

Curriculum Vitae

Personal Information

First Name: **Paolo**
Last Name: **Bestagini**
Date of Birth: 22/02/1986
Place of birth: Novara (Italy)
Nationality: Italian
Phone: +39 02 2399 9654
E-mail: paolo.bestagini@polimi.it
Website: <http://home.deib.polimi.it/bestagini/>



Education

01/2011 – 02/2014 **PhD in Information Technology** at the Politecnico di Milano, Italy
Thesis: Reverse engineering of video content for forensic analyses
Supervisor: Prof. A. Sarti
Final grade: cum laude

09/2008 – 12/2010 **MSc in Telecommunication Engineering** at the Politecnico di Milano, Italy
Thesis: A geometric approach to localization of acoustic sources and reflectors
Supervisor: Prof. A. Sarti
Final grade: 110 cum laude / 110

07/2005 – 07/2008 **BSc in Telecommunication Engineering** at the Politecnico di Milano, Italy
Thesis: Transmission power control for low consumption wireless systems
Supervisor: Prof. U. Spagnolini
Final grade: 110 cum laude / 110

Professional Experience

Since 02/2014 **Post-doc researcher** at the Department of Electronics, Information and Bio-engineering at the Politecnico di Milano, Italy

Teaching Experience

11/2015 – 01/2016 **Lecturer and Teaching Assistant** for the course “Multimedia Signal Processing, 2nd Module”, M.Sc in Computer Engineering, Politecnico di Milano, Italy

05/2013 – 06/2013 **Teaching Assistant** for the course “Sound Analysis, Synthesis and Processing”, M.Sc in Computer Engineering, Politecnico di Milano, Italy (Prof. A. Sarti)

05/2011 – 06/2011 **Teaching Assistant** for the course “Sound Analysis, Synthesis and Processing”, M.Sc in Computer Engineering, Politecnico di Milano, Italy (Prof. A. Sarti)

Co-supervision of Graduate Students

- AY 2013/2014 **MSc Thesis** in Mathematical Engineering at the Politecnico di Milano, Italy
Student: L. Gaborini
Thesis: Image tampering detection and localization
Supervisor: Prof. S. Tubaro
- AY 2011/2012 **MSc Thesis** in Computer Engineering at the Politecnico di Milano, Italy
Students: L. Albonico, A. Paganini
Thesis: Feature based classification for audio bootleg detection
Supervisor: Prof. A. Sarti
- AY 2011/2012 **MSc Thesis** in Computer Engineering at the Politecnico di Milano, Italy
Student: S. Battaglia
Thesis: Detection of motion interpolation in video sequences
Supervisor: Prof. M. Tagliasacchi

Research Activities

Acoustic Signal Processing

Acoustic source localization has been a leading research topic in the audio and acoustics communities for quite a few decades [C2, C3]. This research theme has gained particular attention in the past twenty years as applications to teleconferencing and hands-free communications, as well as distributed sensor networks have become commonplace. A wide range of techniques has been presented in the literature.

Among these, methodologies based on Time Differences of Arrivals (TDOAs) measurements taken with microphone arrays have proved robust against reverberations and environmental noise. To this purpose, in [J1, J4] we developed novel source localisation techniques using multiple arrays based on a geometric interpretation of sound propagation. In [J3] we showed that a geometric interpretation of well-known state-of-the-art localisation algorithms is also possible. Working with multiple microphone arrays requires knowing the relative positioning of each array in the space. By exploiting concepts from the computer vision literature, we also addressed the problem of self-calibrating multiple acoustic cameras in [C1].

Multimedia Forensics

With the rapid proliferation of inexpensive acquisition and storage devices multimedia objects can be easily created, stored, transmitted, modified and tampered with by anyone. During its lifetime, a digital object might go through several processing stages, including multiple analog-to-digital (A/D) and digital-to-analog (D/A) conversions, coding and decoding, transmission, editing (either aimed at enhancing the quality, creating new contents mixing pre-existing materials, or tampering with the content). Each of these processing steps necessarily leaves a characteristic footprint, which can be potentially detected to trace back the past history of the available multimedia object in a blind fashion, i.e., without having access to the original content.

Blind forensic techniques can be applied to any media, i.e., audio [C12, C13, C18], images [C15, C19] and, more recently, video [C5, J2]. As an example, with specific regard to video, in [C4, C8] we show how to detect the first codec used in a double encoded video, while in [C6] we show how to detect how many compression steps have been applied. In [C7, C10] we focus on detecting video tampering attacks such as object insertion or video splicing. Finally, in [C9] we show how to distinguish between original and recaptured videos. Notice that the knowledge of traces left by processing operations can be also used to study specific attacks to multimedia content [C11, C14] and for authentication purpose [C24].

As the diffusion of user-generated content has determined the possibility of jointly analysing near-duplicate copies of the same object (e.g., slightly modified versions of the same image), the phylogenetic analysis of images [C17, C22, C23] and videos [C16, C20, C21] has also proved to be a research area of paramount interest with direct application in security, law and copyright enforcement, and news tracking services.

Research Projects

Acronym	Funding scheme	Title	Period	Role
REWIND	FP7-ICT-2009-C FET-Open	REVers engineering of audio-VIsual coNtent Data	2011-2014	Scientific Investigator
SCENIC	FP7-ICT-2009-C FET-Open	Self-Configuring Environmental-aware Intelligent aCoustic sensing	2010-2011	Scientific Investigator

Scientific Publications

H-index: 9; i10-index: 9; 237 citations (source: Google Scholar)

International Journals

- J4 A. Canclini, P. BESTAGINI, F. Antonacci, A. Sarti, S. Tubaro, "**A Robust and Low-Complexity Source Localization Algorithm for Asynchronous Distributed Microphone Networks**", IEEE/ACM Transactions on Audio, Speech, and Language Processing, vol. 23, pp. 1563-1575, 2015
- J3 P. BESTAGINI, M. Compagnoni, F. Antonacci, A. Sarti, S. Tubaro, "**TDOA-based acoustic source localization in the space-range reference frame**", Multidimensional Systems and Signal Processing, vol. 25, pp. 337-359, 2014
- J2 S. Milani, M. Fontani, P. BESTAGINI, M. Barni, A. Piva, M. Tagliasacchi, S. Tubaro, "**An overview on video forensics**", APSIPA Transactions on Signal and Information Processing, vol. 1, pp. e2, 2012
- J1 M. Compagnoni, P. BESTAGINI, F. Antonacci, A. Sarti, S. Tubaro, "**Localization of acoustic sources through the fitting of propagation cones using multiple independent arrays**", IEEE Transactions on Audio, Speech, and Language Processing, vol. 20, pp.1964-1975, 2012

International Conferences

- C24 I. Amerini, P. BESTAGINI, L. Bondi, R. Caldelli, M. Casini, S. Tubaro, "**Robust smartphone fingerprint by mixing device sensors features for mobile strong authentication**", IS&T International Symposium on Electronic Imaging, San Francisco, USA, 2016
- C23 P. BESTAGINI, M. Tagliasacchi, S. Tubaro, "**Image phylogeny tree reconstruction based on region selection**", IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP), Shanghai, China, 2016
- C22 S. Milani, M. Fontana, P. BESTAGINI, S. Tubaro, "**Phylogenetic analysis of near-duplicate images using processing age metrics**", IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP), Shanghai, China, 2016
- C21 F. O. Costa, S. Lameri, P. BESTAGINI, Z. Dias, A. Rocha, M. Tagliasacchi, S. Tubaro, "**Phylogeny reconstruction for misaligned and compressed video sequences**", IEEE International Conference on Image Processing (ICIP), Québec City, Canada, 2015
- C20 A. Melloni, S. Lameri, P. BESTAGINI, M. Tagliasacchi, S. Tubaro, "**Near-duplicate detection and alignment for multi-view videos**", IEEE International Conference on Image Processing (ICIP), Québec City, Canada, 2015
- C19 L. Gaborini, P. BESTAGINI, S. Milani, M. Tagliasacchi, S. Tubaro, "**Multi-clue image tampering localization**", IEEE International Workshop on Information Forensics and Security (WIFS), Atlanta, USA, 2014

- C18 M. Buccoli, P. BESTAGINI, M. Zanoni, A. Sarti, S. Tubaro, "**Unsupervised feature learning for bootleg detection using deep learning architectures**", IEEE International Workshop on Information Forensics and Security (WIFS), Atlanta, USA, 2014
- C17 A. Melloni, P. BESTAGINI, S. Milani, M. Tagliasacchi, A. Rocha, S. Tubaro, "**Image phylogeny through dissimilarity metrics fusion**", European Workshop on Visual Information Processing (EUVIP), Paris, France, 2014
- C16 S. Lameri, P. BESTAGINI, A. Melloni, S. Milani, A. Rocha, M. Tagliasacchi, S. Tubaro, "**Who is my parent? Reconstructing video sequences from partially matching shots**", IEEE International Conference on Image Processing (ICIP), Paris, France, 2014
- C15 S. Milani, P. BESTAGINI, M. Tagliasacchi, S. Tubaro, "**Demosaicing strategy identification via eigenalgorithms**", IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP), Firenze, Italy, 2014
- C14 S. Milani, P. BESTAGINI, M. Tagliasacchi, S. Tubaro, "**Antiforensic synthesis of motion vectors using template algorithms**", IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP), Firenze, Italy, 2014
- C13 S. Milani, P.F. Piazza, P. BESTAGINI, S. Tubaro, "**Audio tampering detection using multimodal features**", IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP), Firenze, Italy, 2014
- C12 P. BESTAGINI, M. Zanoni, L. Albonico, A. Paganini, A. Sarti, S. Tubaro, "**Feature-based classification for audio bootlegs detection**", IEEE International Workshop on Information Forensics and Security (WIFS), Guangzhou, China, 2013
- C11 A. Melloni, P. BESTAGINI, A. Costanzo, M. Barni, M. Tagliasacchi, S. Tubaro, "**Attacking image classification based on Bag-of-Visual-Words**", IEEE International Workshop on Information Forensics and Security (WIFS), Guangzhou, China, 2013
- C10 P. BESTAGINI, S. Milani, M. Tagliasacchi, S. Tubaro, "**Local tampering detection in video sequences**", IEEE International Workshop on Multimedia Signal Processing (MMSP), Pula, Italy, 2013
- C9 P. BESTAGINI, M. Visentini-Scarzanella, M. Tagliasacchi, P. L. Dragotti, S. Tubaro, "**Video recapture detection based on ghosting artifact analysis**", IEEE International Conference on Image Processing (ICIP), Melbourne, Australia, 2013
- C8 P. BESTAGINI, S. Milani, M. Tagliasacchi, S. Tubaro, "**Video codec identification extending the idempotency property**", European Workshop on Visual Information Processing (EUVIP), Paris, France, 2013
- C7 P. BESTAGINI, S. Battaglia, S. Milani, M. Tagliasacchi, S. Tubaro, "**Detection of temporal interpolation in video sequences**", IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP), Vancouver, Canada, 2013
- C6 S. Milani, P. BESTAGINI, M. Tagliasacchi, S. Tubaro, "**Multiple compression detection for video sequences**", IEEE International Workshop on Multimedia Signal Processing (MMSP), Banff, Canada, 2012
- C5 P. BESTAGINI, M. Fontani, S. Milani, M. Barni, A. Piva, M. Tagliasacchi, S. Tubaro, "**An overview on video forensics**", European Signal Processing Conference (EUSIPCO), Bucharest, Romania, 2012
- C4 P. BESTAGINI, A. Allam, S. Milani, M. Tagliasacchi, S. Tubaro, "**Video codec identification**", IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP), Kyoto, Japan, 2012
- C3 P. Annibale, F. Antonacci, P. BESTAGINI, A. Brutti, A. Canclini, L. Cristoforetti, E. Habets, J. Filos, W. Kellermann, K. Kowalczyk, A. Lombard, E. Mabande, D. Markovic, P. Naylor, M. Omologo, R. Rabenstein, A. Sarti, P. Svaizer, M. Thomas, "**The SCENIC project**:"

Space-time audio processing for environment-aware acoustic sensing and rendering", Audio Engineering Society Convention, 2011, New York, United States

- C2 P. Annibale, F. Antonacci, P. BESTAGINI, A. Brutti, A. Canclini, L. Cristoforetti, E. Habets, W. Kellermann, K. Kowalczyk, A. Lombard, E. Mabande, D. Markovic, P. Naylor, M. Omologo, R. Rabenstein, A. Sarti, P. Svaizer, M. Thomas, "**The SCENIC project: Environment-aware sound sensing and rendering**", European Future Technologies Conference and Exhibition, Budapest, Hungary, 2011
- C1 S. D. Valente, M. Tagliasacchi, F. Antonacci, P. BESTAGINI, A. Sarti, S. Tubaro, "**Geometric calibration of distributed microphone arrays from acoustic source correspondences**", IEEE International Workshop on Multimedia Signal Processing (MMSP), Saint-Malo, France, 2010

Seminars

- S4 P. BESTAGINI, "**Detection and alignment of near-duplicate videos for original sequence reconstruction**", GTTI Thematic Meeting on Multimedia Signal Processing, Forni di Sopra (UD), Italy, February 2014
- S3 P. BESTAGINI, "**Video re-capture detection for forensic analysis**", Communication and Signal Processing Group, Imperial College London, United Kingdom, December 2012
- S2 P. BESTAGINI, "**Localization of acoustic sources through the fitting of propagation cones using multiple independent arrays**", Dipartimento di Elettronica e Informazione (Department of Electronics and Information), Politecnico di Milano, Italy, July 2012
- S1 P. BESTAGINI, "**A geometric approach to localization of acoustic sources**", Sound and Music Computing Lab, Politecnico di Milano (Como Campus), Italy, February 2011

Awards

- A4 **EUVIP Best Student Paper Award** for the work "Image phylogeny through dissimilarity metrics fusion", Paris, France, 2014
- A3 **MMSP 2013 Top-10% Paper Award** for the work "Local tampering detection in video sequences", Pula, Italy, 2013
- A2 **GTTI-MMSP 2013 Best Demo Award** for the work "Video recapture detection based on ghosting artifacts Analysis", Vezza D'Oglio, Italy, 2013
- A1 **MMSP 2012 Top-10% Paper Award** for the work "Multiple compression detection for video sequences", Banff, Canada, 2012

Major Collaborations

- 08/2012 – 12/2012 **Visiting PhD Student** at the Imperial College London, UK.
Supervisor: Prof. P. L. Dragotti