

MAP-I Joint doctoral programme in Computer Science of Universidade do Minho,
Universidade de Aveiro and Universidade do Porto
2018/19 Course Edition

Urban Computing

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I. Course Description

This document describes a course on “Urban Computing” to be offered as part of the 2018/19 edition of the Joint doctoral programme in Computer Science of Universidade do Minho, Universidade de Aveiro and Universidade do Porto (MAP-I).

The course is being proposed as one of the elective courses in Technologies and is being proposed for the first time.

This course provides an introduction to the emerging field of Urban Computing, an interdisciplinary field of research and practice that uses information technology for the analysis, management, planning, and usability of cities. The course is organised by researchers with a comprehensive and complementary research experience in this topic.

Urban Computing is a major trend in information technologies and increasingly part of post-graduate programmes in many international institutions. In general, the digital transformation of cities is already the topic of entire MSc programmes at European and US Universities, e.g. UCL, Imperial college or Boston. These programmes emphasise the interdisciplinary nature of Urban Computing and provide a comprehensive approach to the key issues across different disciplines.

Urban Computing is also offered as an elective course in many Informatics curricula. Reference examples include the courses at UC Berkeley (Urban Informatics and Visualization), University of Melbourne (Urban Informatics), University of Pittsburgh (Urban Computing), Trinity College Dublin (Urban Computing), Northeastern University (Big Data for Cities), KU Leuven (Architectural and Urban Computing) or University of Michigan (Urban Informatics). These courses tend to emphasise the technological and data science perspectives and are more focused on a Computer Science perspective.

II. Objectives and Learning Outcomes

The course addresses different perspectives of Urban Computing, with a particular emphasis on urban data and services. At the end of this course, students should be able to understand the opportunities and challenges raised by the continued integration of information technology in urban spaces. More specifically, students who complete the Urban Computing course should be able to:

- Explain the key technical, commercial and social drivers behind the transition to smart cities and the key challenges involved
- Explain the design space of how urban media can integrate urban ecosystems and the key implications involved
- Analyse how the city, as a system of systems, is composed by many autonomous, but strongly interrelated, infrastructures, with specific complexities that need to be managed as a whole
- Explain how playable features can have an important role in the design of urban interfaces that aim to go beyond efficiency
- Describe different approaches for participatory sensing and compare their respective challenges within the context of a specific sensing situation
- Describe the different layers of knowledge in a model of a city, and the data collection challenges for each;
- Identify technology possibilities used to collect, store and process data for urban computing, and integration challenges
- Describe the steps of a data processing chain, and name and use at least one method for each of the steps
- Use at least one machine learning method for extracting information from an urban dataset
- Design and build a prototype of a system to provide a service in the context of urban computing

III. Syllabus

Given the diversity of themes that can be associated with urban computing, the course is organized as a series of modules, each covering with some depth a key topic related with urban computing. Each module should take between 1-3 sessions depending on the final outline of the course.

Module Smart cities

Learning Outcomes:

- Explain the key technical, commercial and social drivers behind the transition to smart cities and the key challenges involved

Contents:

- Key factors determining the transition to smart cities
- Different views on smartness and city benchmarking
- Digital Strategy
- Main research directions in Smart Cities

Module Urban Media

Learning Outcomes:

- Explain the design space of how urban media can integrate urban ecosystems and the key implications involved

Contents:

- Urban media and public space
- Shared media vs personalized media
- Attention and ambient displays

- Situated content
- Desaturated cities
- Case Study: Project Endless displays

Module Urban Infrastructures for the digital age

Learning Outcomes:

- Analyse how the city, as a system of systems, is composed by many autonomous, but strongly interrelated, infrastructures, with specific complexities that need to be managed as a whole

Contents:

- Deployment challenges
- Infrastructure integration
- Physical, digital and hybrid infrastructures
- Field study on digital infrastructures
- Case Study: Smart fleets as urban infrastructures

Module Playable cities

Learning Outcomes:

- Explain how playable features can have an important role in the design of urban interfaces that aim to go beyond efficiency

Contents:

- Playful technology
- Interaction in public space
- Playful design
- Case study: Playable Cities project

Module Participatory Sensing

Learning Outcomes:

- Describe different approaches for participatory sensing and compare their respective challenges within the context of a specific sensing situation

Contents:

- Participatory sensing
- Citizen engagement
- Key sensing properties
- Participatory sensing approaches

Module IoT for Smart Cities

Learning outcomes:

- Describe the different layers of knowledge in a model of a city, and the data collection challenges for each;
- Identify technology possibilities used to collect, store and process data for urban computing, and integration challenges

Contents:

- Smart city as a complex system of systems and a trans-disciplinary research field
- Internet of Things architecture model, platforms and protocols
- State-of-the-art wireless technologies
- Case study Porto.LivingLab

Module Urban Data Processing

Learning outcomes:

- Describe the steps of a data processing chain, and name and use at least one method for each of the steps
- Use at least one machine learning method for extracting information from an urban dataset

Contents:

- Typical challenges of real world data
- Data cleaning and data exploration techniques
- Spatio-temporal data processing
- Case studies on data usage

Practical work: Design an Urban Service

Learning outcome: Design and build a prototype of a system to provide a service in the context of urban computing

Students will propose a project to be carried out over a 4 weeks, using hardware and know-how available in the research groups supporting the course. The project will be carried out on student's time, with on-demand supervision. There will be two intermediate milestones: 1) project description; 2) project architecture; and a final delivery of the project including demonstration and individual evaluation by a jury.

IV. Teaching and Assessment

This course corresponds to 5 ECTS involving a broad range of learning activities with a particular focus on active learning. Lecturing will often be used to provide a quick initial presentation of the topic. Students will then be guided into the exploration of the wide range of principles, challenges and techniques related with the urban computing topic addressed in each module.

The teaching approach will seek to emphasise some of the relevant ongoing research and innovation taking place in this field. Students will be exposed to the many facets involved in urban computing and specific challenges of taking Information Technologies to urban spaces. The use of concrete case studies will often be used as a concrete instance for illustrating the presentation of the topics and as a context for analytical exercises.

Assessment will be based on the following two items:

- 30% based on practical assignments proposed during classes
- 70% based on an individual survey monograph or group project.

V. Lecturing Team

Rui José is an Assistant Professor at the University of Minho, where he leads the Ubicomp research group. Rui José received his PhD in Computer Science from Lancaster University in 2001. His research interests are in ubiquitous systems in general and particularly on the design and development of ubiquitous information services that are situated within particular physical and social settings. In recent years, he has been focusing on Urban Media and on the convergence of physical and digital aspects of the city. He has been PI or co-PI in multiple international research projects (FP7, FET-OPEN, Portugal/CMU partnership) and also national projects (QREN, FCT). Rui José is a member of ACM and its SIGCHI.

Rui José has been part of several program committees, such as the International Conference on Indoor Positioning and Navigation (IPIN); the International Conference on Advances in Computer Entertainment Technology (ACE), the International Symposium in Ambient Intelligence (ISAmI), the International Workshop on Ambient Assisted Living (IWAAL-2011), the International Conference on Intelligent Environments (IE), the International Conference on Human-Computer Interaction with Mobile Devices and Services (MobileHCI), the Workshop on Pervasive Advertising, the International Symposium on Ubiquitous Computing and Ambient Intelligence (UCAmI'11), and the International Symposium on Pervasive Displays (PerDis).

In previous editions of MAP-I, Rui José has been involved in courses on Ambient Intelligence and Ubiquitous Computing and also Interactive Computing Systems. He has supervised on successful MAP-I student.

Ana Aguiar is an Assistant Professor at the University of Porto (UP), and a researcher at Instituto de Telecomunicações (IT), where she leads the Shannon Lab. She graduated in Electrical and Computer Engineering from UP in 1998 and received a PhD (Dr-Ing) in Engineering (Telecommunication Networks) from the Technical University of Berlin in June 2008. She is visiting faculty at the Computer Science Department at Carnegie Mellon University.

She works on wireless networked systems, concretely on mobile sensing, mobile IoT and mobile 802.11 links within the scope of several industry and state funded projects with applications in the field of smart cities. She has built the mobile crowdsensing tool SenseMyCity within the scope of the FP7 Future Cities project in Porto.

She is also operating the UrbanSense platform of environmental sensors deployed in Porto. She applies data mining and machine learning to concrete problems in the field of smart cities, like congestion prediction, transport mode estimation, etc. She was PI for the FCT funded project VOCE which aimed at detecting stress in speech.

She has participated in the organisation of 18 conferences and published more than 50 journal and conference articles, and is reviewer for IEEE Communications Magazine, IEEE Transactions on Intelligent Transportation Systems, Transactions on Mobile Computing, as well as several IEEE conferences.

VI. Recent Publications by the Team

- P. M. Santos, J. G. P. Rodrigues, S. B. Cruz, T. Loureno, P. M. DOrey, Y. Luis, C. Rocha, S. Sousa, S. Crisstomo, C. Queirs, S. Sargento, A. Aguiar, and J. Barros, PortoLivingLab: An IoT-Based Sensing Platform for Smart Cities, IEEE Internet of Things Journal, vol. 5, no. 2, pp. 523-532, April 2018
- C. Pereira, J. Cardoso, A. Aguiar, R. Morla. Benchmarking Pub/Sub IoT middleware platforms for smart services, Springer Journal of Reliable Intelligent Environments, Vol. 4, No 1, pp 2537, April 2018
- 4. C. Pereira, A. Pinto, D. Ferreira, A. Aguiar, Experimental Characterization of Mobile IoT Application Latency, IEEE Internet of Things Journal, Vol. 4, No. 4, pp. 1082 - 1094, August, 2017
- J.G.P. Rodrigues, M. Kaiseler, A. Aguiar, J.P.S. Cunha, J. Barros. A Mobile Sensing Approach to Stress Detection and Memory Activation for Public Bus Drivers, IEEE Transactions on Intelligent Transportation Systems, Vol. 16, No. 6, 2015
- E. Lima, A. Aguiar, P. Carvalho. Offloading Surrogates Characterization via Mobile Crowdsensing, 1st ACM Workshop on Mobile Crowdsensing Systems and Applications (CrowdSenSys 17), 2017
- J. Rodrigues, J. Pereira and A. Aguiar. Impact of Crowdsourced Data Quality on Travel Pattern Estimation, 1st ACM Workshop on Mobile Crowdsensing Systems and Applications (CrowdSenSys 17), 2017
- Y. Rojo, P. Santos, TFS Loureno, CPP Perez-Penichet, T.C. Cal_cada, A. Aguiar, UrbanSense: an Urban-scale Sensing Platform for the Internet of Things, IEEE International Smart Cities Conference (ISC2), 2016
- P. M. Santos, T. Calcada, A. Sa, S. Sargento, A. Aguiar, and J. Barros, Experimental Characterization of I2V Wi-Fi Connections in an Urban Testbed, ACM Workshop on Challenged Networks (CHANTS), 2015
- A. Vilaça, A. Aguiar, C. Soares. Estimating Fuel Consumption from GPS Data, IbPRIA 2015: 7th Iberian Conference on Pattern Recognition and Image Analysis, 2015
- Rui José, André Pinheiro and Helena Rodrigues. Exploring networked message signs as a new medium for urban communication. PerDis '18, June 6–8, 2018, Munich, Germany
- Ana Ines Xavier and Rui José. I am in here: Implicit assumptions about proximate selection of nearby places. WorldCist'18 - 6th World Conference on Information Systems and Technologies, Naples, Italy, 27 - 29 March 2018.
- Pedro Coutinho, Rui Jose, Bruno Silva. Understanding media situatedness and publication practices in place-based digital displays. The 5th ACM International Symposium on Pervasive Displays. Oulu, Finland. 20-22 June, 2016
- Rui Jose, Jorge C. S. Cardoso and Jason Hong. User Expectations for Media Sharing Practices in Open Display Networks. Sensors 2015, 15(7), 16210-16224. ISSN 1424-8220

- Fernando Reinaldo Ribeiro and Rui Jose. Smart Displays in Ambient Intelligence Environments. Recent Advances in Ambient Intelligence and Context-Aware Computing. A volume in the Advances in Computational Intelligence and Robotics (ACIR) Book Series. IGI Global, 2015
- Helena Rodrigues and Rui Jose. System implications of context-driven interaction in smart environments. Interacting with Computers. 2014
- Nelson Gonçalves, Rui Jose and Carlos Baquero. Collaborative and privacy-aware sensing for observing urban movement patterns. 8th DPM International Workshop on Data Privacy Management. 12-13 September 2013. Egham, UK. Springer Lecture Notes in Computer Science: 8247 LNCS.2014
- Rui Jose, Hélder Pinto, Bruno Silva and Ana Melro. Pins and Posters: Paradigms for Content Publication on Situated Displays. IEEE Computer Graphics and Applications, vol. 33, no. 2, pp. 64-72, March-April 2013. IEEE Computer Society.

VII. Recent Projects by the Team

- Mobi.Wise (P2020)
- S2MovingCity (CMU|PT)
- Generation.Mobi (P2020)
- Urby.Sense (FCT)
- Future Cities project (FP7)
- INNOVCAR. Inovação para Veículos Inteligentes Agência para o Investimento e Comércio Externo de Portugal
- Tice Mobilidade. Sistemas de Mobilidade Centrado no Utilizador (Projetos Mobilizadores)
- PD-NET. Towards Future Pervasive Display Networks. Future Emerging Technologies (FET-OPEN)