

**MAP-I**  
**Joint doctoral programme in Computer Science of**  
**Universidade do Minho, Universidade de Aveiro and**  
**Universidade do Porto**

**2017/18 Course Edition**

**Interactive Computing Systems**

April, 2017

This document describes a course on “Interactive Computing Systems” to be offered as part of the 2017/18 edition of the Joint doctoral programme in Computer Science of Universidade do Minho, Universidade de Aveiro and Universidade do Porto (MAP-I). This course was lectured on the academic years 2013/14, 2014/15 and 2015/2016 as one of the options in the curricular unit on Technologies.

**Team:**

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## Course Description

### I. The topic, its rationale and context

This document describes a course on “Interactive Computing Systems” to be offered as part of the 2017/18 edition of the Joint doctoral programme in Computer Science of Universidade do Minho, Universidade de Aveiro and Universidade do Porto (MAP-I). The course covers topics in the area of Human-Computer Interaction, with a particular emphasis on the Engineering of Interactive Computing Systems. At the end of this course, students should be able to understand the opportunities and challenges raised by the continued evolution of interaction technology.

The course is organised by researchers from the Universities of Minho and Aveiro with a vast and complementary research and teaching experience in the field of Human-Computer Interaction. After three successful editions in 2013/14, 2014/15 and 2015/16 academic years, the course is again proposed as one of the options in the curricular unit on Technologies.

Human-Computer Interaction (HCI) is “a discipline concerned with the design, evaluation and implementation of interactive computing systems for human use and with the study of major phenomena surrounding them” (Hewett et al. 1996). The term ‘Computing systems’ is used here in a broad sense to denote from systems consisting of a single user interacting with a single computer to spaces enhanced with ubiquitous technology to support the activities or needs of multiple users. Technological development, in particular in the areas of embedded and mobile systems, means that “the interface between humans and computers is harder than ever to define” while at the same time we become more and more dependent on technology (Sellen et al. 2009) making the discipline an active area of research.

HCI is addressed at the post-graduate programme level in top tier institutions (e.g. CMU, Stanford, Virginia Tech, UCL, Uppsala, etc.). Offerings range from HCI courses in Information Systems, Informatics, or Computer Science programmes to HCI specific PhD programmes. Being an highly interdisciplinary field, HCI can be approached from a variety of angles. The current proposal takes an approach which is akin to that of courses such as ‘Advanced Topics in Human-Computer Interaction’ (Virginia Tech) or ‘Research Topics in Human Computer Interaction’ (Stanford). Hence, the course focusses in presenting an in-depth view of a number of advanced topics in relevant areas of the engineering of interactive computing systems (Evaluation, Interaction techniques, Interaction paradigms, and Design and development methods).

### II. Objectives and Learning Outcomes

This course approaches HCI from an Engineering perspective, drawing on the background of the team. As explained above, the objective is to present students with in-depth treatment of a number of selected topics. Upon successful completion of this curricular unit, students should be able to:

- formulate UI hypothesis and devise validation experiments, discussing and applying different evaluation techniques;

- explain the advantages and limitations of describing interactive computing systems with models, as a way to abstract from the systems' complexity and to reason about their properties;
- discuss the main 3D interfaces available, their currently more significant applications (e.g. Virtual and Augmented environments) and limitations, as well as the guidelines for their development, and present the main challenges in 3D and Natural User Interfaces applications;
- identify which types of context information, context-sensitive procedures, and interaction techniques might be realistically supported given the limitations of the technology and the specificities of a particular interaction scenario;
- explain the concepts of Lean UX and Model-based User Interface development and contrast their roles in developing interactive computing systems.
- discuss the advantages, limitations and challenges of interaction through public displays, the role of the shared nature of public displays in user engagement, and the key interaction techniques with them.

### III. Syllabus

#### 1. Introduction to HCI

A general introduction to HCI to provide students with enough background for the topics addressed in the course.

#### 2. Evaluation

The evaluation of interactive computing systems is addressed from a number of different perspectives. Traditional approaches based on user testing or expert review are covered first. Then, the role of models in the analyses of interactive systems (Harrison et al. 2008; Barbosa, Paiva, and Campos 2011) is discussed, and the opportunities that a clear expression of the problem and systematic analysis techniques may afford presented.

1. Usability inspection – expert reviews
2. User studies – usability testing and controlled experiments
3. Automated analysis through model-based testing
4. Automated analysis through formal verification.

#### 3. Interaction techniques

A number of promising and useful interaction methods are covered. The topic addresses 3D interfaces and the tracking and displaying technology required to deliver information according to the user point of view, as well as more recent results using multi-sensory information. The new perspectives of use open by Natural User Interfaces, and their ability to bind physical and real world and benefit from the capabilities that users already have to

interface with the real world are also addressed (Bowman, McMahan, and Ragan 2012; Kulik 2009).

1. 3D interaction
2. Multi-sensory interfaces
3. Natural user interfaces
4. Development technologies and guidelines.

#### 4. Interaction paradigms

A number of advanced topics on Interaction Paradigms are addressed here, with a particular emphasis on Ubiquitous Computing. Topics range from the capability of systems to adapt to their usage situations (both during design and once deployed) through implicit interactions and context-awareness (A. Schmidt 2013), to the development of public displays having the ability to create a shared experience between nearby people and the challenges this creates, such as shared ownership and social negotiation around their use. Virtual reality systems are also addressed, in particular the use of 3D application server as a means of prototyping Ubiquitous Computing environments.

1. Context-aware sensing systems
2. Interactive Public Displays
3. Virtual reality systems and the prototyping of Ubiquitous Computing environments.

#### 5. Design and development approaches

This module introduces students to two different, and to an extent antagonistic, approaches: Lean UX (Gothelf and Seiden 2013), which is strongly anchored on fast iterations over multiple designs and on measuring the results of those designs to support the evolution of the project; and Model-Based User Interface Development (Meixner, Paternò, and Vanderdonckt 2011), which is based on the idea of a structured development progressing from more conceptual models to the final user interface through a process of model refinement. The students will have the opportunity to contrast the two approaches and explore the roles that each might play in the development of an Interactive Computing System.

1. Lean UX
2. Model-based development.

## IV. Teaching and Assessment

This course corresponds to 5 ECTS involving a broad range of learning activities with a particular focus on active learning techniques. These will be favoured, not only for their ability in stimulating student engagement, but mainly because the learning outcomes proposed for this

course include high-level objectives that can only be achieved through the execution, by the students, of analysis, development and discussion tasks. Furthermore, the high quality of the students involved, will contribute to maximise participation and therefore the benefits of the approach.

Lectures will be used to provide an initial background and quickly prepare everyone to the topic. The use of videos and the study of reference case studies will be used to complement the presentation of the topics and guide the study of the most commonly used approaches and issues. Student presentations and exercises will be used to promote engagement and exercise the analysis of existing work.

- 50% based on written or practical assignments proposed at the end of selected course units.
- 50% based on an individual survey monograph.

## V. Main Bibliography

Bellotti, Victoria, Maribeth Back, W. Keith Edwards, Rebecca E. Grinter, Austin Henderson, and Cristina Lopes. 2002. "Making Sense of Sensing Systems: Five Questions for Designers and Researchers." In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, 415–22.

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Cairns, P., and A. Cox, eds. 2008. *Research Methods for Human Computer Interaction*. Cambridge University Press.

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Gothelf, Jeff, and Josh Seiden. 2013. *Lean UX: Applying Lean Principles to Improve User Experience*. O'Reilly Media.

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Haller, M., M. Billinghamurst, and B. Thomas, eds. 2007. *Emerging Technologies of Augmented Reality - Interfaces and Design*. Idea Group Publishing.

José, R., H. Pinto, B. Silva, and A. Melro. 2013. "Pins and Posters: Paradigms for Content Publication on Situated Displays." *IEEE Computer Graphics and Applications* 33 (2): 64–72.

Leahu, Lucian, Phoebe Sengers, and Michael Mateas. 2008. "Interactionist AI and the Promise of Ubicomp, or, How to Put Your Box in the World Without Putting the World in Your Box." In *Proceedings of the 10th International Conference on Ubiquitous Computing*, 134–43. ACM.

## VI. Additional references

Barbosa, A., Ana C. R. Paiva, and José Creissac Campos. 2011. "Test Case Generation from Mutated Task Models." In *Proceedings of the 3rd ACM SIGCHI Symposium on Engineering Interactive Computing Systems*, edited by Fabio Paternò, Kris Luyten, Frank Maurer, Prasun Dewan, and Carmen Santoro, 175–84. ACM.

Bowman, D., R. McMahan, and Eric D. Ragan. 2012. "Questioning Naturalism in 3D User Interfaces." *Communications of the ACM* 55 (9): 78–88.

Harrison, Michael D., José Creissac Campos, G. Doherty, and K. Loer. 2008. "Connecting Rigorous System Analysis to Experience Centred Design." In *Maturing Usability: Quality in Software, Interaction and Value*, edited by E. Law, E. Hvannberg, and G. Cockton. Human-Computer Interaction Series. Springer.

Hewett, Thomas T., Ronald Baecker, Stuart Card, Tom Carey, Jean Gasen, Marilyn Mantei, Gary Perlman, Gary Strong, and William Verplank. 1996. *ACM SIGCHI Curricula for Human-Computer Interaction*. New York, NY, USA: ACM; ACM.

Kulik, Alexander. 2009. "Building on Realism and Magic for Designing 3D Interaction Techniques." *IEEE Computer Graphics and Applications* 29 (6): 22–33.

Meixner, Gerrit, Fabio Paternò, and Jean Vanderdonck. 2011. "Past, Present, and Future of Model-Based User Interface Development." *I-Com* 10 (3): 2–11.

Schmidt, Albrecht. 2013. "Context-Aware Computing: Context-Awareness, Context-Aware User Interfaces, and Implicit Interaction." In *The Encyclopedia of Human-Computer Interaction*, edited by Mads Soegaard and Rikke Friis Dam, 2nd ed. The Interaction Design Foundation.

Sellen, Abigail, Yvonne Rogers, Richard Harper, and Tom Rodden. 2009. "Reflecting Human Values in the Digital Age." *Commun. ACM* 52 (3). New York, NY, USA: ACM: 58–66.

## VII. Lecturing Team

### **Beatriz Sousa Santos**

is an Associate Professor with the Department of Electronics Telecommunications and Informatics/University of Aveiro where she has taught several HCI and Visualization courses at graduate and postgraduate level. She obtained "Agregação" in Human-Computer Interfaces. Her main research interests are within Interactive Data and Information Visualization and Virtual and Augmented Reality. She has supervised or co-supervised six PhD theses and about thirty MSc pre and post-Bologna dissertations. She has integrated the Program Committees of more than 40 international conferences. She currently belongs to the Executive Board of the Eurographics Association and to the Editorial Board of IEEE Computer Graphics and Applications.

### **José Creissac Campos**

is an Assistant Professor within the Departamento de Informática/Universidade do Minho, where he has taught and been responsible for a number of Human-Computer Interaction (HCI) courses at postgraduate level, and a researcher at HASLab/INESC TEC. He has successfully supervised 2 PhDs and 19 MScs. His research interests lie in the intersection of Software Engineering and HCI. Current and recent funded research includes the model-based testing,

reverse engineering and formal analysis of user interfaces, and the prototyping of ambience intelligence systems. He is a member of IFIP WG 2.7/13.4 on User Interface Engineering. He has served in the organizing and programme committees of, among others, IFIP TC13 INTERACT, ACM CHI (WIP) and ACM SIGCHI EICS, of which he is a member of the steering committee. He was full papers co-chair for EICS 2016. He was awarded an International Excellence Award by the BCS HCI Group in 2009, and a Recognition of Service Award by ACM in 2012.

#### **Paulo Dias**

is an Assistant Professor within the Department of Electronics Telecommunications and Informatics/University of Aveiro where he has taught several HCI and Visualization courses at graduate and postgraduate level as well as several courses on programming. His main research interests are within, Virtual Reality, Computer Vision, Visualization Combination and fusion of data from multiple sensors and 3D Reconstruction. He has supervised a PhD thesis and several MSc dissertations in these areas. He is involved in the AcoustiCAVE project (PTDC/EEA-ELC/112137/2009) that aims Auralisation Models and Applications in Virtual Reality Environments and the Produtech PTI project (QREN 13851) where he was involved in developing VR training tools to allow interaction with software simulations of real industrial facilities. More recently he integrates the FCT/funded edupArk project (Mobile Learning, Augmented Reality and Geocaching in Science Education). He was involved in the past years in the reviewing process of several HCI conferences such as ACM CHI and IFIP INTERACT.

#### **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 public digital displays and how they can be transformed into a new open communication medium for public and semi-public spaces. 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). Rui José was the main promoter of the course on Ambient Intelligence and Ubiquitous Computing that took place in previous editions of MAP-i.

### **VIII. Recent Publications by the Team**

- Campos, J.C., Abade, T., Silva, J.L. and Harrison, M.D. (2017) Don't Go In There! Using the APEX framework in the design of ambient assisted living systems. *Journal of Ambient Intelligence and Humanized Computing*. (online first, doi: 10.1007/s12652-016-0444-6)

- J.C. Campos, M. Sousa, M. Alves and M.D. Harrison (2016) Formal Verification of a Space System's User Interface with the IVY workbench. *IEEE Transactions on Human-Machine Systems*, 46(2):303-316. (doi: 10.1109/THMS.2015.2421511)
- B. Sousa Santos, B. Quintino Ferreira, P. Dias (2016) Using Heuristic Evaluation to Foster Visualization Analysis and Design Skills, *IEEE Computer Graphics and Applications*, 36(1):6-10, Jan/Fev.
- P. Dias, L. Neves, D. Santos, C. Coelho, M. T. Ferreira, H. Santos, S. Silva, B. Sousa Santos (2015). CraMs, an application for craniometric analysis using 3D skull models, *IEEE Computer Graphics and Applications*, 35 (6): 11-17, Nov-Dec.
- M.D. Harrison, J.C. Campos and P. Masci (2015) Reusing models and properties in the analysis of similar interactive devices. *Innovations in Systems and Software Engineering*, 11(2):95-111, June. (doi: 10.1007/s11334-013-0201-3)
- J.C. Campos, G. Doherty and M.D. Harrison (2014) Analysing interactive devices based on information resource constraints. *International Journal of Human-Computer Studies*, 72(3):284-297, March. (doi: 10.1016/j.ijhcs.2013.10.005)
- P. Dias, T. Sousa, J. Parracho, I. Cardoso, A. Monteiro, B. Sousa Santos (2014) Student Projects Involving Novel Interaction with Large Displays. *IEEE Computer Graphics and Applications* 34(2): 80-86, Mar-Apr.
- Goncalves V., Dias P., Fontoura M.J., Moura R., Sousa Santos B. (2014) Investigating Landfill Contamination by Visualizing Geophysical Data. *IEEE Computer Graphics and Applications*, 34(1): 16-21, Jan-Feb.
- R. José, H. Pinto, B. Silva, A. Melro (2013) Pins and Posters: Paradigms for Content Publication on Situated Displays. *IEEE Computer Graphics and Applications* 33(2): 64-72.
- Mendonça C., Campos G., Dias P., Vieira J., Ferreira J., Santos J.A. "On the Improvement of Auditory Accuracy with Non-Individualized HRTF-based Sounds". *Journal of the Audio Engineering Society*, vol. 60, no. 10, October 2012.
- J.L. Silva, J.C. Campos and M.D. Harrison (2014) Prototyping and Analysing Ubiquitous Computing Environments using Multiple Layers. *International Journal of Human-Computer Studies*, 72(5):488-506, May. (doi: 10.1016/j.ijhcs.2014.02.001)
- H. Rodrigues, R. José (2014) System Implications of Context-Driven Interaction in Smart Environments. *Interacting with Computers* 26(2): 105-117.
- C. Taivan, R. José, B. Silva, I. Elhart, J. Cardoso (2013) Design Considerations for Application Selection and Control in Multi-user Public Displays. *J. UCS* 19(17): 2526-2542.

#### **IX. Recent Projects by the Team**

- PD-NET – Towards Future Pervasive Display Networks (FET-OPEN, 06/2009-05/2012)
- MobiPag – Iniciativa Nacional para Pagamentos Móveis (QREN, 09/2010-12/2012)
- SUM – Sensing and Understanding human Motion dynamics (FCT, 01/2011-12/2012)

- PRODUTECH-PTI: new process and technologies for the production industry (QREN, Started 2011 - 3 years)
- AcousticAVE: Auralisation Models and Applications in Virtual Reality Environments. (FCT, Started 2011 - 3 years)
- ~~APEX - Agile Prototyping for user EXperience (FCT, started 01/02/2011 - 3.5 year)~~
- PBGT - Pattern Based GUI Testing (FCT, started 01/04/2012 - 3 years)
- Languages and Tools for Critical Real Time Systems (ON.2, started 01/01/2013 - 2.5 years)
- High-Assurance Medical Cyber-physical Systems (P2020, started 01/07/2016 - 3 years)
- Trustworthy Software Design with Alloy (FCT, started 01/09/2016 - 3 years)
- EduPARK: Mobile Learning, Augmented Reality and Geocaching in Science Education (FCT 3 years).

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