



UNIVERSITÀ DI PISA
DIPARTIMENTO DI INGEGNERIA DELL'INFORMAZIONE
Dottorato di Ricerca in Ingegneria dell'Informazione

Doctoral Course

“Computer Vision: 3D structure from motion”

Prof. João Paulo Costeira

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Short Abstract: This course introduces foundational representations, models and processes to extract 3D information from streams of images. It introduces the geometric camera model and the relations in a multiview scenario as well as the techniques to compute 3D structure from image sequences. In a second part 3D information is used in a class of problems involving 3D registration: Self-Localization and Mapping (SLAM), 3D shape recognition and tracking. Finally the course will analyse the recent trend towards data-driven tools based in deep-learning models. For each of these topics the a set of software tools will be introduced and the course will be evaluated.

Course Contents in brief:

- Linear Algebra review
- Perspective camera and transformations
- 3D Reconstruction : BA and bilinear methods
- 3D Registration : ICP
- SLAM: Solving the Pose-graph
- Applications and tools

Total # of hours of lecture: 18 hours

References:

- [1] Richard Szelisky, “Computer Vision: Algorithms and Applications”, Springer 2011
[2] J. Ponce, B Forsyth, “Computer Vision a Modern Approach”, 2n edition
-

CV of the Teacher

João Paulo Salgado Arriscado Costeira

Electrical and Computer Eng. Department, Instituto Superior Técnico

<http://www.isr.ist.utl.pt/~jpc>

Academic Degrees

- (1995) - PhD in Electrical and Computer Engineering, Instituto Superior Técnico
- (1989) - Msc in Electrical and Computer Engineering , Instituto Superior Técnico
- (1985) - Licenciatura in Electrical Engineering Instituto Superior Técnico

Research Interests

Computer/robotic vision, 3D reconstruction, object recognition in large databases, networked sensing, localization and mapping..

Current Professional Status/Activities

Associate Professor, Electrical and Computer Engineering Department (IST) since March 2007
Coordinator of the Signal and Image Processing Group at Instituto de Sistemas e Robótica
(<http://www.isr.ist.utl.pt>) - since 2012.

Previous Positions

Scientific Director – Carnegie Mellon|Portugal program (2014-18)
Co-Director of the Dual PhD Program in Electrical and Computer Engineering - Carnegie Mellon-Portugal Program– 2008-18. (<http://cmuportugal.org>)
Director of the Dual PhD Program in Robotics of the Carnegie-Mellon|Portugal Program - 2011-18.
Vice President for Scientific Affairs, Instituto Sistemas e Robótica 2014-2016
Thematic Area Co-coordinator of LarSys Associated Laboratory, <http://www.larsys.pt> 2005-2013
Researcher at the Vision and Autonomous System Center/Robotics Institute, Carnegie Mellon University. 1991-1995

Teaching Activities

Since 1995 lectures courses in the ECE Dep.at IST. Courses lectured: Image Processing and Vision (PhD, MSc) , Signal and Systems (BSc), Control Theory (BSc), Circuit Analysis (BSc). Starting Sep. 2019 - Sensing and Information Processing (MSc) at Faculty of Architecture (Joint degree in Interactive Design)

PhD Thesis Supervision

Concluded

1-João Lourenço T. Sousa Maciel, IST 2002, 2-Ricardo Raposo Oliveira, IST 2008, 3-Nuno Pinho da Silva, IST 2010, 4-Ricardo da Silva Ferreira (co advised J. Xavier), IST 2010, 5-Manuel Ricardo Marques, IST 2011, 6-Ricardo Cabral (co-advised with F. De la Torre-CMU) CMU-Portugal 2015, 7-Susana Brandão (co-advised with M. Veloso - CMU) CMU-Portugal Program 2015, 8) Qiwei Han (co-advised with P. Ferreira, CMU), CMU-Portugal Program 2017, 9)- Jayakorn Vongkulbhisal (co-advised with F. De la Torre, CMU), CMU-Portugal Program 2018, 10)- Shanghang Zhang (co-advised with J.F. Moura, CMU), CMU-Portugal Program 2018

In Progress

1- João Carvalho (co-advised with Manuel Marques, IST), 2-Beatriz Quintino (co-advised J.P. Gomes, IST), 3- Jude Mukundane IST (co-advised with C. Csikszentmihalyi -UMa)

Scientific Committee Member

European Conf. on Computer Vision (ECCV) 2002, 2004, 2006
International Conference on Image Analysis (ICIAR)2002-2010
Asian Conference on Computer Vision (ACCV) 2010,
International Conference on Computer Vision (ICCV) 2011-13

Conference Organization

“Where Computer Vision Meets Art”: European Conf. on Computer Vision ECCV Workshop - 2016- Amsterdam, 2014-Zurich, 2012-Florence <http://visarts.eu>
IFAC Symposium on Intelligent Autonomous Vehicles 2004, IEEE SPAWC 2003, 10th IEEE- Mediterranean Conference on Control, 2002

Academic/ Synergetic Activities

Project Evaluator for the Swiss Science Foundation (2012/2013)
Project Evaluator ADI (Innovation Agency, Portugal) – (2009-12)
Member of the Senate of IST's Scientific Council (2004-2006).
NEOTEC (venture capital program for startups) – Member of selection committee (2006-07)

Prizes and Awards

Science Prize of the British Machine Vision Association – Best paper of the British Machine Vision Conf. (BMVC 2000).
Advisor of the PhD thesis winner of IBM Science Prize 2002
Advisor of the PhD thesis winner of IBM Science Prize 2014
Adobe Research Inc – US\$20.000 unrestricted gift (2019)

Selected Past Projects (Principal Investigator)

– CIRA - Critical Infrastructures and Risk Assessment (<http://cmuportugal-ece.ist.utl.pt/>, Jan 2007- Dec 2012) -FCT Project CMU-PT/0011/2007, funded with 2M€ to develop a research program and reinstate the dual PhD in ECE. Coordinated IST faculty, 2 hired faculty and 17 PhD students.
– PrintArt- Content and Ontology based Art Image Annotation and Retrieval (<http://printart.isr.ist.utl.pt> - Jan. 2010-Jan. 2013) - FCT funded PTDC/EEA-CRO/098822/2008, Principal Investigator. Development of image-based retrieval
– IMASEG3D Learning to Combine Hierarchical Image Modeling with 2-D Segmentation and 3-D Pose Recovery of Visual Objects (<http://printart.isr.ist.utl.pt/mcurie>, 2009-2011)- European FP7 project under Marie Curie Fellowship Program PIIF-GA-2009-236173

Current Projects Principal Investigator/Participant

– Multidrone (<http://multidrone.eu>, started Jan 2017) – Development of a multiple drone platform for media coverage of large scale events. Funded by EC's H2020 program. Negotiated IST's participation and contributes in visual tracking and video segmentation tasks.
– AI4EU (<http://ai4eu.org>, started Jan 2019) – European Union's landmark project on Artificial Intelligence. A 20M€ H2020 project involving partners from 21 countries that will develop the European platform for AI-on-demand. Local Principal Investigator leads one task to develop subsystems for “Physical AI”, and is the national representative in the AI4EU Foundation.
– Feedbot (<http://www.isr.ist.utl.pt/~manuel/feedbot>, Oct 2018- Sep 2019) – Seed project to develop a manipulator to feed people with disabilities. Funded by FCT/CMU Portugal program, our role is to develop algorithms for face detection and tracking from 3D data.

Patents - PCT Patent Application No:PCT/US18/26341 “Deep Learning Methods for Estimating Density and/or Flow of Objects, and Related Methods and Software”, filed on May 4th, 2018. Inventors : José F. Moura, João Paulo Costeira, Shanghang Zhang and Evgeny Toropov, Applicants: Carnegie Mellon University and Instituto Superior Técnico

Most Cited Publications (GScholar)

- J. Costeira, T. Kanade - A Multibody Factorization Method for Independent Moving Objects”, International Journal on Computer Vision 29(3),pp. 159-179, Set 1998 -
- J. Costeira, T. Kanade - A Multibody Factorization Method for Motion Analysis, IEEE-International Conference on Computer Vision ICCV 1995, Boston MA, USA –

- J. Maciel, J. Costeira - A Global Solution to Sparse Correspondence Problems- IEEE Transactions on Pattern Analysis and Machine Intelligence – Feb.2003,
- Cabral, F Torre, JP Costeira, A Bernardino -Matrix completion for multi-label image classification Advances in Neural Information Processing Systems NIPS 2011 – 150 c.
- Ricardo Cabral, Fernando De la Torre, João P. Costeira, Alexandre Bernardino - "Matrix Completion for Weakly-supervised Multi-label Image Classification", IEEE Trans. Pattern Analysis and Machine Intelligence 2015 –

Recent Publications:

- J Vongkulbhisal, F De la Torre, JP Costeira, Discriminative Optimization: Theory and Applications to Computer Vision, IEEE Transactions on Pattern Analysis and Machine Intelligence, PAMI 41 (4), January 2019
- H Zhao, S Zhang, G Wu, JMF Moura, JP Costeira, GJ Gordon Adversarial multiple source domain adaptation, Advances in Neural Information Processing Systems, 8559-8570, NIPS 2018.
- J Vongkulbhisal, B Irastorza Ugalde, F De la Torre, JP Costeira ,Inverse composition discriminative optimization for point cloud registration, Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition, CVPR 2018.
- S Zhang, X Shen, Z Lin, R Měch, JP Costeira, JMF Moura, Learning to understand image blur, Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition, CVPR2018
- A Candeias, T Rhodes, M Marques, M Veloso - Vision Augmented Robot Feeding Proceedings of the European Conference on Computer, ECCV Workshops Jan 2018
- J Carvalho, M Marques, JP Costeira, Understanding people flow in transportation hubs, IEEE Transactions on Intelligent Transportation Systems, (99) December, 2017
- S Zhang, G Wu, JP Costeira, JMF Moura, Fcn-rlstm: Deep spatio-temporal neural networks for vehicle counting in city cameras, IEEE International Conference on Computer Vision, ICCV 2017
- J Vongkulbhisal, F De la Torre, JP Costeira, Discriminative optimization: theory and applications to point cloud registration, IEEE International Conference on Computer Vision and Pattern Recognition, CVPR 2017

Room and Schedule

Room: *Aula Riunioni del Dipartimento di Ingegneria dell'Informazione, Via G. Caruso 16, Pisa – Ground Floor*

Schedule:

Day1 – time

Day2 – time

Day3 – time