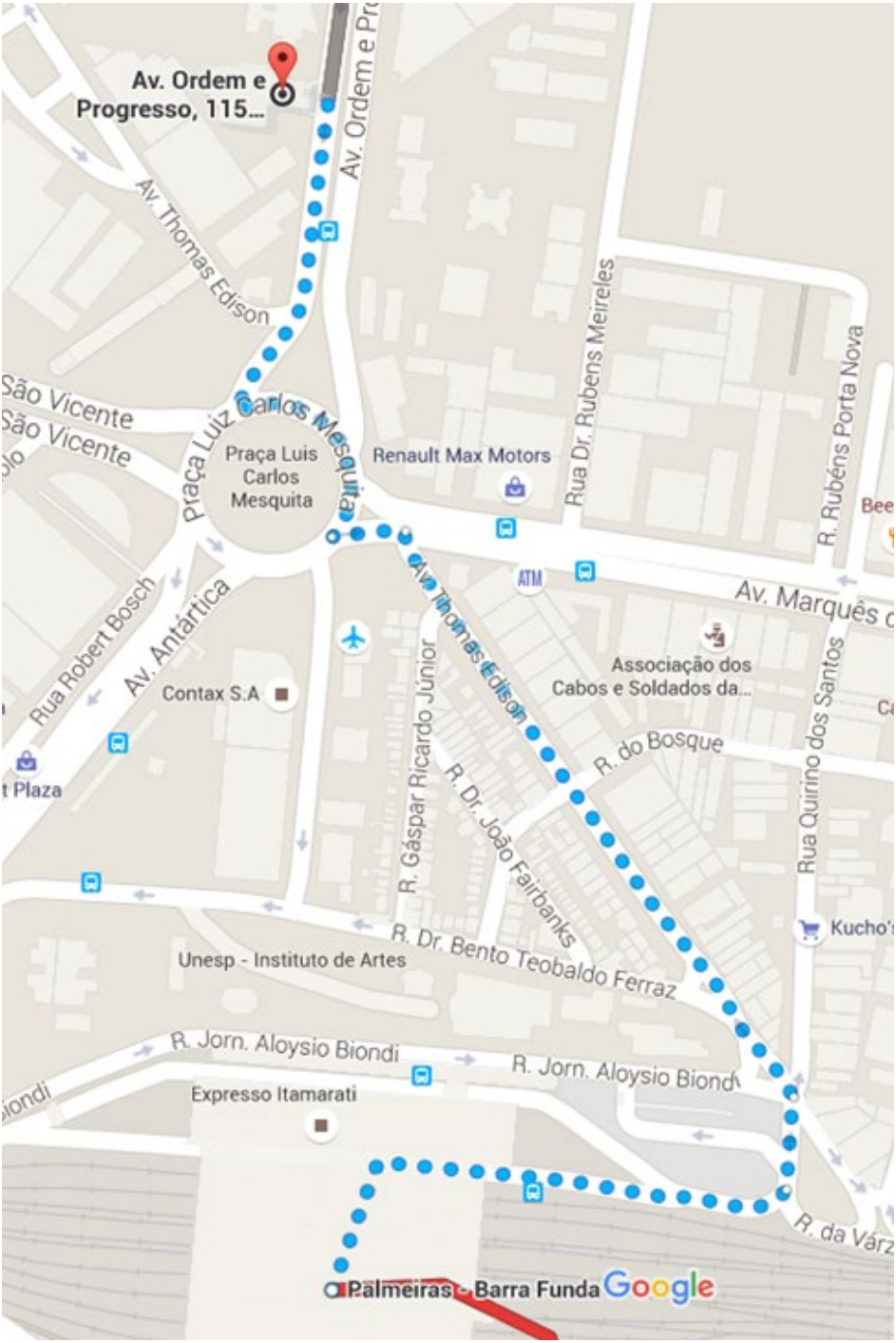
- Take the metro at "**Republica**" station towards "**Palmeiras Barra-Funda**"
- Get off at **Palmeiras Barra-Funda** (which is the third stop); Follow the signs to the exit which is called Av. Marques de Sao Vicente. After passing through the turnstiles, turn left and walk until the end of the station. At the end of the station, go down the stairs and you will see immediately a large white and blue building across the street in front of you. The white and blue building is the Instituto de Artes, and next to it is a large white and **green building** which is the Instituto de Fisica Teorica.
- Check the map on option 1 (next page).

Bus schedule from the airport to Praça da República:

05:40	06:10	06:40	07:10
07:40	08:10	08:40	09:10
09:50	10:20	11:00	11:30
12:10	12:50	13:30	14:00
14:30	15:00	15:30	16:00
16:40	17:10	17:40	18:10
18:50	19:20	20:00	20:30
21:10	21:40	22:10	22:40
23:40			

Option 3:

By taxi - As you get out of the terminal, you will see buses and taxi companies, there is a company called Guarucoop (which we recommend). It is on


Av. Ordem e Progresso, 115...
Av. Thomas Edison
Av. Ordem e Pr
São Vicente
São Vicente
Praça Luiz Carlos Mesquita
Praça Luis Carlos Mesquita
Renault Max Motors
Rua Dr. Rubens Meireles
R. Rubéns Porta Nova
ATM
Av. Marquês d
Rua Robert Bosch
Av. Antártica
Contax S.A
Av. Thomas Edison
Associação dos Cabos e Soldados da...
R. do Bosque
R. Gáspar Ricardo Júnior
R. Dr. João Fairbanks
Rua Quirino dos Santos
Kucho'
R. Dr. Bento Teobaldo Ferraz
Unesp - Instituto de Artes
R. Jorn. Aloysio Biondi
R. Jorn. Aloysio Biondi
Expresso Itamarati
R. da Várz
Palmeiras - Barra Funda
Google

the sidewalk just outside the airport and you can pay with credit card. The ride from the airport to the hotel will cost around 160 Brazilian reais (approximately 40 USD).

The hotel address is: Hotel Panamby – Av. Ordem e Progresso, 115 – Várzea da Barra Funda - São Paulo. The trip should take 40-100 minutes depending on traffic.

GROUND TRANSPORTATION FROM CONGONHAS AIRPORT TO PANAMBY HOTEL

Option 1:

- As you get out of the airport, you will see the bus stop. Take the bus-line 675I – 10 (Metrô São Judas) or 675 A – 10 (Metrô São Judas);
- Get off at **Metro São Judas** (it takes approximately 15 minutes);
- Click here to print out the full version of the subway map of São Paulo
- From **Metro São Judas** take the metro Blue line (linha azul) towards "Tucuruvi"
- Get off at **Sé**;
- From **Sé** take the red line (linha vermelha) towards **Palmeiras Barra Funda**;
- Get off at **Palmeiras Barra Funda** (which is the fifth station); Follow the signs to the exit which is called Av. Marques de Sao Vicente. After passing through the turnstiles, turn left and walk until the end of the station. At the end of the station, go down the stairs and you will see immediately a large white and blue building across the street in front of you. The white and blue building is the Instituto de Artes, and next to it is a large white and green building which is the Instituto de Fisica Teorica.
- From **Palmeiras Barra Funda** walk to Panamby Hotel (10-15 minutes; see map opposite).

Option 2:

By taxi - As you get out of the terminal, you will see buses and taxi companies, there is a company called Táxi Comum Ponto 606 (which we recommend). You can pay with credit card. The ride from the airport to the hotel will cost around 80 Brazilian reais (approximately 20 USD).

The hotel address is: Hotel Panamby – Av. Ordem e Progresso, 115 – Várzea da Barra Funda - São Paulo. The trip should take 50 minutes depending on traffic.

GROUND TRANSPORTATION FROM PANAMBY HOTEL TO THE INSTITUTE

The whole journey takes around 10 minutes (see next page for map):

- Turn right toward Av. Ordem e Progresso
- At the roundabout, take the 4th exit onto R. Federação Paulista de Futebol
- Walk to R. Federação Paulista de Futebol, 271, and you will reach the parking place of UNESP
- Enter the parking place and turn left. Walk straight until you see a the large white and green building, the Instituto de Fisica Teorica. From the green building go to the 4th floor

Institute address: Rua Dr. Bento Teobaldo Ferraz, 271 – Bloco 2, 4th floor, Barra Funda – São Paulo.


Osten BMW
Hotel Panamby São Paulo
Av. Ordem e Progresso
Av. Thomas Edison
Praça Luiz Carlos Mesquita
Praça Luis Carlos Mesquita
Renault Max Motors
Rua Dr. Rubens Meireles
Av. Antártica
Contax S.A
Associação dos Cabos e Soldados da...
R. do Bosque
R. Federação Paulista de Futebol, 271...
Unesp - Instituto de Artes


R. Federação Paulista de Futebol, 271 - Várzea da Barra Funda
São Paulo - SP
01141-040
Directions


Praça Orlando Zanfelice Júnior
Praça Luis Carlos Mesquita
Av. Antártica
R. do Bosque
Av. Tomás Edson
Estação Barra Funda
Palmeiras - Barra Funda
Palmeiras - Barra Funda
Barra Funda

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