

Research Activities and Publications

Research Activities

Elena Casiraghi's interest in the information technology research field date to the year 2000, when she was hired as a "trainee researcher" in VTT (Valtion Teknillinen Tutkimuskeskus), Department of Information Technology. During the year spent at VTT, she started to work in the European project Internet Middleware for Customized Service Bundling to develop mathematical methods for the automatic insertion of digital photographs into a 3D virtual world; this problem required a continuous adaptation of the image according to the user movements into the 3D world. Her work was highly judged and treated as an important issue during the international reporting of the project. After the end of the project, she worked in a research project studying computational methods for observing early signs of deterioration of CD-ROM discs; after presenting a detailed analysis of the problem, the developed recovering system was considered as efficient and effective.

Since she began to work in Università degli Studi di Milano, Elena Casiraghi's research interests have been mainly focused in the field of artificial intelligence, to develop automatic systems for image processing and pattern recognition.

Specifically, she began her researches with investigations in the field of image processing, to develop automatic applications for face localization, identification, and recognition. These problems allowed her to study and apply supervised and unsupervised learning algorithms.

Subsequently, she focused on the medical and biomedical image processing fields, where she studied and developed computer aided diagnosis (CAD) systems. In detail, she started working on digital chest radiographs, to detect subtle lung nodules at their early stages; the developed CAD system can be successfully applied to aid radiologists during their decision making process, thus increasing their nodule identification performance. After these researches she focused on the problem of living donor liver transplantation and developed an automatic system for the 3D reconstructions of abdominal organs (e.g. liver, spleen, and kidney) from computed tomography (CT) images, with the final aim of measuring their volume. Both these systems required the development of applications being able to cope with data of high dimensionality. Furthermore, her investigations lead her to the development of learning systems treating highly unbalanced learning datasets of high cardinality.

Other minor researches in the medical field were aimed at 3D volume reconstruction and biometric analysis of fetal brain from MR images.

In the bio-medical field, she developed an automatic system for the segmentation of mice images produced with molecular imaging. The system identifies anatomical organs of interest where it computes specific measurements; the precision of the obtained measures has been considered particularly helpful by pharmacologists that needed to evaluate and compare the pharmacological effect produced by different drugs, that is drugs produced according to different biochemical interactions.

After these researches, she has successfully investigated and developed learning algorithms

dealing with high dimensional data belonging to unbalanced datasets of both high and low cardinality.

In the latest years, she has been investigating in the field of pattern recognition, manifold learning, and intrinsic dimensionality estimation, to develop novel theories and automatic algorithms dealing with high-dimensional datasets characterized by a small cardinality (Small Sample Size Problem). These researches led to the development of methods whose performance has been evaluated both by the comparison with state of the art techniques and by tests on synthetic and real datasets related to problems in the fields of signal processing, image analysis, and bioinformatics.

The aforementioned studies are currently exploited to investigate and experiment solutions to reduce one of the main problem of deep learning techniques, which is the huge computational (time and memory) costs. To this aim, researches are aimed at compressing deep neural networks, by reducing their layer size to the intrinsic dimension estimated on the layers' filters. To effectively reduce the filter dimension different techniques are going to be experimented.

In the past two years, she has been collaborating with the biological researchers of Consorzio M.I.A - Microscopic Image Analysis (University of Milan-Bicocca) to develop automatic systems for the microscopic image analysis.

She started her collaboration with expert biologists, as well as cardiovascular surgeons, to investigate the main factors behind carotid plaques' instability, the latest being the main cause of cerebral stroke. More specifically, during the study she developed an automatic system which is able to detect and quantify different biological structures of interest (such as vascular structures) which are immunohistochemically stained in different microscopic images of contiguous carotid sections containing plaques. Once detected and quantified, the marked contiguous sections are registered to allow an objective visual and comparative analysis of the spatial distribution of each marker (markers relative location). The developed system additionally computes novel measures of markers co-existence in tissue volumes depending on their density. Since each marker allows to detect a particular biological structure of interest, the accurate analysis and study of the computed densities and co-localization measures is considered by surgeons and biological scientists as a valid help to discover structures whose appearance could be exploited as an early alert of plaque instability, avoiding unnecessary surgical procedures. Discovering factors positively or negatively relate at plaques' instability would have an high impact on cerebral stroke prevention.

The developed system (called MIAQuant) has been lately adapted and generalized through the usage of machine learning techniques in order to be able to process images depicting tissue sections belonging to different body structures. Precisely, the novel system (called MIAQuant_Learn) extracts, quantifies and analyze the co-existence of markers characterized by any color and shape and being stained in contiguous sections extracted from any body tissue.

The promising results obtained by the MIAQuant_Learn motivate its extensive usage in the oncological field to quantify and analyze cancerous tissues images produced either by Ospedale San Raffaele (Milano) and by the Department of Experimental Oncology and Molecular Medicine (Fondazione IRCCS Istituto Nazionale dei Tumori).

Journal Publications

- [1] V. Huber, V. Vallacchi, V. Fleming, X. Hu, A. Cova, M. Dugo, E. Shahaj, R. Sulsenti, E. Vergani, P. Filipazzi, A. De Laurentiis, L. Lalli, L. Di Guardo, R. Patuzzo, B. Vergani, E. Casiraghi, M. Cossa, A. Gualeni, V. Bollati, F. Arienti, F. De Braud, L. Mariani, A. Villa, P. Altevogt, V. Umansky, M. Rodolfo, L. Rivoltini (August 2018). miRNAs delivered by tumor extracellular vesicles induce myeloid suppressor cells in melanoma patients and predict resistance to immunotherapy. Submitted to Journal of Cancer Investigation.

- [2] A. Villa, D. Belloni, B. Vergani, S. Cenci, G. Cavalli, R. Biavasco, M. Rodolfo, E. Casiraghi, M.G. Cangi, C. Doglioni, L. Dagna, E. Ferrero, M. Ferrarini (August 2018). 3D culture of Erdheim-Chester disease tissues unveils histiocyte metabolism as a new therapeutic target. Submitted to *Cancer Research*.
- [3] J. Gliozzo, P. Perlasca, M. Mesiti, A. Petrini, E. Casiraghi, M. Frasca, G. Grossi, M. Re, A. Paccanaro, G. Valentini (August 2018). Network modeling of patients' biomolecular profiles for clinical phenotype/outcome prediction. Submitted to *PLOS Computational Biology*.
- [4] E. Casiraghi, V. Huber, M. Frasca, M. Cossa, M. Tozzi, L. Rivoltini, B.E. Leone, A. Villa, B. Vergani (2017). A novel computational method for automatic segmentation, quantification and comparative analysis of immunohistochemically labeled tissue sections. Accepted for publication at *BMC Bioinformatics*.
- [5] E. Casiraghi, M. Cossa, V. Huber, M. Tozzi, L. Rivoltini, A. Villa, B. Vergani (Nov. 2017). MIAQuant, a novel system for automatic segmentation, measurement, and localization comparison of different biomarkers from serialized histological slices. *European Journal of Histochemistry*, vol. 61 (4):2838. doi: 10.4081/ejh.2017.2838.
- [6] E. Casiraghi, S. Ferraro, M. Franchin, A. Villa, B. Vergani, M. Tozzi (December 2016). Analisi semi automatica nella valutazione della neo-vascularizzazione della placca carotidea. *Italian Journal of vascular and endovascular surgery (Minerva Medica Publishing)*, vol. 23 (4), pp. 55-56, Suppl.I, ISSN 1824-4777, Online ISSN 1827-1847.
- [7] P. Campadelli, E. Casiraghi, C. Ceruti, A. Rozza (2015). Intrinsic Dimension Estimation: Relevant techniques and a Benchmark Framework. *Mathematical Problems in Engineering (Hindawi Publishing Corporation)*, vol. 2015, Article ID 759567, 21 pages, 2015. doi:10.1155/2015/759567.
- [8] A.A. Esposito, M. Zilocchi, P. Fasani, C. Giannitto, S. Maccagnoni, M. Maniglio, M. Campoleoni, R. Brambilla, E. Casiraghi, P.R. Biondetti (2015). The value of precontrast thoraco-abdominopelvic CT in polytrauma patients. *European Journal of Radiology*. doi:10.1016/j.ejrad.2015.02.015. ISSN 0720-048X. - 84:6 (2015 Jun), pp. 1212-1218 (Available online 3 March 2015).
- [9] C. Giannitto, A.A. Esposito, E. Casiraghi, P.R. Biondetti (2014). Epidemiological profile of non-traumatic emergencies of the neck in CT imaging: our experience. *La Radiologia Medica*. doi: 10.1007/s11547-014-0389-9 (Epub ahead of print).
- [10] C. Ceruti, S. Bassis, A. Rozza, G. Lombardi, E. Casiraghi, and P. Campadelli (2014). DANCo: Dimensionality from Angle and Norm Concentration. *PATTERN RECOGNITION*, vol. 47, Issue 8, pp. 2569-2581, ISSN: 0031-3203, doi:10.1016/j.patcog.2014.02.013.
- [11] A. Rozza, G. Lombardi, C. Ceruti, E. Casiraghi, P. Campadelli (2012). Novel high intrinsic dimensionality estimators. *MACHINE LEARNING*, vol. 89, Issue 1, pp.37-65, ISSN: 0885-6125, doi: 10.1007/s10994-012-5294-7.
- [12] A. Rozza, G. Lombardi, E. Casiraghi, P. Campadelli (2012). Novel fisher discriminant classifiers. *PATTERN RECOGNITION*, vol. 45, pp. 3725-3737, ISSN: 0031-3203, doi: 10.1016/j.patcog.2012.03.021.
- [13] F. Bredolo, A. Esposito, E. Casiraghi, G. Cornalba, P. Biondetti (2011). Intestinal interposition: the prevalence and clinical relevance of non-hepatodiaphragmatic conditions (non-Chilaiditi forms) documented by CT and review of the literature. *LA RADIOLOGIA MEDICA*, pp. 607-619, ISSN: 0033-8362, doi: 10.1007/s11547-011-0665-x.
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- [15] A. Rozza, G. Lombardi, M. Rosa, E. Casiraghi (2010). O-IPCAC and its application to EEG classification. *JOURNAL OF MACHINE LEARNING RESEARCH*, vol. 11, pp. 4-11, ISSN: 1533-7928.
- [16] P. Campadelli, E. Casiraghi, S. Pratissoli, and G. Lombardi (2009). Automatic Abdominal Organ Segmentation from CT images. *ELCVIA. ELECTRONIC LETTERS ON COMPUTER VISION AND IMAGE ANALYSIS*, vol. 8, pp. 1-14, ISSN: 1577-5097.
- [17] P. Campadelli, E. Casiraghi, and A. Esposito (2008). Liver Segmentation from CT Scans : a Survey and a New Algorithm. *ARTIFICIAL INTELLIGENCE IN MEDICINE*, vol. 45, pp. 185-196, ISSN: 0933-3657, doi: 10.1016/j.artmed.2008.07.020.
- [18] P. Campadelli, E. Casiraghi, and D. Artioli (2006). A Fully Automated Method for Lung Nodule Detection From Postero-Anterior Chest Radiographs. *IEEE TRANSACTIONS ON MEDICAL IMAGING*, vol. 25, pp. 1588-1603, ISSN: 0278-0062, doi: 10.1109/TMI.2006.884198.
- [19] P. Campadelli, E. Casiraghi, and G. Valentini (2005). (2005). Support vector machines for candidate nodules classification. *NEUROCOMPUTING*, vol. 68, pp. 281-288, ISSN: 0925-2312, doi: 10.1016/j.neucom.2005.03.005.

International Conference Publications

- [17] C. Ceruti, P. Campadelli, E. Casiraghi (2017). Linear Regularized Compression of Deep Convolutional Neural Networks (ICIAP 2017). LNCS 10484, pp. 244-253, ISBN=978-3-319-68559-5, doi=10.1007/978-3-319-68560-1_22, url=http://dx.doi.org/10.1007/978-3-319-68560-1_22, Springer International Publishing.
- [18] P. Campadelli, E. Casiraghi, C. Ceruti (2015). Neighborhood Selection for Dimensionality Reduction. Proceedings of International Conference on Image Analysis and Processing (ICIAP 2015). LNCS 9279-81, pp. 183-191, ISBN=978-3-319-23230-0, doi=10.1007/978-3-319-23231-7_17, url=http://dx.doi.org/10.1007/978-3-319-23231-7_17, Springer International Publishing.
- [19] Vitellaro M., Signoroni S., Casiraghi E., Sala P., Ballardini G., Delconte G., and Bertario L. (2015) Survival rate of patients who develop cancer in rectal stump after Colectomy and IRA in FAP patients. Selected for oral Presentation at the International Society for Gastrointestinal Hereditary Tumours (InSiGHT 2015). The 6th Biennial Meeting. Sao Paulo-Brazil.
- [20] Campadelli P., Casiraghi E., Ceruti C., Lombardi G., Rozza A. (2013). Local Intrinsic Dimensionality Based Features for Clustering. Image Analysis and Processing – ICIAP 2013: 17th International Conference, Naples, Italy, September 9-13, 2013. Proceedings, Part I, , pp. 41-50, Springer Berlin Heidelberg, Berlin Heidelberg, ISBN: 978-3-642-41181-6, DOI: 10.1007/978-3-642-41181-6_5.
- [21] Bassis S., Rozza A., Ceruti C., Lombardi G., Casiraghi E., and Campadelli P. (2012), A Novel Intrinsic Dimensionality Estimator based on Rank-order Statistics. International Workshop on Clustering High-Dimensional Data (CHDD12), Naples, Italy, May 15th, 2012, Springer Verlag, LNCS, 2012.
- [22] Rozza A., Lombardi G., Rosa M., Casiraghi E., Campadelli P. (2011). IDEA: Intrinsic Dimension Estimation Algorithm. In: G. Maino, G. Foresti (Eds.). 16th International Conference on Image Analysis and Processing (ICIAP 2011): Proceedings (part I). Ravenna, Italy, September 14-16, 2011. vol. 6979, pp. 433-442, Springer New York, ISBN: 9783642240843, doi: 10.1007/978-3-642-24085-0_45.

- [23] Lombardi G., Rozza A., Ceruti C., Casiraghi E., Campadelli P. (2011). Minimum Neighbor Distance Estimators of Intrinsic Dimension. In: D. Gunopulos, T. Hofmann, D. Malerba, and M. Vazirgiannis (Eds.). *Machine learning and knowledge discovery in databases: European conference (ECML PKDD 2011): Proceedings (part II)*. Athens, Greece, September 5-9, 2011. vol. 6912, pp. 374-389, Springer-Verlag Berlin Heidelberg, ISBN: 978-960-89282-2-0, doi: 10.1007/978-3-642-23783-6_24.
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- [26] Campadelli P., Casiraghi E., Lombardi G., Serrao G. (2009). 3D Volume Reconstruction and Biometric Analysis of Fetal Brain from MR Images. In: F. Masulli, R. Tagliaferri, and G.M. Verkhivker (Eds.). *Computational Intelligence Methods for Bioinformatics and Biostatistics, 5th International Meeting (CIBB 2008): Revised Selected Papers*. Vietri sul Mare, Italy, October 3-4, 2008. vol. 5488, pp. 188-197, Springer-Verlag Berlin Heidelberg, ISBN: 978-3-642-02503-7, doi: 10.1007/978-3-642-02504-4_17.
- [27] Rando G., Arca S., Casiraghi E., Campadelli P., Maggi A. (2009). Automatic Segmentation of Mouse Images. In: V. Capasso, G. Aletti, and A. Micheletti (Eds.). *Stereology and Image Analysis. 10th European Conference of ISS (Ecs10): Proceedings*. Milano, Italy, June 22-26, 2009. Esculapio Bologna, ISBN: 978-88-7488-310-3.
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National Conference Publications

- [42] Lombardi G., Rozza A., Casiraghi E., Campadelli P. (2012). A Novel Approach for Geometric Clustering based on Tensor Voting Framework. In: B. Apolloni, S. Bassis, A. Esposito, F.

Morabito (Eds.). *Neural Nets WIRN11: Proceedings of the 21st Italian Workshop on Neural Nets*. Vietri sul Mare, Salerno, Italy, June 3-5, 2011. vol. 234, pp. 129-138, IOS Press, 2012, ISBN: 978-1-60750-971-4.

- [43] Rozza A., Arca S., Casiraghi E., Campadelli P., Natale M., Bucci E., Consoli P. (2012). Automatic Alignment of Gel 2D Images. In: B. Apolloni, S. Bassis, A. Esposito, F. Morabito (Eds.). *Neural Nets WIRN11: Proceedings of the 21st Italian Workshop on Neural Nets*. Vietri sul Mare, Salerno, Italy, June 3-5, 2011. vol. 234, pp. 3-10, IOS Press, 2012, ISBN: 978-1-60750-971-4.
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Book Chapters

- [49] Rozza A., Lombardi G., Re M., Casiraghi E., Valentini G., Campadelli P. (2011). A Novel Ensemble Technique for Protein Subcellular Location Prediction. In: O. Okun, G. Valentini, and M. Re (Eds.). *Ensembles in Machine Learning Applications*. vol. 373/2011, pp. 151-167, Springer-Verlag Berlin Heidelberg, ISBN: 978-3-642-22909-1, doi: 10.1007/978-3-642-22910-7_9.
- [50] Lombardi G., Casiraghi E., Campadelli P. (2010). The Neighbors Voting Algorithm and its Applications. In: O. Okun, G. Valentini. *Applications of Supervised and Unsupervised Ensemble Methods*. vol. 245/2009, pp. 151-173, Springer-Verlag Berlin Heidelberg, ISBN: 9783642039980, doi: 10.1007/978-3-642-03999-7_9.

Poster Presentations

- [51] Gliozzo J., Notaro M., Petrini A., Perlasca P., Mesiti M., Casiraghi E., Grossi G., Re M., Paccanaro A., Valentini G. (2017). Modeling biomolecular profiles in a graph-structured sample

space for clinical outcome prediction with melanoma and ovarian cancer patients. 14th Annual Meeting of the Bioinformatics Italian Society (BITS 2017), July 5-7, 2017, Cagliari, Italy.

- [52] Casiraghi E., Vergani B., Villa A. (2017). An automated method for biological marker segmentation, quantification, and colocalization, from histochemical and immunohistochemical images. 14th Annual Meeting of the Bioinformatics Italian Society (BITS 2017), July 5-7, 2017, Cagliari, Italy.
- [53] Casiraghi E., Ferraro S., Franchin M., Villa A., Vergani B., Tozzi M. (2016). Analisi semi automatica nella valutazione della neo-vascularizzazione della placca carotidea. SICVE 2016, XV Annual Meeting of Societ italiana di Chirurgia Vascolare ed Endovascolare, 22-25 Rome, Italy.
- [54] Rozza A., Lombardi G., Re M., Casiraghi E., Valentini G., Campadelli P. (2011). A novel ensemble approach for the subcellular localization of proteins. In: BITS 2011: 8th annual meeting of the Bioinformatics Italian Society: June 20-22, 2011, Pisa, Italy: Proceedings. Pisa, 2011, p. 105-106, PISA:ETS, ISBN: 9788846730695.

Conference talks and Awards

- [55] The 25th of October the Abstract/Poster presented at SICVE (entitled: “Analisi semi automatica nella valutazione della neo-vascularizzazione della placca carotidea.”) won the award for being judged the best work presented at the Conference.
- [56] The 16th of February, 2005 she an invited speaker at the Workshop: “Digital Image Processing in medicine and biology” (Palermo), organized by “Centro Interdipartimentale Tecnologie della Conoscenza” (CITC, Università degli Studi di Palermo), “Scuola di specializzazione in Anatomia Patologica” (Università degli Studi di Palermo) and the Department of biotechnologies and Legal Medicine (Università degli Studi di Palermo). She presented her research “Computerized lung nodule detection from Postero-Anterior chest radiographs”.
- [57] The 9th of March, 2007 she was an invited speaker at the Workshop: “Biomedical Imaging Systems for diagnosis” (Palermo), organized by “Centro Interdipartimentale Tecnologie della Conoscenza” (CITC, Università degli Studi di Palermo), “Scuola di specializzazione in Anatomia Patologica” (Università degli Studi di Palermo) and the Department of biotechnologies and Legal Medicine (Università degli Studi di Palermo). She presented her research “Computerized liver segmentation method from Computed Tomography (CT) images”.
- [58] The 28th-29th of April, 2008 she was an invited speaker at the Workshop: “Shape and Size in Medicine, Biotechnology and Materials Science”, organized by the Department of Mathematics, Università degli Studi di Milano. She presented her research “Computer aided diagnosis systems in medical imaging”.
- [59] The 30th of November 2006 she participated at “Obiettivo ICT” award, presenting her business idea project, together with Prof. Paola Campadelli. The project was selected as one of the best 10 projects.
- [60] The 26th of October 2007 she participated at “Start Cup Milano Lombardia” award, presenting her research project, together with Prof. Paola Campadelli. The project won the Special award of CCIIA Milano.

Phd Thesis

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