

# Roberto Mecca

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## Curriculum Vitae

### Research Interests

- **Mathematical modeling of the following applied problems:**
  - Computer vision: 3D shape reconstruction using Multi-view Stereo and Shape from Shading, Photometric Stereo, Polarization, Defocusing;
  - Image processing: denoising and inpainting.
- **Numerical analysis:**
  - Non-linear partial differential equations of Hamilton-Jacobi type with discontinuous coefficients;
  - System of non-linear partial differential equations with discontinuous coefficients;
  - Non-linear partial differential equation with fractional derivation order;
  - Finite difference and semi-Lagrangian schemes;
  - Fast-sweeping and fast-marching acceleration methods.

### Employment

- 2015 – Present Marie Curie Research Fellow of the INdAM, Italy
- Supervisor Professor Roberto Cipolla and Professor Fiorella Sgallari
- Institution Department of Engineering, University of Cambridge, United Kingdom and Department of Mathematics, University of Bologna
- Description Combining Diffuse and Specular reflection into a single framework based on hyperbolic PDEs related to the 3D shape reconstruction with the Photometric Stereo technique. New differential approaches for the Shape from Polarization and Defocusing problems.
- February - November 2015 Postdoctoral Research Fellow
- Supervisor Professor Fiorella Sgallari
- Institution Department of Mathematics, University of Bologna, Italy
- Description Numerical analysis of new approach to the (Uncalibrated) Photometric Stereo problem. Fractional derivative operators. Novel numerical approach to high order generalized Grünwald-Letnikov type of formula for fractional derivative.
- 2013 - 2015 Postdoctoral Research Fellow
- Supervisor Professor Vittorio Murino and Alessio Del Bue
- Institution Department of Pattern Analysis and Computer Vision, Italian Institute of Technology, Italy

Description Shape from Photometric Stereo with bias of ambient light. Shape from Uncalibrated Photometric Stereo and Shape from Polarization.

2012 - 2013 Postdoctoral Research Fellow

Supervisor Professor Alfred Marcel Bruckstein and Ron Kimmel

Institution Department of Computer Science, Technion - Israel Institute of Technology, Israel

Description New models for the Perspective Shape from Shading problem solved using Photometric Stereo technique and related Numerical Methods for Non-Linear Partial Differential Equations.

2011 - 2012 Postdoctoral Research Fellow

Supervisor Professor Maurizio Falcone

Institution Department of Mathematics, Sapienza - University of Rome, Italy

Description Numerical Methods for Non-Linear Partial Differential Equations. Numerical analysis for hyperbolic partial differential equations applied to Shape from Shading problem and granular flow.

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## Education

2007 - 2011 PhD Student

Advisor Professor Maurizio Falcone

Institution Department of Mathematics, Sapienza - University of Rome, Italy

Description 3D shape recovery from digital images using Photometric Stereo, system of non-linear PDE of the Hamilton-Jacobi type.

2005 - 2007 Undergraduate Student

Advisor Professor Maurizio Falcone

Institution Department of Mathematics, Sapienza - University of Rome, Italy

Description A Variational Approach to the Image Warping and Applications. Interpolation with radial basis functions used for the deformation of digital images.

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## Industrial Experiences

2007 **Digital Video** - cartoon animation, Rome, Italy

Activity Research and implementation of image warping algorithm for a special effect option for the development of the software "Toonz 5.1".

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## Awards and Funding

2015–2017 Marie Curie Fellowship of the INdAM (Italian Institute of Advanced Mathematics)

2007–2011 Italian Government scholarship for the Ph.D. course in Applied Mathematics

## Publications

### Peer Reviewed Journal Papers

- (1) Y. Quèau, **R. Mecca**, J.D. Durou, X. Descombes, Photometric Stereo with Only Two Images: A Theoretical Study and Numerical Resolution, *Image and Vision Computing*, Vol. 57, pp. 175-191, 2017.
- (2) **R. Mecca**, Y. Quèau, F. Logothetis and R. Cipolla, A Single Lobe Photometric Stereo Approach for Heterogeneous Material, *SIAM Journal on Imaging Sciences*, Vol. 9, No. 4, pp. 1858-1888, 2016.
- (3) S. Tozza, **R. Mecca**, M. Duocastella and A. Del Bue, Direct Differential Photometric Stereo Shape Recovery of Diffuse and Specular Surfaces, *Journal of Mathematical Imaging and Vision*, Vol. 56, No. 1, Page 57, 2016.
- (4) **R. Mecca**, E. Rodolà and D. Cremers, Realistic photometric stereo using partial differential irradiance equation ratios, *Computers & Graphics*, Vol. 51, pp. 8-16, 2015.
- (5) **R. Mecca**, A. Wetzler, A. M. Bruckstein and R. Kimmel, Near Field Photometric Stereo with Point Light Sources, *SIAM Journal on Imaging Sciences*, Vol. 7, No. 4, pp. 2732-2770, 2014.
- (6) **R. Mecca**, A. Tankus, A. Wetzler and A. M. Bruckstein, A Direct Differential Approach to Photometric Stereo with Perspective Viewing, *SIAM Journal on Imaging Sciences*, Vol. 7, No. 2, pp. 579-612, 2014.
- (7) **R. Mecca** and M. Falcone, Uniqueness and approximation of a Photometric Shape-from-Shading model, *SIAM Journal on Imaging Sciences*, Vol. 6, No. 1, pp. 616-659, 2013.

### Book Chapters

- (1) **R. Mecca** and S. Tozza, Shape Reconstruction of Symmetric Surfaces using Photometric Stereo, In book: *Innovations for Shape Analysis*, Publisher: Springer Berlin Heidelberg, Editors: Breuß, Michael and Bruckstein, Alfred and Maragos, Petros, pp.219-243 (2013).

### Peer Reviewed Conference Publications

- (1) **R. Mecca**, F. Logothetis and R. Cipolla, A Differential Approach to Shape from Polarisation, *Proceedings of the British Machine Vision Conference (BMVC 2017)*, London, UK, September 4 - 7, 2017.
- (2) F. Logothetis, **R. Mecca** and R. Cipolla, Semi-calibrated Near Field Photometric Stereo, *Proceedings of IEEE Conference on Computer Vision and Pattern Recognition (CVPR 2017)*, Hawaii, USA, July 22 - 25, 2017.
- (3) F. Logothetis, **R. Mecca**, Y. Quèau and R. Cipolla, Near-Field Photometric Stereo in Ambient Light, *Proceedings of the British Machine Vision Conference (BMVC 2016)*, York, UK, September 19 - 22, 2016.
- (4) Y. Quèau, **R. Mecca** and J.D. Durou, Unbiased Photometric Stereo for Colored Surfaces: A Variational Approach, *Proceedings of IEEE Conference on Computer Vision and Pattern Recognition (CVPR 2016)*, Las Vegas, USA, June 26 - July 1, 2016.
- (5) **R. Mecca** and Y. Quèau, Unifying Diffuse and Specular Reflections for the Photometric Stereo Problem, *Proceedings of IEEE Winter Conference on Applications of Computer Vision (WACV 2016)*, Lake Placid, USA, March 7-9, 2016.
- (6) **R. Mecca**, E. Rodolà and D. Cremers, Analysis of surface parametrizations for modern photometric stereo modeling, *Proceedings of the Twelfth International Conference on Quality Control by Artificial Vision (QCAV 2015)*, Le Creusot, France, June 3-5, 2015;
- (7) A. Wetzler, **R. Mecca**, A. M. Bruckstein and R. Kimmel, Close-range Photometric Stereo with Point Light Sources, *Proceedings of 3D Vision Conference (3DV 2014)*, Tokyo, Japan, December

Department of Engineering, University of Cambridge – United Kingdom

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- 8-11, 2014;
- (8) **R. Mecca**, A. Wetzler, R. Kimmel, and A. M. Bruckstein, Direct Shape Recovery from Photometric Stereo with Shadows, *Proceedings of 3D Vision Conference (3DV 2013)*, Seattle, United States, June 29-July 1, 2013;
  - (9) **R. Mecca**, G. Rosman, R. Kimmel, and A. M. Bruckstein, Perspective Photometric Stereo with Shadows, *Proceedings of the 4th International Conference on Scale Space and Variational Methods in Computer Vision (SSVM 2013)*, Leibnitz, Austria, June 2-6, 2013;
  - (10) **R. Mecca**, A. Tankus and A. M. Bruckstein, Two-Image Perspective Photometric Stereo using Shape-from-Shading, *Proceedings of the 11th Asian Conference on Computer Vision (ACCV 2012)*, Daejeon, South Korea, November 5-9, 2012;
  - (11) S. Larnier and **R. Mecca**, Fractional-Order Diffusion for Image Reconstruction, *Proceedings of the 2012 IEEE International Conference on Acoustic Speech and Signal (ICASSP 2012)*, Kyoto, Japan, March 25-30, 2012;
  - (12) **R. Mecca**, Uniqueness for Shape from Shading via Photometric Stereo Technique, *in the Proceeding of the 2011 IEEE International Conference on Image Processing (ICIP 2011)*, Brussels, Belgium, September 11-14, 2011, pp. 2994-2997;
  - (13) **R. Mecca** and J.D. Durou, Unambiguous Photometric Stereo Using Two Images, *in G. Maino and G.L. Foresti (Eds.), Image Analysis and Processing, ICIAP 2011, 16th International Conference on Image Analysis and Processing, Ravenna, Italy, September 14-16, 2011. Lectures Notes on Computer Science*, Volume 6978, pp. 286-295, Springer, 2011.

## Involvement in International Conferences Organisation

- June 2018 In the organising committee of the SIAM Conference on Imaging Science, Bologna, Italy
- September 2017 In the international program committee of the ACM Symposium on Applied Perception 2017, Cottbus, Germany

## Conference and Workshop Presentations

- July 2017 IEEE conference on Computer Vision and Pattern Recognition, CVPR 2017, (Hawaii, USA)
- February 2017 Workshop on Optical Imaging and Inverse Problems, Institute of Mathematics and its Applications, University of Minnesota (USA)
- March 2016 IEEE Winter Conference on Applications of Computer Vision, WACV 2016, (Lake Placid, USA)
- June 2015 International Conference on Quality Control by Artificial Vision, Le Creusot (France)
- January 2014 Numerics in Image and Surface Processing, Department of Mathematics, University of Bologna (Italy)
- June 2013 International Conference on 3D Vision, 3DV 2013 (Seattle, USA)
- June 2013 4th International Conference on Scale Space and Variational Methods in Computer Vision, SSVM 2013 (Leibnitz, Austria)
- November 2012 11th Asian Conference on Computer Vision, ACCV2012 (Daejeon, South Korea)
- September 2011 16th International Conference on Image Analysis and Processing, ICIAP2011 (Ravenna, Italy)

- September 2011 IEEE 18th International Conference on Image Processing, ICIP2011 (Brussels, Belgium)
- May 2011 International conference on Scale Space and Variational Methods in computer vision, SSVM2011 (Ein Gedi, Israel)
- April 2011 Innovations for Shape Analysis: Models and Algorithms (Dagstuhl, Germany)

## Selected Symposium Presentations

- December 2016 invited speaker by Professor Maurizio Falcone, at the Sapienza - University of Rome, Department of Mathematics (Italy)
- July 2013 invited speaker by Professor Vittorio Murino, at the Italian Institute of Technology, Department of Pattern Analysis and Computer Vision (Italy)
- May 2013 invited speaker by Professor Melvyn Smith, at Western England University, Centre for Machine Vision, Bristol Robotics Laboratory (England)
- May 2013 invited speaker by Professor Edwin Hancock, at the York University, Department of Computer Science (England)
- May 2013 invited speaker by Professor D. Samaras, at the Stony Brook University, Department of Computer Science (United States)
- May 2013 invited speaker by Professor B.K.P. Horn, at the Massachusetts Institute of Technology, Department of Electrical Engineering and Computer Science (United States)
- April 2013 invited speaker by Professor A. Vladimirsky, at the Cornell University, Department of Mathematics (United States)
- December 2011 Recent advances on theory and applications of semi-Lagrangian methods, Sapienza University (Rome, Italy)
- September 2011 invited speaker by Professor J. Weickert at the Saarland University, Faculty of Mathematics and Computer Science (Germany)

## Patent

Title Image Processing Method and System  
Application number: GB1713192.1

Title Direct shape recovery from photometric stereo with shadows  
Provisional patent application no. 61/878, 401  
Filed with the US patent office on 16/9/2013

## Reviewing Activity for Scientific Journals

American Mathematical Society  
Nature Scientific Reports  
International Journal of Computer Vision  
Journal of Mathematical Imaging and Vision  
IEEE Transactions on Image Processing

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## Research Periods Abroad

- April–May 2013 Visiting Researcher  
Institution Department of Mathematics, Cornell University, Ithaca, United States  
Description New differential model for the object reconstruction combining Photometric Stereo and Stereo Vision  
Advisor Professor Alexander Vladimirovsky
- March–April 2010 Visiting PhD student  
Institution Institut de Mathematiques de Toulouse, Paul Sabatier University, Toulouse, France  
Description inpainting and denoising problem using PDE with fractional derivative  
Advisor Professors Mohammed Masmoudi and Jean Micheal Roquejoffre
- May–June 2010 Visiting PhD student  
Institutions Institute de Recherche en Informatique de Toulouse, Paul Sabatier University and Ecole Nationale Supérieure d'Electrotechnique, d'Electronique, d'Informatique, d'Hydraulique et des Telecommunications, Toulouse, France  
Description Shape from Shading problem Using Photometric Stereo Technique, numerical algorithms for to find the set of points for which it is possible to recover the shape without ambiguity  
Advisor Professor Jean-Denis Durou

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## Teaching

- 2017 - Lent Demonstrator of the second year course *C++ Computing (IB)* supervising students during lab hours  
Institution Department of Engineering, University of Cambridge, United Kingdom
- 2017 - Lent Supervisor of the third year course *Numerical Methods (3M1)* teaching small groups of students  
Institution Department of Engineering, University of Cambridge, United Kingdom
- 2015 - II Teaching Assistant for the course *Numerical Methods* of the International Master Course in Chemical and Process Engineering and Environmental Engineering  
Institution Department of Engineering, University of Bologna, Italy
- 2007–2008 Teaching Assistant for the courses *Calculus I* and *Calculus II*  
Institution Department of Electrical Engineering and Security Engineering, Sapienza - University of Rome, Italy
- 2008–2011 Teaching Assistant for the course *Programming and Computing Laboratory*  
Institution Department of Mathematics, Sapienza - University of Rome, Italy

2010–2011 Teacher of the introduction course of mathematic for the students of the Faculty of Science

Institution Department of Mathematics, Sapienza - University of Rome, Italy

2010–2011 Teaching Assistant for the course *Numerical Analysis I*

Institution Department of Mathematics, Roma Tre University, Italy

## Computer skills

Computer Programming C, MatLab, PYTHON

Operative System Mac OS X, Linux, Microsoft Windows

Text Editing L<sup>A</sup>T<sub>E</sub>X, OpenOffice, Microsoft Office, Pages, Keynote, Numbers

Image/Video Editing Final Cut Pro, Adobe Illustrator, After Effects, Photoshop, Muse

## Soft Skills

- Team building and leadership skills, mentorship/coaching strategies proven throughout the supervision of students
- Excellent communication techniques
- Ability to prioritize and meet deadlines as needed, as well as coordinate the group activities juggling multiple tasks effectively

## Languages

Italian Native speaker

English Fluent in writing and speaking

French Basic knowledge

## Interests

- Trumpet

- Music

- Running

- Football

- Cinema

- Cycling