

CV

Giovanni Denaro - Email: giovanni.denaro@unimib.it

Associate Professor INF/01 at Università di Milano-Bicocca, Milano, Italy

ASN title as Prima Facia (Full Professor) in INF/01 since 2019

Born: 01/01/1973

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Education and Career

2017 - today: Associate Professor at Università di Milano-Bicocca, Milano, Italy

2020 - today: Vice-director of Dipartimento di Informatica, Sistemistic e Comunicazione at Università di Milano-Bicocca, Milano, Italy

2017-18, 2020-21, 2021-22: External Professor of “Software Engineering”, Università della Svizzera Italiana (USI), Lugano, Switzerland

2005 to 2016: Assistant Professor (Ricercatore) at Università di Milano-Bicocca, Milano, Italy

2001 to 2004: Post-doctoral Research Fellow at
University College London, London, UK
Università di Milano-Bicocca, Milano, Italy
Politecnico di Milano, Milano, Italy

2002: PhD in Software Engineering, Politecnico di Milano, Milano, Italy.

1997: Master in ICT at CEFRIEL Milano

1997: Laurea in Computer Science Engineering, Politecnico di Milano, Milano, Italy.

Articles, h Index, PhDs supervised

- 53 articles in indexed journals and international conferences
- G Scholar h index: 23 (13 since 2017)
- G Scholar i10 index: 37 (18 since 2017)
- 1590 total citations (484 since 2017)
- 4 PhD dissertations supervised in the last 10 years. Supervision of further 3 PhD students currently ongoing
- Associate Editor of *Software Quality Journal*, Springer, ISSN 0963-9314
- Member of the Association for Computing Machinery (ACM) and IEEE Computer Society

Topics of Expertise

- Software analysis and testing based on symbolic execution
- Constraint solving and constraint reuse
- Search-based automatic test generation
- Data flow analysis and testing
- Automatic failure prediction in distributed software
- Self-adaptation in service-oriented software
- Blockchain technologies

CV Summary

My area of work is software engineering, with specific focus on software quality, software testing and program analysis. A main research line is on techniques that exploit symbolic execution to automatically generate test cases that can reach high code coverage on industrial-scale programs. In this area, the main results of my research concern with extending traditional

symbolic execution with new techniques that make the analysis effective for industrial-scale software, including term rewriting for coping with non-linear constraints on the program inputs [FSE:2013], the handling of programs that take data structures as input [FSE:2015], the integration between forward and backward analysis to discriminate between feasible and infeasible program paths [SQJ:2011, TSE:2016], and the reuse of constraint solutions to mitigate the heavy impact of constraint solving on the analysis [ISSTA:2015, ICSE:2017, TSE:2019]. Another recent research line is on generating test cases with search-based techniques to effectively sample the test sequences of object-oriented programs [ISSTA:2017, ICSE:2018], the execution space of parallel programs in map-reduce style [FSE:2019], test inputs to expose performance bugs [WOSP:2004, ISSRE: 2018, STVR:2020], and the relevant interactions of Web applications [ASE:2020]. I also studied the application of data-flow analysis for object-oriented software, demonstrating that the traditional (fully static) embodiment of data-flow analysis likely misses a very large portion of the relevant interactions in object-oriented programs [FASE:2008, ICST:2014], and proposing a novel embodiment of the analysis that integrates results from both static and dynamic analysis to overcome these limitations [ICSE:2015]. Other relevant results of my research address techniques to engineer self-adaptive service-oriented architectures, in which the applications are able to automatically adapt in order to interchangeably integrate new versions of their web services as these evolve over time [FSE:2009, TOSEM:2013].

Advising of PhD students

- Dr. Luca Guglielmo: Evidence-based measurement of software testability. University of Milano-Bicocca, started in 2019
- Dr. Elson Kurian: Automatic test case generation for safety critical systems. University of Milano-Bicocca, started in 2019
- Dr. Rahim Heydarov: Failure prediction for cloud-based applications with deep learning. University of Lugano, started in 2019
- Dr. M. Chen: Reusing Constraint Proofs in Program Analysis. University of Lugano, 2018.
- Dr. A. Aquino: Reusing Solutions Modulo Theories. University of Lugano, 2018
- Dr. M. Vivanti: Dynamic Data Flow testing. University of Lugano, 2015
- Dr. M. Baluda: Test Generation for High Coverage with Abstraction Refinement and Coarsening, University of Lugano, 2014
- Dr. D. Tosi: Self-managed Solutions For SOA-based Applications. University of Milano-Bicocca, 2007

Partecipazione in National and International Projects

- Research and Development project funded by Rete Ferroviaria Italiana: “Analisi e progettazione delle metodologie di sviluppo e test delle funzioni di segnalamento ERTMS con applicazione al sottosistema EVC” nell’ambito dell’Accordo Quadro Ingegneria del Software per applicazioni ferroviarie Rubrica DAC n. 553/2017 - CIG71017716D2.
- Project SISMA: **SISMA**: Solutions for Engineering Microservices Architectures, MUR PRIN 2017. Role in the project: Co-Investigator.
- Project GAUSS: Governing Adaptive and Unplanned Systems of Systems, MUR PRIN 2015. Role in the project: Co-Investigator.
- Project IDEAS: Integrated Design and Evolution of Adaptive Systems, MIUR PRIN 2012. Role in the project: Co-Investigator.
- Project PINCETTE: Validating Changes and Upgrades in Networked Software, EU STREP 2010-2013. Role in the project: Co-Investigator.

- Project SHADOWS: Self-Healing Approach to Designing Complex Software Systems, EU STREP 2003-2009. Role in the project: Co-Investigator.
- Project COMMUTA: Componenti HW/SW Mutanti per Sistemi Distribuiti Dinamicamente Riconfigurabili, MIUR PRIN 2006-2007. Role in the project: Co-Investigator.
- Project “Fiera Virtuale per il Rilancio dell’Artigianato Comasco”, Fondo Europeo per lo Sviluppo Regionale, Regione Lombardia 2006. Role in the project: Co-investigator.
- Project SEGRAVIS: Syntactic and Semantic Integration of Visual Modelling Techniques - European Research Training Network, 2002-2006. Role in the project: Research Fellow con Borsa di Mobilità finanziata dal progetto.
- Project QUACK: Piattaforma per la Qualità di Sistemi Embedded Integrati di Nuova Generazione, MIUR COFIN 2002-2003. Role in the project: Co-Investigator con Assegno di Ricerca finanziato.
- Project PROSPECTS: Properties of Aspects, nell’ambito del programma di finanziamento MIUR “Giovani Ricercatori” 2000-2001. Role in the project: Co-Investigator.
- Project PROMOTE: PROcess improvement through Measurement Of Test, EU-ESSI 27907 1998-2000. Co-Investigator con Assegno di Ricerca finanziato.
- Project LAW: Legacy Assessment Workbench, EU-ESPRIT 22110, 1995-97. Co-Investigator con Borsa di Studio presso CEFRIEL Milano.

Publications

International Journals and Conferences

- [1] M Brunetto, G Denaro, L Mariani, M Pezzè. On introducing automatic test case generation in practice: A success story and lessons learned. *Journal of Systems and Software* 176, 2021
- [2] L Guglielmo, A Riboni, G Denaro. Towards evidence-based testability measurements. *IEEE/ACM 43rd International Conference on Software Engineering, Track on New Ideas an Emerging Results*, 2021
- [3] M Calani, G Denaro, A Leporati. Exploiting the Blockchain to Guarantee GDPR Compliance while Consents Evolve under Data Owners’ Control. *Italian Software Security Conference, ITASEC*, 2021
- [4] A Aquino, P Braione, G Denaro, P Salza. Facilitating Program Performance Profiling via Evolutionary Symbolic Execution. *Software Testing Verification and Reliability*, 30 (2). 2020
- [5] D Clerissi, G Denaro, M Mobilio, L Mariani. Plug the Database & Play With Automatic Testing: Improving System Testing by Exploiting Persistent Data. *Proceedings of the IEEE/ACM International Conference on Automated Software Engineering*, 2020.
- [6] L Baresi, G Denaro, G Quattrocchi. *Symbolic execution-driven extraction of the parallel execution plans of Spark applications*. *Proceedings of the 2019 27th ACM Joint Meeting on European Software Engineering*, 2019.
- [7] A Aquino, G Denaro, M Pezzè. *Reusing Solutions Modulo Theories*. *IEEE Transactions on Software Engineering*, 2019.
- [8] L Baresi, G Denaro, G Quattrocchi. Big-Data Applications as Self-Adaptive Systems of Systems, 2019 *IEEE International Symposium on Software Reliability Engineering Workshops (ISSREW)*, Berlin, Germany, 2019
- [9] A. Riboni, G Denaro, L. Guglielmo, M. Orrù, P. Braione. Design for Testability of ERMTS Applications, 2019 *IEEE International Symposium on Software Reliability Engineering*

Workshops (ISSREW), Berlin, Germany, 2019

- [10] P. Braione, G Denaro. SUSHI and TARDIS at the SBST2019 Tool Competition, 2019 IEEE/ACM 12th International Workshop on Search-Based Software Testing (SBST), Motreal, QC, Canada, 2019
- [11] G Denaro, L Guglielmo, L Mariani, and O Riganelli. GUI testing in production: challenges and opportunities. In Proceedings of the Conference Companion of the 3rd International Conference on Art, Science, and Engineering of Programming (Programming '19).mACM, 2019
- [12] A Aquino, G Denaro, P Salza. *Worst-Case Execution Time Testing via Evolutionary Symbolic Execution*. IEEE 29th International Symposium on Software Reliability Engineering, 2018.
- [13] P Braione, G Denaro, A Mattavelli, M Pezzè. *SUSHI: a test generator for programs with complex structured inputs*. 2018 IEEE/ACM 40th International Conference on Software Engineering. ICSE 2018
- [14] P Braione, G Denaro, A Mattavelli, M Pezzè. *Combining symbolic execution and search-based testing for programs with complex heap inputs*. Proceedings of the 26th ACM SIGSOFT International Symposium on Software Testing and Analysis, 2017
- [15] A Aquino, G Denaro, M Pezzè. *Heuristically matching solution spaces of arithmetic formulas to efficiently reuse solutions*. 2017 IEEE/ACM 39th International Conference on Software Engineering.
- [16] M. Baluda, G Denaro, M. Pezze. *Bidirectional Symbolic Analysis for Effective Branch Testing*. IEEE Transactions on Software Engineering, 2016
- [17] A. Margara, G Denaro, M. Pezze, M. Vivanti. *Dynamic Data Flow Testing of Object Oriented Systems*. International Conference on Software Engineering (ICSE 2015), pp 947–958, 2015
- [18] P. Braione, G Denaro, M. Pezzè. *Symbolic execution of programs with heap inputs*. Proceedings of the 2015 10th Joint Meeting on Foundations of Software Engineering, pp 602–613, 2015
- [19] A. Aquino, F. Bianchi, M. Chen, G Denaro, M. Pezzè. *Reusing constraint proofs in program analysis*. Proceedings of International Symposium on Software Testing and Analysis, pp 305–315, 2015
- [20] P. Braione, G Denaro, A. Mattavelli, M. Vivanti, A. Muhammad. *Software testing with code-based test generators: data and lessons learned from a case study with an industrial software component*. Software Quality Journal, Volume 22, Issue 2, June 2014
- [21] G Denaro, M. Pezzè, M. Vivanti. *On the Right Objectives of Data Flow Testing*. Proceedings of the IEEE International Conference on Software Testing, Verification, and Validation (ICST 2014), USA, IEEE 2014
- [22] G Denaro, M. Pezzè, D. Tosi. *Test-and-Adapt: An Approach for Improving Service Interchangeability*. ACM Transactions on Software Engineering and Methodology, Vol. 22, No. 4, Article 28, October 2013
- [23] P. Braione, G Denaro, M. Pezze. *Enhancing Symbolic Execution with Built-In Term Rewriting and Constrained Lazy Initialization*. Proceedings of the Joint meeting of the European Software Engineering Conference and ACM SIGSOFT Symposium on the Foundations of Software Engineering (ESEC/FSE 2013), Saint Pietersburg, Russia, ACM Press, 2013
- [24] H Chockler, G Denaro, M Ling, G Fedyukovich, A Hyvrinen, L Mariani, A Muhammad, M Oriol, A Rajan, O Sery, N Sharygina, M Tautschnig. *PINCETTE-Validating Changes and Upgrades in Networked Software*. Proceedings of the European Conference on Software Maintenance and Reengineering (CSMR 2013), 2013
- [25] G Denaro, M. Pezzè, M. Vivanti. *Quantifying the Complexity of Dataflow Testing*. Proceedings of the 8th International Workshop on Automation of Software Test (AST 2013), San Francisco, USA, IEEE Press, 2013
- [26] G Denaro. *All-Values Symbolic Execution*. Proceedings of the 7th International Workshop on Automation of Software Test (AST 2012), Zurich, Switzerland, 2012
- [27] P. Braione, G Denaro, A. Mattavelli, M. Vivanti, A. Muhammad. *An Industrial Case Study of the Effectiveness of Test Generators*. Proceedings of the 7th International Workshop on Automation of Software Test (AST 2012), Zurich, 2012
- [28] M. Baluda, G Denaro, P. Braione, M. Pezze. *Enhancing structural software coverage by incrementally computing branch executability*. Software Quality Journal, Volume 19, Issue 4, December 2011
- [29] G Denaro, M. Pezzè, D. Tosi. *Towards Autonomic Service-Oriented Applications*.

International Journal of Autonomic Computing, Vol. 1, No. 1, Inderscience Enterprises Ltd., 2009.

- [30] M. Baluda, P. Braione, G Denaro, M. Pezzè. *Structural Coverage of Feasible Code*. Proceedings of 5th International Workshop on Automated Software Testing (AST 2010), colocated with ICSE 2010.
- [31] G Denaro, M. Pezzè, D. Tosi. *Ensuring Interoperable Service-oriented Systems through Engineered Self-Healing*. Proceedings of the 7th joint meeting of the European Software Engineering Conference and the ACM SIGSOFT Symposium on the Foundations of Software Engineering (ESEC/FSE 2009), Amsterdam, The Netherlands, August 2009.
- [32] G Denaro, A. Gorla, M. Pezzè. *DaTeC: Contextual Data Flow Testing of Java Classes*. Proceedings of 31st International Conference on Software Engineering (ICSE 2009), Research Demo, Vancouver, 2009.
- [33] A. Carzaniga, G Denaro, J. Estublier, M. Pezzè, A. Wolf. *Toward Deeply Adaptive Societies of Digital Systems*. Proceedings of 31st International Conference on Software Engineering (ICSE 2009), Track on New Ideas and Emerging Results, Vancouver, Canada, May 2009.
- [34] G Denaro, A. Gorla, M. Pezzè. *Contextual Integration Testing of Classes*. Proceedings of the International Symposium on the Fundamental Approaches to Software Engineering (FASE 2008), Budapest, 2008
- [35] P. Braione, G Denaro, B. Krena, M. Pezzè. *Verifying LTL Properties of Bytecode with Symbolic Execution*. Proceedings of the 2nd Workshop on Bytecode Semantics, Verification, Analysis and Transformation (Bytecode 2008), Budapest, Hungary, April 2008
- [36] G Denaro, M. Pezzè, D. Tosi. *Designing Self-Adaptive Service-Oriented Applications*. Proceedings of the International Conference on Autonomic Computing (ICAC 2007), Orlando, USA, June 2007.
- [37] G Denaro, M. Pezzè, D. Tosi. *SHIWS: a Self-Healing Integrator for Web Services*. Proceedings of 29th International Conference on Software Engineering (ICSE 2007), Research Demo, Minneapolis, 2007
- [38] G Denaro, M. Pezzè, D. Shilling, D. Tosi. *Towards Self-Adaptive Service-Oriented Architectures*. Proceedings of Workshop on Testing, Analysis and Verification of Web Services and Applications (TAV-WEB 2006), Portland Maine, USA, July 2006
- [39] G Denaro, L. Mariani, M. Pezzè, D. Tosi. *Adaptive Runtime Verification of Autonomic Communication Infrastructures*. Proceedings of the 1st International Workshop on Autonomic Communication and Computing (ACC 2005), Taormina, Italy, June 2005.
- [40] G Denaro, M. Pezzè, D. Tosi. *Adaptive Integration of Third-Party Web-Services*. Proceedings of the International Workshop on Design and Evolution of Autonomic Application Software (DEAS 2005), St Louis, USA, May 2005.
- [41] G Denaro, L. Mariani. *Towards Testing and Analysis of Systems that Use Serialization*. Proceedings of the 2nd International Workshop on Test and Analysis of Component-Based Systems (TACoS 2004), Electronic Notes on Theoretical Computer Science, Vol. 116, Elsevier, January 2005.
- [42] G Denaro, M. Pezzè, A. Baldini, G. Lipari, M. Rossi, D. Rogai. *QUACK: A Platform for the Quality of New Generation Integrated Embedded Systems*. Proceedings of the 2nd International Workshop on Test and Analysis of Component-Based Systems (TACoS 2004), Electronic Notes on Theoretical Computer Science, Vol. 116, 2005.
- [43] G Denaro, A. Polini, W. Emmerich. *Early Performance Testing of Distributed Software Applications*. Proceedings of the 4th International Workshop on Software and Performance (WOSP 2004), Redwood City, California, January 2004.
- [44] G Denaro, S. Morasca, M. Pezzè. *Towards Industrially Relevant Fault-Proneness Models*. International Journal of Software Engineering and Knowledge Engineering, Vol. 13, No. 4, ISSN:0218-1940, World Scientific Publishing Co., August 2003.
- [45] G Denaro, L. Lavazza, M. Pezzè. *An Empirical Evaluation of Object-Oriented Metrics*. 5th CaberNet Plenary Workshop, Porto Santo, Portugal, November 2003.
- [46] A. Baldini, G Denaro, M. Pezzè, P. Prinetto. *Design for Testability for Highly Reconfigurable Component-Based Systems*. Proceedings of the International Workshop on Test and Analysis of Component-Based Systems (TACoS 2003), Electronic Notes on Theoretical Computer Science, Vol. 82(6), September 2003.

- [47] G Denaro, L. Mariani, M. Pezzè. *Self-Test Components for Highly Reconfigurable Systems*. Proceedings of the International Workshop on Test and Analysis of Component-Based Systems (TACoS 2003), Electronic Notes on Theoretical Computer Science, Vol. 82(6), September 2003.
- [48] G Denaro, S. Morasca, M. Pezzè. *Deriving Models of Software Fault-Proneness*. Proceedings of the 14th International Conference on Software Engineering and Knowledge Engineering (SEKE 2002), Ischia, Italy, July. 2002. This paper was selected among the best papers of the conference.
- [49] L. Baresi, G Denaro, L. Mainetti, P. Paolini. *Assertions to Better Specify the Amazon Bug*, Proceedings of the 14th International Conference on Software Engineering and Knowledge Engineering (SEKE 2002), Ischia, Italy, July 2002.
- [50] G Denaro, M. Pezzè. *An Empirical Evaluation of Fault-Proneness Models*, Proceedings of the 24th International Conference on Software Engineering (ICSE 2002), Orlando, Florida, May 2002.
- [51] A. Coen-Porisini, G Denaro, C. Ghezzi, M. Pezzè. *Using Symbolic Execution for Verifying Safety-Critical Systems*, Proceedings of the Joint 8th European Software Engineering Conference and 9th ACM SIGSOFT Symposium on the Foundations of Software Engineering (ESEC/FSE 2001), Vienna University of Technology, Austria, Sept. 10-14, 2001.
- [52] M. Monga. *An Experience on Verification of Aspect Properties*, Proceedings of the International Workshop on Principles of Software Evolution (IWPSE01), Vienna, Austria, September 2001.
- [53] G Denaro. *Estimating Software Fault-Proneness for Tuning Testing Activities*, Proceedings of the 22nd International Conference on Software Engineering (ICSE2000), Doctoral Workshop, Limerick, June 2000.

Edited books

- [54] G Denaro, M. Pezzè, O. Shehory. *Proceedings of the Fourth International Workshop on Software Quality Assurance (SOQUA 2007)*. In conjunction with the 6th ESEC/FSE joint meeting, Dubrovnik, Croatia, 2007

Book chapters

- [55] P. Braione, G Denaro, O. Riganelli, M. Baluda, A. Muhammad. *Static/Dynamic Test Case Generation For Software Upgrades via ARC-B and Deltatest*. In: *Validation of Evolving Software*, pp 147-184, Springer, 2015
- [56] P. Braione, G Denaro, M. Pezzè. *On the integration of software testing and formal analysis*. In: *Empirical Software Engineering and Verification*, LNCS 7007, pp 158-193, Springer, 2012
- [57] G Denaro, L. Lavazza, M. Pezzè. *Le Metriche Object-Oriented nelle Realtà Aziendali*. In: *Metriche del software -- Esperienze e ricerche*, GUFPI-ISMA, ISBN 88-464-7139-3, FrancoAngeli, 2006.
- [58] G Denaro, A. Polini, W. Emmerich. *Performance Testing of Distributed Component Architectures*. In: *Testing Commercial-off-the-Shelf Components and Systems*, S. Beydeda and V. Gruhn editors, Springer, 2005.
- [59] G Denaro, M. Pezzè. *Petri Nets and Software Engineering*. In: *Advances on Petri Nets*, W. Reisig editor, Springer-Verlag, to appear in fall 2004.

Theses

- [60] G Denaro. *Fault-Proneness Models for Classes of Software Products*, PhD dissertation, Politecnico di Milano, January 2002.
- [61] G Denaro. *Un Approccio alla Verifica Formale delle Proprietà dei Programmi*, Laurea dissertation, Politecnico di Milano, October 1997.