
CURRICULUM VITAE

Gabriele Facciolo

Short Bio

Gabriele Facciolo received his B.Sc. and M.Sc. from Universidad de la Republica del Uruguay, and his Ph.D. from the DTIC at Universitat Pompeu Fabra (Barcelona, Spain) under the supervision of Vicent Caselles. He is currently at the CMLA, ENS Paris-Saclay working within Jean-Michel Morel's group. He has 16 publications in international journals, and 17 in peer-reviewed international conferences. The algorithms for 3D reconstruction and the satellite stereo pipeline (S2P) he has developed at the CMLA has been adopted as the CNES's official pipeline, and has won the 2016 IARPA 3D Stereo Mapping Challenge. The denoising algorithms he has developed are currently beating the state-of-the-art. He has been teaching mathematics and image processing for over 10 years, and has co-supervised three Ph.D theses. G. Facciolo is one of the founding Editors of IPOL (www.ipol.im), the first journal publishing articles associated to online executable algorithms.

Summary

Post-Doctoral Research Associate at CMLA ENS Paris-Saclay

Mathematics applied to image processing and computer vision.

Doctor from Universitat Pompeu Fabra, Barcelona (2011)

- **Advisor:** Vicent Caselles
- **Examining board:** Jean-Michel Morel (chair), José Mazón Ruiz, and Andrés Almansa

Habilitation à diriger des recherches (HDR) from ENS Paris-Saclay (2016)

- **Advisor:** Jean-Michel Morel
- **Examining board:** Mila Nikolova (chair), Julie Delon, Laure Blanc-Réraud, Luis Alvarez, Pascal Monasse, Andrés Almansa, and Guillermo Sapiro

Research subjects: Stereovision and optical flow estimation; 3D reconstruction from satellite images; Image and video restoration; Patch-based methods applied to inpainting and denoising; Variational modeling

Publications:

- **16** in international journals (2×IJCVCV, 3×MMS, 5×IPOL, 3×SIIMS, M3AS, JPCS, OSA)
- **17** in peer reviewed conferences (6×ICIP, 2×EMMCVPR, 2×BMVC, VISAPP, ISPRS Annals, IGARSS, 2×CIARP, GRETSI, NCIMP)

Supervised PhDs:

- Carlo de Franchis. *Earth Observation and Stereo Vision*. ENS-Cachan, Oct. 5, 2015. Co-supervisor (50-50) with Jean-Michel Morel. Currently: Postdoc at ENS Paris-Saclay.
- Nicola Pierazzo. *Advances in image denoising*. ENS-Cachan, Sep. 2016. Co-supervisor (50-50) with Jean-Michel Morel. Currently: Research Engineer at Google.
- Martin Rais. *Fast and Accurate Image Registration Applications to On-board Satellite Imaging*. ENS-Cachan, Dec. 2016. Co-supervisor (25%) with Jean-Michel Morel and Bartolomeu Coll-Vicens. Currently: Postdoc at ENS Paris-Saclay.

Teaching:

- Lecturer at **École des Ponts ParisTech (101h in total)**
Course: *Algorithms and Programming*
- Lecturer and internship mentoring at **ENS-Cachan (148h in total)**
Courses: *Introduction to Fourier Analysis, and supervision of five (L3) internships*
- Lecturer and Teaching assistant at **Universitat Pompeu Fabra, Barcelona (368h in total)**
Courses: *Introduction to image processing, Linear algebra, Graph theory, and Calculus*
- Teaching assistant at **UdelaR, Uruguay, Faculty of Engineering, Uruguay (10h in total)**.
Course: *Introduction to Fourier Analysis*

Personal Information and Addresses

Gabriele Facciolo

Birth date: september 18th, 1978

Citizenship: Italian

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Professional address:

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Ecole Normale Supérieure Paris-Saclay

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Current Situation

Since April 2016

Laboratory

Mentor

Subject

Keywords

Post-Doctoral Research Associate

CMLA, École Normale Supérieure Paris-Saclay

Prof. Jean-Michel Morel

Mathematics applied to image processing and computer vision

stereovision, satellite imaging, denoising, optic flow, variational methods

Education

2016

Habilitation à diriger des recherches, ENS Paris-Saclay (June 20, 2016)

Discipline: mathematics

Title: Geometry-aware patch modelling for 3D reconstruction and image denoising

Advisor: Jean-Michel Morel

Examining board: Mila Nikolova (chair), Julie Delon (rapporteur), Laure Blanc-Réraud (rapporteur), Luis Alvarez (rapporteur), Pascal Monasse, Andrés Almansa, Guillermo Sapiro

2005-2011

PhD in Information and Communication Technologies (*Summa cum Laude*),
Universitat Pompeu Fabra (UPF), Barcelona (March 3, 2011)

The PhD candidates at UPF must teach ~70 h/year, thus are also teaching assistants.

Title: Irregularly sampled image restoration and interpolation

Advisor: Prof. Vicent Caselles

Examining board: Jean-Michel Morel (Chair), José Mazón Ruiz (rapporteur), Andrés Almansa (rapporteur)

2004-2005

Master in Computer Sciences,

FING, Universidad de la Republica Oriental del Uruguay

2001-2005

Worked as a full-time engineer at

ANTEL (Telecommunications company), Montevideo, Uruguay

1996-2001

Degree in Computer Engineering (eq. BAC+5),

FING, Universidad de la Republica Oriental del Uruguay

Specific skills

- **Image processing and computer vision:** data structures, stereo-vision, optical flow, 3D reconstruction, satellite imaging, variational methods, patch-based inpainting and denoising, image restoration and interpolation, video editing
- **Coding/Unix:** C/C++, Python, Bash, L^AT_EX, XHTML, CSS, JavaScript, Matlab/Octave, OpenGL, git, Novell Certified Linux Administrator (ID: 10112069)
- **Languages:** Italian (native), Spanish (native), English (fluent), and French (fluent)

Professional experience

- since 2016 **Post-doc at CMLA, ENS Paris-Saclay** (apr 2016 – present)
Topic: Mathematics applied to image processing and computer vision.
Collaborator: Prof. Jean-Michel Morel
- since 2016 **Image Science Researcher at DxO Labs** (apr 2016 – present)
Topic: Oversee the work of three to four small teams of engineers in the image processing and image quality evaluation departments. Advising on the design and specification of new algorithms and protocols.
Collaborators: Frédéric Guichard and Wolf Hauser
- 2015 **Consultant for *Digital Sense Technologies*** (nov 2015–jan 2016)
Topic: Analysis of physical model approximations of satellite pushbroom sensors.
Supervisor: Javier Preciozzi
- 2014 **Consultant for *CS Systèmes d'information*** (sep–dec 2014)
Topic: Etude métiers Benchmark MEDICIS, Logiciel CNES de Traitement d'Images.
Supervisor: Myriam Cournet
- 2014-2016 **Post-doc at IMAGINE/LIGM, École des Ponts ParisTech** (jul 2014 – apr 2016)
Topic: High precision stereovision using noiseless images.
Collaborators: Prof. Pascal Monasse and Prof. Jean-Michel Morel
- 2013 **Invited at the TAMI Lab of Universitat Illes Balears, Palma de Mallorca** (sep 2013 – nov 2013)
Topic: Reliable stereo matching.
Collaborator: Antoni Buades
- 2011-2014 **Post-doc at CMLA, ENS-Cachan** (apr 2011 – jul 2014)
Topic: Mathematics applied to image processing and computer vision. Design and development of the state-of-the-art and online publication.
Collaborator: Prof. Jean-Michel Morel
- 2010 **Research staff at BarcelonaMedia** (sep–dec 2010)
Topic: Temporally consistent video inpainting.
Supervisor: Monica Caballero
- 2005-2011 **PhD in Information and Communication Technologies, Universitat Pompeu Fabra, Spain** (sep 2005 – mar 2011)
Title: Irregularly sampled image restoration and interpolation.
Advisor: Prof. Vicent Caselles
- 2001-2005 **Worked at ANTEL (Telecommunications company), Uruguay**
Role: Unix administrator and system integration engineer.
- 1999-2005 **Part-time jobs at Universidad de la Republica Oriental del Uruguay**
Roles: Sysadmin and system integration engineer.

Thesis supervision

- **PhD thesis co-advising of Carlo de Franchis (ENS Cachan, 2012–2015)**

Co-advisor (50-50): Jean-Michel Morel

Description: This thesis deals with the problem of computing accurate digital elevation models of the Earth's surface from optical images taken by pushbroom observation satellites. This work stems from a long time collaboration with the CNES. The main contribution of this thesis is s2p: a fully automatic and modular stereo pipeline to produce digital elevation models from satellite images. The s2p pipeline can be tested on-line on a large database of satellite images (<http://dev.ipol.im/~carlo/s2p/>).

Personal commitment: I coordinate the work, serve as permanent interlocutor to evacuate doubts, and support in the preparation of the scientific publications. I also provide support and formation with the technical development.

Scientific production: Four peer reviewed international conferences, two national journals, one international journal, and other two international journal papers in preparation.

- C. de Franchis, E. Meinhardt, D. Greslou, and G. Facciolo. Attitude Refinement for Orbiting Pushbroom Cameras: a Simple Polynomial Fitting Method. *Image Processing On Line*, 2015.
- G. Facciolo, C. de Franchis, and E. Meinhardt MGM: A Significantly More Global Matching for Stereovision. *BMVC*, 2015. (ORAL PRESENTATION)
- C. de Franchis, E. Meinhardt, Michel J., J.-M. Morel, and G. Facciolo On stereo-rectification of pushbroom images. *ICIP*, 2014.
- C. de Franchis, E. Meinhardt, Michel J., J.-M. Morel, and G. Facciolo S2P: An automatic and modular stereo pipeline for pushbroom images. *ISPRS Annals*, 2014. (ORAL PRESENTATION)
- C. de Franchis, E. Meinhardt, Michel J., J.-M. Morel, and G. Facciolo Automatic sensor orientation refinement for Pléiades stereo images. *IGARSS*, 2014. (ORAL PRESENTATION)
- Chen A., Darbon J., C. de Franchis, G. Facciolo, E. Meinhardt, Michel J., and J.-M. Morel Numerical simulation of landscape evolution and water run-off on digital elevation models obtained from pléiades. *Revue Française de Photogrammétrie et de Télédétection*, 2014.
- C. de Franchis, E. Meinhardt, Michel J., J.-M. Morel, and G. Facciolo Automatic digital surface model generation from Pléiades stereo images. *Revue Française de Photogrammétrie et de Télédétection, special issue Pléiades Days & ORFEO*, 2014.

- **PhD thesis co-advising of Nicola Pierazzo (ENS Cachan, 2013–2016)**

Co-advisor (50-50): Jean-Michel Morel

Description: This thesis aims at improving the quality of state-of-the-art denoising algorithms. These objectives are in line with a collaboration with DxO. One of the contributions of this thesis is DA3D (<http://dev.ipol.im/~pierazzo/da3d/>), a fast last-step denoising method that improves the visual quality and PSNR of many state-of-the-art algorithms such as NL-Bayes. Current research is focused on further improving the computational efficiency and quality of DA3D and NL-Bayes.

Personal commitment: I participate in the coordination, propose new approaches, and support in the preparation of the scientific publications. I also provide support with the technical development.

Scientific production: Three peer reviewed international conferences and two international journal papers in preparation.

- N. Pierazzo, M. Rais, J.-M. Morel, and G. Facciolo DA3D: Fast and Data Adaptive Dual Domain Denoising. *ICIP* 2015. (ORAL PRESENTATION)
- N. Pierazzo, J.-M. Morel and G. Facciolo Optimizing the Data Adaptive Dual Domain Denoising Algorithm. *CIARP* 2015. (ORAL PRESENTATION)
- N. Pierazzo, M. Lebrun, M. Rais, J.-M. Morel, and G. Facciolo Non-local Dual Image Denoising. *ICIP* 2014. (ORAL PRESENTATION) **Top 10% Paper Award**

- **PhD thesis co-advising of Martin Rais (ENS Cachan, 2013–2016)**

Co-advisor (25%) with Jean-Michel Morel and Bartomeu Coll-Vicens

Description: This thesis studies the problem of fast and accurate image registration for remote sensing applications. It starts with an extensive review of sub-pixel shift estimation methods. The first contribution, which stems from the review, is the identification of a classical shift estimation method

based on image gradients, previously ignored by the remote sensing community. This method is proved to be extremely precise and cheap if carefully refined, and was later applied to measure the wavefront aberrations. The second major contribution is related to the RANSAC algorithm. The proposed variant aggregates the minimal samples generated during the random sampling, instead of keeping just the best one, which permit to improve on state-of-the-art methods.

Personal commitment: I served as permanent interlocutor to evacuate doubts, and support in the preparation of the scientific publications. I also provided support and formation with the technical development.

Scientific production: Three peer reviewed international conferences, two international journals, another submitted, and one in preparation.

- M Rais, G. Facciolo, E. Meinhardt-Llopis, J.-M. Morel, A. Buades, and B. Coll-Vicens. Accurate Motion Estimation through Random Sample Aggregation, Submitted, 2016.
- M. Rais, J.-M. Morel, C. Thiebaut, J.-M. Delvit, and G. Facciolo. Improving wavefront sensing with a Shack-Hartmann device, *OSA Applied Optics*, 2016.
- M. Rais, J.-M. Morel, C. Thiebaut, J.-M. Delvit, and G. Facciolo. Improving the accuracy of a Shack-Hartmann wavefront sensor on extended scenes, IOP Publishing, Journal of Physics: Conference Series NCIMP, 2016. (ORAL PRESENTATION)
- M. Rais, J.-M., Morel, and G. Facciolo. Iterative Gradient-Based Shift Estimation: To Multiscale or Not to Multiscale?, CIARP 2015.

Awards

- **Winner of the IARPA Multi-View Stereo 3D Mapping Challenge.**
C. de Franchis, E. Meinhardt, and G. Facciolo. Presented at the *IARPA's Multi View Stereo 3D mapping Challenge Workshop*, Washington DC, Nov 30, 2016.
- **Top 10% Paper Award** for the conference paper:
N. Pierazzo, M. Lebrun, M. Rais, J.-M. Morel, and G. Facciolo. Non-local Dual Image Denoising. Presented in the *21th IEEE International Conference on Image Processing (ICIP)*, 2014.

Projects

- **Remote sensing with CNES.** I'm involved in several research projects financed by CNES. These projects can be organized in two groups. The first one is concerned with all the mathematical and geometrical issues related to a 3D reconstruction pipeline for satellite images including image quality. The second one aims at developing the theory and practice of reliable and efficient stereo matching algorithms.
 - Strategies d'interpolation thématique pour le calcul de MNT. *Convention CNES. R&T R-S15/OT-0004-080*, 2015–2016
 - Étude portant sur les méthodes d'affinage géométrique de prises de vues satellitaires (Phase 1 et 2). *Étude CNES Ref: DCT/SI/QI-2014.0016366 et DCT/SI/QI-2015.0008639*, 2014–2015
 - Extraction 3D multi-vues en THR optique: Tri-stereo point cloud fusion, Rectification, and Pointing Correction. *Convention CNES. Ref: DCT/SI/AP-2013.00014055. R&T R-S13/OT-0004-068 et R-S13/OT-0001-098*, 2014–2015
 - RAFA2: Méthode automatique de calcul du relief par adaptation géométrique des fenêtres aux occlusions et déformations du relief. *Convention CNES No. 115681/00*, 2012–2013
 - Chaîne stéréo avec contrôle de fausses alarmes. *Convention CNES No. 115686/00, EOTP: R-S11/OT-0004-042*, 2011–2012
 - Comparaison et fusion d'algorithmes de stéréoscopie (méthodes denses et non denses). *Convention CNES No. 103894/00, EOTP: R-S10/OT-0004-047 et EOTP: R-S10/OT-0004-049*, 2010–2011
 - Échantillonnage irrégulier, Restitution du 3D par stéréoscopie à très faible B/H. *Convention CNES*, 2007–2008

Since 2012, I'm also involved in the elaboration of the project proposals for the CNES R&T (Research and Technology) calls. So far, four of these research projects have been accepted.

- G. Facciolo, A. Buades, and J.-M. Morel Stéréo satellitaire multi-vue par méthode locale et globale rapide. *Appel à idées R&T CNES 2016*, September 2015.
 - G. Facciolo and J.-M. Morel Modèles numériques d'élévation denses: conception et évaluation de stratégies d'interpolation pour des zones urbaines et rurales. *Appel à idées R&T CNES 2015*, September 2014.
 - A. Buades, G. Facciolo, and J.-M. Morel Débruiter avant de compresser? L'impact du débruitage sur la transmissibilité et la qualité des images d'observation de la Terre (UIB). *Appel à idées R&T CNES 2013*, September 2012.
 - G. Facciolo and J.-M. Morel Exploitation de données Pléiades multi-vues synchrones: adaptation des algorithmes stéréoscopiques et synthèse de nuages 3D (CMLA). *Appel à idées R&T CNES 2013*, September 2012.
- **Image denoising with DxO.** This research project, financed by DxO aims at inventing and industrializing the state-of-the-art in denoising algorithms.
 - **Participation in the research project with Schlumberger: *Traitement des données images acquises dans les puits de forage par des méthodes de traitement d'images et d'apprentissage.*** A two year research project, financed by Schlumberger, that started in May 2015. I participate in the realization of the state-of-the-art and research new approaches for the automatic interpretation of borehole images.
 - **Participation in project as Barcelona Media staff (sep–dec 2010).** Integrated Project - "2020 3D Media: Spacial Sound and Vision", Financed by EC, 7mo Programa Marco, ICT - call 1. Working on temporally consistent video editing and inpainting.
 - **IPOL.** The IPOL journal is an initiative to establish a clear and reproducible state-of-the-art in the domain of image processing. An IPOL article must include an algorithmic description of the proposed method, its code, and an on-line demo. I'm involved with the IPOL journal since its beginnings (in 2011) at several levels: as technical aid for the on-line demo infrastructure, as a spokesperson to publicize the project, as **member of the steering committee**, as **editor**, and as author.

Summary of Research Activities

During my thesis I contributed to a pioneering mathematical formalization of the inpainting problem [16], and a formulation of temporally consistent video editing robust to illumination changes [12]. Motivated by remote sensing applications, I also worked on variational image restoration from irregular samples [18] and image interpolation using Riemannian metrics on the image [17].

During my postdocs I worked on three main research themes. The first one (financed by the CNES through several projects) is concerned with all the mathematical and geometrical issues linked to the automated 3D reconstruction from satellite images. The second (also financed by CNES) aims at developing the theory and practice of reliable stereo matching algorithms. The third one (a collaboration with DxO) aims at inventing and industrializing the state-of-the-art in denoising algorithms.

3D reconstruction pipeline from satellite images. The increasing availability of high resolution stereo images from Earth observation satellites has boosted the development of tools for producing 3D elevation models. The purpose of these tools is to produce digital elevation models of very large areas with minimal human intervention. These tools are shaped by the constraints of the remote sensing acquisition, for example, using ad hoc stereo matching strategies to deal with the push-broom image acquisition geometry. However, this specialization has also created a gap with respect to the fields of computer vision and image processing, where these constraints are usually factored out.

The geometric analysis of these imaging system allowed us to automatize the 3D reconstruction using large images with non-projective geometry. This collaboration with the CNES led to develop s2p (Satellite Stereo Pipeline) a fully automatic and modular stereo pipeline to produce digital elevation models from satellite images. The purpose of this new pipeline is to integrate off-the-shelf computer vision tools while abstracting from the complexity associated to satellite imaging [27]. To this aim, images are cut into small tiles for which we proved that the push-broom geometry is very accurately approximated by the pinhole model [26]. These tiles are then processed with standard stereo image rectification and stereo matching tools. The specifics of satellite imaging such as pointing accuracy refinement [28, 6], estimation of the initial elevation from SRTM data, and geodetic coordinate systems are handled transparently by s2p.

This pipeline is routinely used at the CNES to create large scale elevation models for several applications [42, 43]. An on line version of the pipeline permits to test s2p on a large database of satellite images: <http://dev.ipol.im/~carlo/s2p>.

This research project is central to Carlo de Franchis' PhD, which I co-supervised with J.-M. Morel.

Reliable stereovision and motion estimation. This research project aims at creating stereo matching algorithms that produce reliable but not necessarily dense disparity maps [52]. We evaluated several approaches to this problem. We started assessing the quality of exhaustive block-matching methods [11], and compared them to differential motion estimation techniques using multiscale strategies [13, 22].

The limitations of block-matching are: lack of regularity and occurrence of mismatches. Based on the advances made by (Sabater et al., 2012) on meaningful stereo matching, we identified two ways to limit the invalid matches. The first is to improve the computation of disparities at places where the fronto-parallel hypothesis is invalid: like discontinuities and slanted surfaces. The second is the proper detection of invalid or ambiguous matches. The resulting *multi-scale multi-window* algorithm [9] uses oriented windows to deal with slanted surfaces and discontinuities, and incorporates new parameter-less mismatch detection techniques. This algorithm is very competitive in terms of mismatch rates, with a reasonably high density.

The advantage of “global” optic flow methods [13] is that many mismatches are recovered by the regularity constraint, however this global regularity also forces the solution to be continuous even near discontinuities. This led us to investigate the celebrated *semi-global matching* (SGM) algorithm (Hirschmüller 2008) which uses an approximate regularizer. We noted that the optimization strategy in SGM introduces streaking artifacts in the result. We then proposed “more global matching” (MGM) [23], a new algorithm that prevents the apparition of streaking artifacts and is as performant as SGM. An on line demonstrator and source code of MGM is available at: <http://dev.ipol.im/~facciolo/mgm/>.

Image denoising with DxO. This research project supported by DxO, has among its objectives to invent better image denoising algorithms [40], regardless of their complexity. Nowadays, non-local algorithms produce state-of-the-art results but tend to remove low contrast details. Frequency-based algorithms, on the other hand, preserve these details but introduce ringing artifacts. The recently proposed Dual Domain

Image Denoising (DDID) algorithm (Knaus and Zwicker, 2013) suggests a mechanism to combine these spatial and spectral denoising techniques. Our analysis of DDID lead to a breakthrough in quality [24, 25] and performance [21]. The resulting DA3D algorithm [24] improves the visual quality and PSNR of many state-of-the-art methods such as NL-Bayes.

The qualitative analysis of current denoising algorithms shows that they behave better on high frequency noise. This is due to the relatively small size of the blocks and search windows used in these single-scale algorithms. Hence, we propose a new multi-scale scheme applicable to any denoising algorithm. This method makes it possible to eliminate most of the low-frequency noise by decomposing the image on a DCT pyramid, while avoiding the appearance of ringing artifacts. The algorithm resulting from combining these two advances improves the state of the art in terms of PSNR and in terms of visual results for smooth and textured areas: <http://dev.ipol.im/~pierazzo/CombinedDenoising/>.

This research project is central to Nicola Pierazzo's PhD, which I co-supervised with J.-M. Morel.

Academic activities and Collective responsibilities

- Member of PhD examining boards
 - Pedro Henriquez - Universidad de las Palmas de Gran Canaria, 28 jun 2013
 - Miguel Colom Barco - Universitat de les Illes Balears, 25 jun 2014
 - Carlo de Franchis - École Normale Supérieure de Cachan, 5 oct 2015
 - Nicola Pierazzo - École Normale Supérieure Paris-Saclay, 20 sep 2016
 - Roberto Pablo Pérez Palomares - Universitat Pompeu Fabra, 6 abr 2017
- Reviewer for international journals and conferences
 - *IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing*
 - *IEEE Transactions on Image Processing*
 - *SIAM Journal on Imaging Sciences*
 - *Journal of Mathematical Imaging and Vision*
 - *Journal of Visual Communication and Image Representation*
 - *Conferencia Latinoamericana en Informática (Program Committee)* , 2013
 - *20th Iberoamerican Congress on Pattern Recognition (Program Committee)* , 2015
 - *Image Processing On Line*
- Member of the editorial board and a founding member of the Journal: Image Processing On Line (IPOL)
- Member of IPOL system administration and technical support teams (2011–present)
- Co-organizer (with A. Buades) of the mini-symposium “High Precision Stereo Vision” in SIAM Conference on Imaging Sciences 2014, Hong Kong Baptist University, May 2014
- Regular presenter at the CMLA image processing group seminars (2011–present)

Teaching

My teaching activities started in 2005 as teaching assistant at the University of the Republic of Uruguay (UdelaR). During my PhD (2005–2011) at the Universitat Pompeu Fabra (UPF), I developed my skills in various aspects of the university teaching: as **teaching assistant in practice/exercise sessions (TD/TP)**, **lecturing (C)**, **preparing exams, and correcting them**. During my post-doc at the ENS Cachan (2011–2014) I was put in charge of an **L3 course** and I mentored three **L3 research internships**. I currently teach a computer science course at the ENPC.

Detail of the courses:

Center	Subject	Responsible	Type	Hours ¹
UdelaR	Introduction to Fourier Analysis	A. Almansa	TP	10h in 2005
UPF	Linear Algebra and Discrete Math. I	C. Ballester	TD/TP	116h in 2005–2006
UPF	Linear Algebra and Discrete Math. II	C. Ballester	TD/TP	54h in 2007
UPF	Mathematical Analysis	C. Ballester	TD/TP	30h in 2008
UPF	Signal Processing II: Image and Video	V. Caselles	C/TD/TP	122h in 2008–2010
UPF	Linear Algebra and Discrete Math. I	C. Ballester	TD/TP	46h in 2009–2010
Cachan	Hilbert and Fourier Analysis (L3)	GF	C/TP	58h in 2011–2013
Cachan	Research Internship (seamless cloning)	F. de Vuyst	Mentoring	15h in 2013
Cachan	Research Internship (scattering transf.)	GF	Mentoring	20h in 2014
Cachan	Research internship (IPOL+Matlab)	GF	Mentoring	15h in 2014
Cachan	Research internship (TGV)	GF	Mentoring	20h in 2016
Cachan	Research internship (Graph-Cuts)	GF	Mentoring	20h in 2016
ENPC	Algorithms and Programming (L3)	P. Monasse	C/TP	101h in 2014-2016

Total hours for each center:

2014-2016 **Lecturer**, ENPC (101h total)

2011-2016 **Lecturer and internships mentoring**, ENS Cachan (148h total)

2005-2011 **Teacher assistant**, UPF (368h total)

2005 **Teacher assistant**, Universidad de la República, Uruguay. (10h total)

Detailed description of the teaching activities

Introduction to Fourier Analysis (UdelaR, 2005)

Description: I assisted the professor with the practice sessions of the course. The course was intended for last year's students (M2 level) of a CS degree, and introduced concepts of Fourier analysis from the viewpoint of signal/image processing.

Linear Algebra and Discrete Mathematics I (UPF, 2005–2010)

Description: Classic course of linear algebra for first year computer science students.

Personal commitment: I was in charge of practice/exercise sessions (TP/TD), and collaborated to the elaboration/correction of the final exams. Although the subject is relatively simple, it was challenging to convey it to computer science students. As instructor I had to be creative in order to attract the students towards the subject. For example, to motivate the rotation and transformation matrices I explained their use in OpenGL for gaming.

Linear Algebra and Discrete Mathematics II (UPF, 2007)

Description: An introductory course to discrete mathematics and elementary graph theory for first year computer science students.

Personal commitment: I was in charge of the practice and exercise sessions (TP/TD), I collaborated in the preparation the material for these sessions as well as the evaluation.

Mathematical Analysis (UPF, 2008)

Description: Classic course of differential and integral calculus for first for first year computer science

¹Note that an year denotes an academic year. For example 2008 corresponds to the academic year 2008/2009, while year spans such as 2009–2010 corresponds to two academic years: 2009/2010 and 2010/2011.

students.

Personal commitment: I was in charge of the practice and exercise sessions (TP/TD), and contributed to the elaboration and correction of the exams. In 2008 the course was adapted to conform new European standards. As a result the concrete planning of the lectures, TP, and TD (to which I contributed) had to be determined and frequently adjusted. Although my role was “practice instructor”, in many occasions I found myself repeating the lectures during the practice sessions and during office hours.

Signal Processing II: Image and Video (UPF, 2008–2010)

Description: A broad introductory course to image processing for third year computer science students. Each lecture covers a different subject: visual system and color perception, linear operators in images, Fourier analysis and sampling, contrast manipulation, mathematical morphology, information theory, and JPEG compression.

Personal commitment: At first I was assigned to the practice/exercise sessions (TP/TD), then the lectures and the coordination of the course. I contributed to the elaboration of new practice materials in Matlab. For the lectures I adapted the content of course notes and elaborated support material to facilitate the lecture, some material is still accessible on-line: <http://dev.ipol.im/~facciolo/procsig>.

Hilbert and Fourier Analysis (ENS Cachan, 2011–2013)

Description: It is an analysis course intended for third year (L3) mathematics students. This course (based on lecture notes from Fabre-Morel-Gousseau) presents the Hilbert and Fourier Analysis from the optics of image and signal processing. Some fundamental integration theorems are enunciated and assumed (Lebesgue, Fubini, and density of C in L^1), from which are developed: Lebesgue integral, L^p spaces, Hilbert spaces, Fourier series, sampling theorems, DFT, Sobolev spaces, and Distributions. Applications to image processing are used to motivate the analysis, particularly for the subjects of Fourier analysis and sampling.

Personal commitment: I was in charge of the lectures (in French), the practice sessions (TP), and elaborated/corrected the final exams. I elaborated, in collaboration with M. Delbracio, new course notes and support materials for the lectures. These resources (accessible here <http://dev.ipol.im/~facciolo/hilbert/index2012.html>) are often used by new teachers as a reference for preparing the lectures. In 2013 I coordinated the course, corrected the exams, and trained the new instructors.

Algorithms and Programming (ENPC, 2014-present)

Description: An introductory programming and algorithms course intended for third year (L3) engineering students. In the course C++ is taught using a graphic library designed for students and beginners (Imagine++). This simple yet powerful library allows to easily visualize the introduced concepts.

Personal commitment: I'm in charge of lectures (in French) and the practice sessions (TP).

Mentoring of L3 research internships (ENS Cachan, 2013–present)

Description: I've proposed and mentored five internships at the ENS Cachan: four research internships for third year mathematics students, and one internship for an engineering student from TélécomParis-sud.

- A research internship was aimed at analyzing mathematically a recent image cloning technique: *Convolution Pyramids* proposed by *Farbman et al. 2011*.
- Another research internship aimed at studying the *Scattering Transform* by *Bruna and Mallat 2013*, and conduct an empirical analysis of its robustness to image blur. Image blur constitute a large class transformations which are not considered by the Scattering Transform modeling.
- An internship considered the problem of systematically converting IPOL publications to Matlab MEX. Converting IPOL code from C/C++ to MEX is difficult due to the variability of coding styles. This work contributes to *increasing the impact of the IPOL journal in the scientific community*.
- One research internship in 2016 is concerned with applications of *Graph-Cuts to image inpainting*.
- Another internship in 2016 aims at studying the *Total Generalized Variation* by *Bredies et al. 2010*.

Personal commitment: For all the internship, but the second, I have chosen the subject and delimited the problem. I guided the study of the subject, the coding, and the preparation of the reports.

Coding

My philosophy on coding is “*to use the best tool for each task*”. I usually code in C/C++, use Matlab or Python/Numpy for prototyping, and bash or Python for scripting.

Many of my publications include the source code for reproducing the experiments (<http://dev.ipol.im/~facciolo/publications.html>). I highlight here some recent and interesting coding projects I've contributed to:

- **MGM: A Significantly More Global Matching for Stereovision.** Implementation of the algorithm published in *BMVC 2015*. This algorithm permits to efficiently compute approximate solutions to MRF energies defined on the 4- or 8-connected image grids.
<https://github.com/gfacciol/mgm>
- **Image denoising tools.** Implementations of the DA3D and NLDD algorithms as well as curated and/or improved versions of some state-of-the art denoising algorithms such as NL-Bayes, BM3D, and DCT denoising. Developed in collaboration with N. Pierazzo.
http://dev.ipol.im/~facciolo/code_denoising.html
- **S2P: Satellite Stereo Pipeline.** Open source automatic stereo pipeline for 3D reconstruction from satellite image written in Python and C/C++. This is the engine of the on-line demo: <http://dev.ipol.im/~carlo/s2p/>. Developed in collaboration with C. de Franchis, E. Meinhardt, and J. Michel.
<https://github.com/carlodef/s2p>
- **RPC cropper.** Standalone Python tool to crop satellite images and their RPC. The camera calibration information of satellite images is represented with a rational polynomial model (RPC) which refers to the entire image (usually 40000×40000 pixels). This tool allows to crop a satellite image and compute the associated RPCs. Developed in collaboration with C. de Franchis and E. Meinhardt.
https://bitbucket.org/carlodef/rpc_cropper
- **pvflip.** An OpenGL accelerated image viewer written in Python. The interest of this tool is that it reads and display many image formats, the most interesting being multi-channel floating-point TIFFs. Developed in collaboration with E. Meinhardt.
<https://github.com/gfacciol/pvflip>
- **IPOL-MEX.** These tools aim at simplifying the conversion of C/C++ published IPOL code into Matlab MEX files. This is an important activity towards making the IPOL publications accessible to a larger public. Developed in collaboration with Paul-Darius Sarmadi (L3 intern).
<https://github.com/Paul-Darius/ipol-matlab>
- **Gradient Based Video Editing in Matlab.** Matlab implementation of the algorithm described in: “*A Variational Model for Gradient-Based Video Editing*”, *IJCV, 2012*. Propagates edits in a video in a temporally consistent way seamlessly blending with its spatial surroundings. The algorithm is able to cope with additive illumination changes. Developed in collaboration with R. Sadek and P. Arias.
<http://gpi.upf.edu/static/gbve12/>

Useful links

- Some of my presentations and posters are on [figshare](http://figshare.com/authors/Gabriele_Facciolo/397809):
http://figshare.com/authors/Gabriele_Facciolo/397809
- My coding page: <http://dev.ipol.im/~facciolo/code.html>
- My github: <https://github.com/gfacciol>

Complete list of publications

I'm dividing the list of my scientific communications in four groups:

- International journals
- Peer reviewed international conferences (with proceedings)
- Other publications
- Relevant invited talks to seminars, conferences, and workshops

Monographs

- [1] G. Facciolo. Geometry-aware patch modelling for 3D reconstruction and image denoising. *Mémoire d'Habilitation à Diriger des Recherches (HDR)*. *École normale supérieure Paris-Saclay*, June 20, 2016.
- [2] G. Facciolo. Irregularly sampled image resotation and interpolation. *PhD. Thesis. Universitat Pompeu Fabra, Departament de Tecnologies de la Informació i les Comunicacions*, March 3, 2011.

International journals

- [3] M. Rais, J.-M. Morel, C. Thiebaut, J.-M. Delvit, and G. Facciolo. Improving wavefront sensing with a Shack-Hartmann device. *OSA Applied Optics*, [Impact Factor: 1.598], Vol. 55, Issue 28, pp. 7836-7846, 2016.
- [4] J. M Di Martino, G. Facciolo, and E. Meinhardt. Poisson Image Editing. *Image Processing On Line*, 6, pp. 300–325, 2016.
- [5] M. Rais, J.-M. Morel, C. Thiebaut, J.-M. Delvit, and G. Facciolo. Improving the accuracy of a Shack-Hartmann wavefront sensor on extended scenes. *IOP Publishing, Journal of Physics: Conference Series*, [Impact Factor: 0.45], Volume 756, Number 1, 2016.
- [6] C. de Franchis, E. Meinhardt, D. Greslou, and G. Facciolo. Attitude Refinement for Orbiting Pushbroom Cameras: a Simple Polynomial Fitting Method. *Image Processing On Line*, 5, pp. 328-361, 2015.
- [7] V. Fedorov, G. Facciolo, and P. Arias. Variational Framework for Non-Local Inpainting. *Image Processing On Line*, 5, pp. 362-386, 2015.
- [8] V. Fedorov, P. Arias, R. Sadek, G. Facciolo, and C. Ballester. Linear Multiscale Analysis of Similarities between Images on Riemannian Manifolds: Practical Formula and Affine Covariant Metrics. *SIAM Journal on Imaging. Sciences*, [impact factor 2.27], 8(3), 2021-2069. 2015.
- [9] A. Buades and G. Facciolo. Reliable multi-scale and multi-window stereo matching.. *SIAM Journal on Imaging. Sciences*, [impact factor 2.27], 8(2), 888-915 2015.
- [10] C. Ballester, F. Calderero, V. Caselles, and G. Facciolo. Multiscale Analysis of Similarities between Images on Riemannian Manifolds. *Multiscale Modeling & Simulation, SIAM*, [impact factor 1.795], 12, 616-649, 2014.
- [11] G. Facciolo, N. Limare, and E. Meinhardt. Integral Images for Block Matching. *Image Processing On Line*, 4, 344-369, 2014.
- [12] R. Sadek, G. Facciolo, P. Arias, and V. Caselles. A variational model for Gradient-Based video editing. *International Journal of Computer Vision*, [impact factor 3.533], 103, 127-162, 2013.
- [13] J. Sánchez, E. Meinhardt, and G. Facciolo. TV-L1 optical flow estimation. *Image Processing On Line*, 3, 137-150, 2013.
- [14] P. Arias, V. Caselles, G. Facciolo, V. Lazcano, and R. Sadek. Nonlocal variational models for inpainting and interpolation. *Mathematical Models and Methods in Applied Sciences*, [impact factor 1.874], 22, 1230003, 2012.

- [15] P. Arias, V. Caselles, and G. Facciolo. Analysis of a Variational Framework for Exemplar-Based Image Inpainting. *Multiscale Modeling & Simulation, SIAM*, [impact factor 1.562], 10, 473-514, 2012.
- [16] P. Arias, G. Facciolo, V. Caselles, and G. Sapiro. A variational framework for Exemplar-Based image inpainting. *International Journal of Computer Vision*, [impact factor 3.741], 1-29, Jan. 2011.
- [17] V. Caselles, G. Facciolo, and E. Meinhardt. Anisotropic Cheeger Sets and Applications. *SIAM Journal on Imaging Sciences*, [impact factor 4.656], 2, 1211-1254, 2009.
- [18] G. Facciolo, A. Almansa, J.-F. Aujol, and V. Caselles. Irregular to Regular Sampling, Denoising, and Deconvolution. *Multiscale Modeling & Simulation, SIAM*, [impact factor 2.198], 7, 1574-1608, 2009.

Peer reviewed international conferences

- [19] M. Rais, J.-M. Morel, C. Thiebaud, J.-M. Delvit, and G. Facciolo. Improving the accuracy of a Shack-Hartmann wavefront sensor on extended scenes. *In 6th International Workshop on New Computational Methods for Inverse Problems (NCIMP)*, 2016. (ORAL PRESENTATION)
- [20] V. Fedorov, P. Arias, G. Facciolo, and C. Ballester. Affine Invariant Self-Similarity for Exemplar-Based Inpainting. *In International Joint Conference on Computer Vision, Imaging and Computer Graphics Theory and Applications (VISAPP)*, 2016. (ORAL PRESENTATION)
- [21] N. Pierazzo, J.-M. Morel, and G. Facciolo. Optimizing the Data Adaptive Dual Domain Denoising Algorithm. *In Progress in Pattern Recognition, Image Analysis, Computer Vision, and Applications (CIARP)*, Springer, 2015. (ORAL PRESENTATION)
- [22] M. Rais, J.-M. Morel, and G. Facciolo. Iterative Gradient-Based Shift Estimation: To Multiscale or Not to Multiscale?. *In Progress in Pattern Recognition, Image Analysis, Computer Vision, and Applications (CIARP)*, Springer, 2015.
- [23] G. Facciolo, C. de Franchis, and E. Meinhardt. MGM: A Significantly More Global Matching for Stereovision. *26th British Machine Vision Conference (BMVC)*, 2015. (ORAL PRESENTATION)
- [24] N. Pierazzo, M. Rais, J.-M. Morel, and G. Facciolo. DA3D: Fast and Data Adaptive Dual Domain Denoising. *22th IEEE International Conference on Image Processing (ICIP)*, 2015. (ORAL PRESENTATION)
- [25] N. Pierazzo, M. Lebrun, M. Rais, J.-M. Morel, and G. Facciolo. Non-local Dual Image Denoising. *21th IEEE International Conference on Image Processing (ICIP)*, 2014. (ORAL PRESENTATION)
Top 10% Paper Award.
- [26] C. de Franchis, E. Meinhardt, J. Michel, J.-M. Morel, and G. Facciolo. On stereo-rectification of pushbroom images. *21th IEEE International Conference on Image Processing (ICIP)*, 2014.
- [27] C. de Franchis, E. Meinhardt, J. Michel, J.-M. Morel, and G. Facciolo. S2P: An automatic and modular stereo pipeline for pushbroom images. *ISPRS Annals of the Photogrammetry, Remote Sensing and Spatial Information Sciences*, 2014. (ORAL PRESENTATION)
- [28] C. de Franchis, E. Meinhardt, J. Michel, J.-M. Morel, and G. Facciolo. Automatic sensor orientation refinement for Pléiades stereo images. *IGARSS*, 2014. (ORAL PRESENTATION)
- [29] V. Lazcano, P. Arias, G. Facciolo, and V. Caselles. A gradient based neighborhood filter for disparity interpolation. *19th IEEE International Conference on Image Processing (ICIP)*, 2012.
- [30] E. Meinhardt, O. D'Hondt, G. Facciolo, and V. Caselles. Relative depth from monocular optical flow. *18th IEEE International Conference on Image Processing (ICIP)*, 2011.
- [31] G. Facciolo, R. Sadek, A. Bugeau, and V. Caselles. Temporally consistent gradient domain video editing. *Energy Minimization Methods in Computer Vision and Pattern Recognition (EMMCVPR)*, 2011. (ORAL PRESENTATION)
- [32] G. Facciolo, P. Arias, V. Caselles, and G. Sapiro. Exemplar-Based Interpolation of Sparsely Sampled Images. *Energy Minimization Methods in Computer Vision and Pattern Recognition (EMMCVPR)*, 2009. (ORAL PRESENTATION)

- [33] G. Facciolo and V. Caselles. Geodesic neighborhoods for piecewise affine interpolation of sparse data. *16th IEEE International Conference on Image Processing (ICIP)*, 2009.
- [34] G. Facciolo, F. Lecumberry, A. Almansa, A. Pardo, V. Caselles, and B. Rougé. Constrained Anisotropic Diffusion and some Applications. *British Machine Vision Conference, Proceedings of (BMVC)*, 2006.
- [35] G. Facciolo, A. Almansa, and A. Pardo. Variational approach to interpolate and correct biases in stereo correlation. *20eme Colloque sur le traitement du signal et des images GRETSI*, 2005. (ORAL PRESENTATION)

Other publications

- [36] M. Renaudin, A.-C. Vlachomitrou, G. Facciolo, W. Hauser, C. Sommelet, C. Viard, F. Guichard. Towards a quantitative evaluation of multi-imaging systems. *IS&T International Symposium on Electronic Imaging (EI 2017)*, 2017.
- [37] J. Michel, C. de Franchis, E. Meinhardt-Llopis, J.M. Morel, G. Facciolo, and J.M. Delvit. S2P: un pipeline libre de restitution du relief par stéréoscopie pour l'imagerie satellite THR. *SFPT: Colloque Photogrammétrie Numérique et Perception 3D: les nouvelles conquêtes*, ENSG, Paris, 15-17 March, 2016. (POSTER)
- [38] J. Michel, C. de Franchis, E. Meinhardt, and G. Facciolo. S2P: a new open-source stereo pipeline for satellite images. *FOSS4G Europe 2015*, Como, Italy 2015. (ORAL PRESENTATION)
- [39] J. Michel, and G. Facciolo. ICE: lightweight, efficient rendering for remote sensing images. *FOSS4G Europe 2015*, Como, Italy 2015.
- [40] M. Colom, G. Facciolo, M. Lebrun, N. Pierazzo, M. Rais, Y.-Q. Wang, and J.-M. Morel. A mathematical perspective of image denoising. *Proceedings of the International Congress of Mathematicians (ICM)*, 2014.
- [41] E. Meinhardt and G. Facciolo. Riemannian Image Processing. *Curves and Surfaces*, Paris, 2014.
- [42] A. Chen, J. Darbon, C. de Franchis, G. Facciolo, E. Meinhardt, J. Michel, and J.-M. Morel. Numerical simulation of landscape evolution and water run-off on digital elevation models obtained from pléiades. *Revue Française de Photogrammétrie et de Télédétection*, 2014.
- [43] C. de Franchis, E. Meinhardt, J. Michel, J.-M. Morel, and G. Facciolo. Automatic digital surface model generation from Pléiades stereo images. *Revue Française de Photogrammétrie et de Télédétection, special issue Pléiades Days & ORFEO*, 2014.
- [44] M. Rodriguez, J. Preciozzi, G. Facciolo, and A. Almansa. Simulation and Real-Time Visualization of Changing Baseline in a Stereo Pair Visualization. *Imaging, and Image Processing VIIP*, 2008.
- [45] A. Almansa and G. Facciolo. Towards a more general psychophysic validation of the Helmholtz Principle” and “Variational approach to interpolate and correct biases in stereo correlation. *Poster at the symposium: Representation of reality by brain and machines, crossed views from neurosciences and computer vision*, Montevideo, Uruguay, November 2004.
- [46] T. Lorenzo and G. Facciolo. Una herramienta de análisis de estrategias de fútbol de robots middle league simurosot. *Workshop en inteligencia artificial aplicada a robotica movil*, Universidad Nacional del Centro de la Provincia de Buenos Aires, June 2004.

Relevant participations to workshops, symposiums and seminars

- [47] 6/12/2016: Meeting MISS: *How to win the IARPA Challenge*, CMLA
- [48] 17/11/2016: “Dagstuhl Seminar #16462: Inpainting-Based Image Compression”. *IPOL: Image Processing On Line*, Schloss Dagstuhl - Leibniz-Zentrum für Informatik
- [49] 13/10/2016: “Séminaire Images Optimisation et Probabilités”. *MGM: A Significantly More Global Matching for Stereovision*, Institut de Mathématiques de Bordeaux, Bordeaux

- [50] 15/07/2015: Encounter on space imaging science - between Beijing Institute of Space Mechanics & Electricity (BISME), Research Center for Space Optical Engineering, Dept. of Astronautics, Harbin Institute of Technology and, CMLA ENS-Cachan with the participation of CNES. *"A perspective on image denoising"*, G. Facciolo, CMLA. (<https://goo.gl/7iWUHK>)
- [51] 05/03/2015: Séminaire de Mathématiques Appliquées au Traitement d'Images (SMATI Seminar), *Data Adaptive Dual Domain Denoising*, LTCI, Telecom ParisTech
- [52] 03/07/2014: Rencontre de Technologies Spatiales (RTS): "Extraction d'informations des images": *Multi-Scale Multi-Window 'our last' word on stereovision*, CNES, Toulouse
- [53] 03/06/2014: IMAGINE Seminar: *Satellite Stereo Pipeline s2p*, ENPC
- [54] 09/01/2014: DTIC Seminar: *Reproducible Research, IPOL, and Satellite Stereo Image*, UPF, Barcelona
- [55] 04/10/2013: Technicolor Seminar: *Temporally consistent gradient based video editing*, Rennes, France
- [56] 22~27/07/2013: Fondation des Treilles seminar participation: *Acting the universality of image science / Reproducible Research in Signal, Image, and Geometric Processing*, Tourtour, France
- [57] 11/04/2013: Oxford Future of Science conference: Rigour and Openness in 21st Century Science: *IPOL: Image Processing On Line; Beyond Traditional Articles*, Oxford, UK
- [58] 29/05/2012: Groupe de travail "Statistique et imagerie" CEREMADE: *Analysis of a variational framework for exemplar based image inpainting*, Université Paris-Dauphine
- [59] 20/05/2012: SIAM Conference on Imaging Science, in Mini-Symposium: "Recent Advances in Patch-based Image Processing": *Analysis of a Variational Framework for Exemplar Based Image Inpainting*, Philadelphia, PA
- [60] 12/08/2011: Santaló's Summer School on Mathematical Models in Image Processing and Computer Vision: *Temporally consistent gradient domain video editing*, UIMP, Santander, Spain
- [61] 30/01/2011: MFO Workshop "Trends in Mathematical Imaging and Surface Processing": *A variational framework for exemplar-based image inpainting* (with P. Arias, V. Caselles, and G. Sapiro), Oberwolfach, Germany
- [62] 06/04/2010: IIE Seminar: *Geodesic Neighborhoods for piecewise affine interpolation of sparse data*, FING, Montevideo, Uruguay