ALLEGATO B

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Luca Magri
CURRICULUM VITAE

INFORMAZIONI PERSONALI (NON INSERIRE INDIRIZZO PRIVATO E TELEFONO FISSO O CELLULARE)

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DATA DI NASCITA	16/11/1986

Luca Magri

Name	Luca Magri
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Highlights

- Postdoc researcher at Dipartimento di Elettronica e Informazione e Bioingegneria (DEIB), Politecnico di Milano; 3-year post-doctoral research experience.
- My major research interests are in *Pattern Recognition* and *Computer Vision*, with a focus on clustering techniques and 3D vision. My most important contributions address methods for multi model fitting and have been published in top tier conferences (3 CVPR, 1 ECCV and 1 BMVC).
- Publications: 4 articles in peer-reviewed international journals, 17 conference proceedings (including 5 papers in top conferences), 2 workshop papers. H-index: 6 (256 cit. in Google Scholar, May 2020). Academic age: 8 years.
- Patents: finalized 2 international patents.
- Research projects:
  - *Research Scientist* in industrial research projects sponsored by Gilardoni Raggi X S.p.A., (leader in manufacturing of X-ray and ultrasound equipment) for designing advanced baggage-inspection systems for airport security (from 2019).
  - *Research Scientist* in industrial research project "*R3Dscan*" in collaboration with 3DFlow srl, aimed at modeling objects using multi-light imaging techniques, sponsored by the HEaD project (Higher Education and Development) (2017 - 2018).
- Teaching assistant at Università degli Studi di Milano (2013 – 2015, 2017).
- Appointed as contract professor at Dipartimento di Elettronica, Informazione e Bioingegneria (DEIB), Politecnico di Milano a.y. 2021.

Positions and Education

Record of Employment

November 2019 – Present

Postdoctoral researcher at Dipartimento di Elettronica, Informazione e Bioingegneria of Politecnico di Milano, Milano, Italy.

Appointed as contract professor, course in Computer Science, Civil and Environmental Engineering, Politecnico di Milano, Milano, Italy.

November 2018 – October 2019

R&D 3D software engineer at Faro Technology, Rezzato (BS), Italy.

October 2017 – October 2018

Postdoctoral researcher at Dipartimento Politecnico di Ingegneria e Architettura of Università degli Studi di Udine, Udine, Italy.

December 2015 – June 2017

Postdoctoral researcher at Dipartimento di Informatica of Università degli Studi di Verona, Verona, Italy.

2013 – 2017

Teaching assistant at Università degli Studi di Milano, Milano, Italy.

January 2012 – June 2012

R&I Intern at ST Microelectronics, Agrate (MB), Italy.

Education

- PhD in Mathematics and Statistic for Computational Sciences at Università degli Studi di Milano, Milano, Italy. December 2015.
  Title: "*Multiple structure recovery via preference analysis in conceptual space*".
  Advisor: *A. Fusiello* (Università degli Studi di Udine).
- M.Sc. (laurea specialistica) in Mathematics, at Università degli Studi di Milano, Milano, Italy. December 2012. Final grade: 110/110 cum laude.
  Title: "*Critical loci for dynamic scenes: an application of algebraic geometry to computer vision*".
  Advisor: *M. Bertolini*.
- B.Sc. (laurea triennale) in Mathematics, at Università degli Studi di Milano, Milano, Italy. February 2009. Final grade: 103/110.
  Title: "*Intuitionistic theory of real numbers,*".
  Advisor: *U. Bottazzini*.
- Classic high school diploma from Liceo Classico G.Berchet. Milano, Italy. July 2005. Grade: 100/100.

Research Visits

- Invited research visit (January 2020) at the *Applied Algebra and Geometry Group*, Czech Institute of Informatics, Robotics and Cybernetics, Czech Technical University in Prague.

Awards and Grants

Awards

- "Bundle Block Adjustment with Constrained Relative Orientations" [Mas+20] won the *ISPRS Young Author Award* 2020.

Grants and Scholarships

- *MIUR Scholarship* to cover PhD studies from November 2013 until November 2015.

Research Interests

My research interest are in Computer Vision and Pattern Recognition and my research activities encompasses two main themes: *multiple structure recovery* and *3D vision* for which I address both theoretical problems and practical applications.

As regard *multiple structure recovery*, I focused on clustering techniques to extract parametric models from data contaminated by noise and outliers. My research interests in *3D vision* concern the problem of acquiring 3D models from multiple images, specifically I worked on motion segmentation, photometric stereo, bundle adjustment and the analysis of critical loci for reconstruction.

Multiple Structure Recovery

Finding multiple models (or structures) that fit data corrupted by noise and outliers is an omnipresent problem in empirical sciences, including Pattern Recognition and Computer Vision, where organizing unstructured visual data in higher level geometric structures is a necessary and fundamental step to derive better descriptions and understanding a scene. This challenging problem presents a chicken-and-egg dilemma: in order to estimate models one needs to first segment the data, and in order to segment the data it is necessary to know which structure points belong to. Most of the multi-model fitting techniques proposed in the literature can be divided in two classes, consensus and preference analysis, depending on which horn of the chicken-egg-dilemma is addressed first. Consensus-based methods (as RanSaC) emphasize on the estimation part of the problem and focus on models that describe as many points as possible. On the other side, preference analysis concentrates on the segmentation side and finds a proper partition of the data, from which model estimation follows. We investigated three main directions to derive a partition of the data exploiting preferences: agglomerative clustering, divisive clustering and set cover formulation.

- **Agglomerative clustering for multiple structures** In [MF14; MF17b] we investigated the preference embedding that lifts data form their ambient space to a high dimensional one, where points are depicted as vectors of preferences granted to a set of models obtained via random sampling. We proposed a continuous relaxation of the preference/no-preference approach implemented by J-linkage, called T-linkage. We were among the first to developed the preference-based approach in its full generality by providing a general framework that integrates the use of M-estimator to robustly depict data preferences. In [MF15a] we investigated the preference embedding from a geometrical point of view, and we provided a foundation to the clustering approach, showing that points belonging to the same model are clustered in high density region, whereas outliers can be characterized as the most separated points. We suggested how to exploit this properties to guide random sampling towards promising tentative model hypotheses. We also addressed the problem of defining a proper inlier threshold to depict point preferences in [MF15c] and developed a method to automatically select this parameter, avoiding the classical model selection trade-off of two terms (data fidelity versus model complexity) in favor of a single term criterion based on consensus clustering. In [MF19] we extended the explanatory power of the preference analysis framework to deal with multiple classes of nested models.

- **Robust divisive clustering** Following the spectral clustering approach, we studied the connections of the preference embedding with low-rank approximation techniques, which recently sprouted out in Pattern Recognition & Data Mining literature. It is well known that spectral clustering yields accurate segmentations in two steps: at first, by projecting the data on the space of the first eigenvectors of the Laplacian matrix and then by applying k-means. The shortcoming of this approach is its lack of robustness to outliers. In [MF15b; MF17a] we proposed to revisit this scheme to enforce robustness: we replaced the eigen-decomposition step by Robust Principal Component Analysis on a pairwise

affinity matrix, and Symmetric Non-Negative Matrix Factorization is used to segment the data in k segments. As a result, we were able to disentangle the chicken-&-egg dilemma: by reducing the multi-model fitting problem to many single-fitting problems that can be solved with the help of robust statistics. The resulting algorithm, termed RPA (Robust Preference Analysis), demonstrated to be robust to noise and outliers. The low rank structure of preferences is also exploited in [Den+16], where we took advantage of a bi-clustering formulation to partition simultaneously points and models in a coherent way.

- **Set Coverage formulation** In [MF16; MF18a] we traced the connection between the problem of multi-model fitting and set covering problem. We observed that the pool of tentative models defines a covering of the data whose elements are the consensus sets of the instantiated hypotheses. The problem of estimating models can hence be neatly translated in finding minimal or optimal coverings. Thanks to this formulation we were able to unify several consensus algorithms in a common theoretical framework, termed RanSaCov. We proposed a simple, yet effective, method that generalizes RanSaC to multiple models and deals with intersecting structures and outliers in a straightforward and principled manner, while avoiding the typical shortcomings of sequential approaches and those of clustering.

- **Applications** Our multi model fitting methods, T-linkage [MF14; MF17b], RPA [MF15b; MF17a] and RansaCov [MF16; MF18a] are very versatile and can be applied to a variety of important Computer Vision tasks including: geometric primitive fitting (e.g. line fitting; circle fitting; 3D plane fitting), multi-body segmentation, plane segmentation, and video motion segmentation. For instance, in [MF18b; MMF19] we address the automatic reconstruction of the walls of an interior environment, which is a fundamental step in any "scan2BIM" application. We addressed this task by resorting to an original and improved version of J-Linkage that leverages on the min-Hash technique to boost the efficiency without sacrificing the accuracy. Our preference methods have also proven to be effective data analysis tools outside of computer vision applications: a prominent example is [Mag+15] where our clustering approach is used to perform a cryptographic attack.

3D VISION

My research in 3D vision concerns the automatic extraction of models and measurements from images. Specifically, I have been working on photometric stereo, registration, bundle adjustment and critical configurations for 3D reconstruction.

- **Low rank and sparse decomposition** In 3D vision problems, specifically, we addressed motion synchronization and photometric stereo. In [Arr+14] we introduced R-GoDec, a robust low rank and sparse matrix decomposition technique that is used to solve the absolute rotation estimation problem, which arises in global registration of 3D point sets and in structure-from-motion. We formulated a novel cost function which inherently copes with data corruption, handling both outlier and missing relative rotations. This formulation has also proved effective for the photometric stereo problem: which consists in recovering surface normals of an object given several images acquired under different lighting conditions. In [Mag+17] we revisited calibrated Lambertian photometric stereo as a robust low-rank matrix recovery problem with both missing and corrupted entries and we integrated R-GoDec in a normal surface estimation algorithm able to cope with shadows and specular reflections.

- **Bundle Adjustment** In 3D reconstruction bundle adjustment is a non-linear minimization procedure that adjusts points and cameras by minimizing the reprojection error of points. This step is performed at the end of each of Structure From Motion pipeline to ensure accurate results. In [MT17]

we investigated how geometric constraints can be integrated in a bundle adjustment framework to mitigate the so-called "doming effect", a phenomenon that disrupts the quality of the attained 3D reconstruction. In [Mas+20] we considered the case of bundle adjustment with constrained cameras, i.e. where the orientation of certain cameras is expressed relatively to others, and these relative orientations are part of the unknowns. In particular, we studied the effect of enforcing relative orientation constraints in bundle adjustment. We provided experimental evidence that these constraints improve the accuracy of the results, while reducing the computational burden as well. We reported for the first time in the literature the complete derivation of the Jacobian matrix for bundle adjustment with constrained cameras.

- **Critical loci for 3D reconstruction** A classical problem in Computer Vision is projective reconstruction: given sufficiently many images of an unknown scene, taken from uncalibrated cameras, the aim is to reconstruct the positions of cameras together with the position of scene points, up to a projective transformation. When sufficiently many corresponding points in general positions in the two views are available, a projective reconstruction can be obtained. However, particular configurations of points and cameras exists that prevent a unique reconstruction: i.e., there are non- projectively equivalent pairs of sets of points and cameras that produce the very same images in the view planes. We have studied these "*critical loci*" using algebraic geometry theory. Specifically, in [BMT19] we demonstrated that corresponding points which are images of critical points are linked by a bi-rational map between the two images which is a quadratic transformation. This transformation is explicitly described and used to investigate the instability phenomena for reconstruction.

Scientific Activities and Services

RESEARCH PROJECTS

Gilardoni Raggi X
TYPE: Industrial research project between DEIB and Gilardoni Raggi X S.p.A.
DATE: 2019 - present
TOPIC: Design of an X-ray baggage-inspection system to meet the new performance standards for airport controls. In particular, the project focuses on machine learning and image-processing algorithms for reducing false alarms.
ROLE: *Research Scientist* Design and implementation of algorithms for image segmentation and their integration in efficient software prototypes.
PROJECT LEADER: Prof. Giacomo Boracchi.

3DFlow
TYPE: Industrial research project between DPIA Università degli Studi di Udine and 3DFlow srl
DATE: 2017 - 2018
TOPIC: Design of algorithms for multi imaging 3D reconstruction.
ROLE: *Research Scientist* Designed algorithms for multi-imaging 3D reconstruction and blueprint generation for scan2bim applications. The algorithm for blueprint generation is currently adopted in the stable release of 3DF Zephyr, the main software solution produced by 3DFlow.
PROJECT LEADER: Prof. Andrea Fusiello.

Program Committee Membership

TPC for the following conferences:

- "*IEEE International Workshop on Multimedia Signal Processing*", 2020.
- "*Photometric Computer Vision Workshop*", Workshop at Conference of Computer Vision and Pattern Recognition, 2019.

Volunteer Services

- Student volunteer at "*International Conference on 3D Vision*", 2018.
- Student volunteer at "*European Conference on Computer Vision*", 2012.

Editorial Activities

Referring Services

I am currenlty a reviewer for the following international journals:

- IEEE Transactions on Pattern Analysis and Machine Intelligence.
- IEEE Transactions on Image Processing.
- ISPRS Journal of Photogrammetry and Remote Sensing.
- Computer Vision and Image Understanding.
- Image and Vision Computing.
- Journal of Real-Time Image Processing.
- IPSJ Transactions on Computer Vision and Applications.

I was a reviewer for the following international conferences:

- "*Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition*", in 2015, 2016, 2018.
- "*Proceedings of the European Conference on Computer Vision*", in 2014, 2016, 2018.
- "*Proceedings of the Asian Conference on Computer Vision*", 2018.
- "*International Conference on 3D Vision*", 2015, 2016, 2018.
- "*British Machine Vision Conference*" 2017.
- "*Proceedings of the International Conference on Computer Vision*" 2015.

I also served as Emergency reviewer at "*International Conference on 3D Vision*", 2018.

Talks and Tutorials

Talks

- "Multiple structure recovery via clustering in preference space" at Czech Technical University, Prague, Czech Republic, January 2020.
- "Multiple structure recovery via clustering in preference space" at Politecnico di Milano, Milano, Italy, December 9, 2019.
- "Multiple structures recovery an application to scan2BIM" at Università degli Studi di Udine, Udine, Italy, May 14, 2018.

Student Supervision

Master Degree Thesis Advisor

- *Antonino Maria Rizzo* (2020), Topic: Multi-template matching. MSc thesis.
- *William Bonvini* (2020), Topic: Deep Learning for multi model fitting. MSc thesis.

Teaching Activities

2020-2021

Computer Science (*Appointed contract professor*) - Civil and Environmental Engineering, Politecnico di Milano - Undergraduate.

Image Analysis and Computer Vision (*Appointed teaching assistant*) - Computer Science Engineering, Politecnico di Milano - Undergraduate.

2017-2018

Introductory course in Mathematics for first-year students (*Teaching Assistant*) - Mathematics, Università degli Studi di Milano - Undergraduate.

2014-2015

Geometry 1 (*Teaching Assistant*) - Physics, Università degli Studi di Milano - Undergraduate.

2013-2014

Mathematics and Statistics (*Teaching Assistant*) - Agricultural and Food Sciences, Università degli Studi di Milano - Undergraduate.

2013-2014

Fundamentals in Mathematics (*Teaching Assistant*) - Natural Sciences, Università degli Studi di Milano - Undergraduate.

2013-2014

Introductory course in Mathematics for first year students (*Teaching Assistant*) - Natural Sciences, Università degli Studi di Milano - Undergraduate.

2012-2013

Geometry 2 (*Teaching Assistant*) - Mathematics, Università degli Studi di Milano - Undergraduate.

2012-2013

Mentoring for student with disabilities - Servizio Disabili, Università degli Studi di Milano.

Complete list of publications

PUBLICATION LIST

BIBLIOMETRY

ACADEMIC AGE: 8 years.
FROM GOOGLE SCHOLAR (QUERY DATE: 2020-07-05)

- Citations (all): 267; h-index: 6; i10-index: 4
- Citations (since 2015): 264; H-index: 6; i10-index: 4

FROM SCOPUS (QUERY DATE:2020-05-27)

- Documents: 17
- Citations: 144
- h-index: 4

FIVE SELECTED PUBLICATIONS

The publications that better present my main research activities are: [MF14], [MF15b], [MF19], [MF18a], [Arr+14],

REFERRED INTERNATIONAL JOURNALS

[BMT19] Marina Bertolini, Luca Magri, and Cristina Turrini. "Critical Loci for two views reconstruction as quadratic transformations between images". In: *Journal of Mathematical Imaging and Vision* (2019). URL: https://doi.org/10.1007/s10851-019-00908-w.

[MF18a] Luca Magri and Andrea Fusiello. "Multiple structure recovery with maximum coverage". In: *Machine Vision and Applications* 29.1 (2018). URL: https://doi.org/10.1007/s00138-017-0883-x.

[MF17a] Luca Magri and Andrea Fusiello. "Multiple structure recovery via robust preference analysis". In: *Image and Vision Computing* 67 (2017). URL: https://doi.org/10.1016/j.imavis.2017.09.005.

[MF17b] Luca Magri and Andrea Fusiello. "Multiple structure recovery with T-linkage". In: *Journal of Visual Communication and Image Representation* 49 (2017). URL: http://dx.doi.org/10.1016/j.jvcir.2017.08.005.

REFERRED INTERNATIONAL CONFERENCES

[AMP20] Federica Arrigoni, Luca Magri, and Tomas Padja. "On the Usage of the Trifocal Tensor in Motion Segmentation". In: *Proceedings of the European Conference on Computer Vision (to appear)*. 2020.

[APM20] Federica Arrigoni, Tomas Padja, and Luca Magri. "Motion segmentation with pairwise matches and unknown number of motions". In: *Proceedings of the International Conference on Pattern Recognition (to appear)*. 2020.

[Mas+20] Eleonora Maset et al. "Bundle Block Adjustment with Constrained Relative Orientations". In: *Proceedings of the XXIV ISPRS Congress (to appear)*. 2020.

[MF19] Luca Magri and Andrea Fusiello. "Fitting Multiple Heterogeneous Models by Multi-Class Cascaded T-Linkage". In: *Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition*. 2019. DOI: 10.1109/CVPR.2019.00764.

[MMF19] E Maset, L Magri, and A Fusiello. “Improving Automatic Reconstruction of Interior Walls from Point Cloud Data”. In: *International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences*. Vol. 42. 2/W13. 2019. DOI: 10.5194/isprs-archives-XLII-2-W13-849-2019.

[MF18b] Luca Magri and Andrea Fusiello. “Reconstruction of interior walls from point cloud data with min-hashed J-linkage”. In: *Proceedins of the International Conference on 3D Vision*. 2018. DOI: 10.1109/3DV.2018.00025.

[MT17] Luca Magri and Roberto Toldo. “Bending the doming effect in structure from motion reconstructions through bundle adjustment”. In: *The International Archives of Photogrammetry, Remote Sensing and Spatial Information Sciences*. Vol. 42. 2017.

[Mag+17] Luca Magri et al. “A Matrix Decomposition Perspective on Calibrated Photometric Stereo”. In: *Proceedings of the International Conference on Image Analysis and Processing*. 2017.

[Den+16] Matteo Denitto et al. “Multiple structure recovery via probabilistic biclustering”. In: *Joint IAPR International Workshops on Statistical Techniques in Pattern Recognition and Structural and Syntactic Pattern Recognition*. 2016. URL: https://doi.org/10.1007/978-3-319-49055-7_25.

[MF16] Luca Magri and Andrea Fusiello. “Multiple model fitting as a set coverage problem”. In: *Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition*. 2016, pp. 3318–3326. DOI: 10.1109/CVPR.2016.361.

[MF15a] Luca Magri and Andrea Fusiello. “Fitting Multiple Models via Density Analysis in Tanimoto Space”. In: *Proceedings of the International Conference on Image Analysis and Processing*. 2015. DOI: 10.1007/978-3-319-23231-7_7.

[MF15b] Luca Magri and Andrea Fusiello. “Robust Multiple Model Fitting with Preference Analysis and Low-rank Approximation”. In: *British Machine Vision Conference*. Vol. 20. 1-20. 2015. URL: https://dx.doi.org/10.5244/C.29.20.

[MF15c] Luca Magri and Andrea Fusiello. “Scale estimation in multiple models fitting via Consensus Clustering”. In: *Proceedings of the International Conference on Computer Analysis of Images and Patterns*. 2015. DOI: 10.1007/978-3-319-23117-4_2.

[Mag+15] Luca Magri et al. “J-DFA: A Novel Approach for Robust Differential Fault Analysis”. In: *Workshop on Fault Diagnosis and Tolerance in Cryptography*. 2015. DOI: 10.1109/FDTC.2015.14.

[Arr+14] Federica Arrigoni et al. “Robust absolute rotation estimation via low-rank and sparse matrix decomposition”. In: *Proceedings of the International Conference on 3D Vision*. Vol. 1. 2014. URL: https://doi.org/10.1109/3DV.2014.48.

[MF14] Luca Magri and Andrea Fusiello. “T-linkage: A continuous relaxation of j-linkage for multi-model fitting”. In: *Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition*. 2014. URL: https://doi.org/10.1109/CVPR.2014.505.

[Fra+12] Pasqualina Fragneto et al. “Uncalibrated view synthesis with homography interpolation”. In: *Proceedings of the IEEE Conference on 3D Imaging, Modeling, Processing, Visualization and Transmission*. 2012. URL: https://doi.org/10.1109/3DIMPVT.2012.39.

International Patents

[Sin+19] Yash Singh et al. *Method for 3D modelling based on structure from motion processing of sparse 2D images*. US Patent App. 10/198,858. Feb. 2019.

[Mag+16] Luca Magri et al. *Method for detecting a straight line in a digital image*. US Patent 9, 245, 200. 2016.

UNDER REVIEW

[LMB] Filippo Leveni, Luca Magri, and Giacomo Boracchi. “Pif: anomaly detection via preference analysis”. Submitted to Proceedings of the International Conference on Pattern Recognition. 2020.

[MLB] Luca Magri, Filippo Leveni, and Giacomo Boracchi. “Multi T-linkage: Multi-class Structure Recovery via Agglomerative Clustering and Model Selection”. Submitted to Proceedings of the International Conference on Pattern Recognition. 2020.

[Stu+] Diego Stucchi et al. “Multimodal QuantTree for Batch-wise Change Detection”. Submitted to Proceedings of the International Conference on Pattern Recognition. 2020.

Consapevole delle sanzioni penali, nel caso di dichiarazioni non veritiere, di formazione o uso atti falsi richiamate dall'art. 763 del D.P.R. 445 del 28 dicembre 2000, nonché della sanzione ulteriore prevista dall'art. 754 del citato D.P.R. 445 del 28 dicembre 2000, consistente nella decadenza dai benefici eventualmente conseguenti al provvedimento emanato sulla base della dichiarazione non veritiera, dichiaro che le informazioni riportate nel presente curriculum vitae sono veritiere.

July 14, 2020 Luca Magri