CURRICULUM VITAE, GIOVANNI COLOMBO

Personal and academic

Giovanni Colombo, Dipartimento di Matematica Pura ed Applicata, Università di Padova, via Belzoni 7, 35131 Padova (Italy)
e-mail: colombo*AT *math.unipd.it
personal web page: `http://www.math.unipd.it/~colombo`
telephone: +39 049 8275945
Full professor, Mathematical Analysis, Department of Mathematics, University of Padua.

- Born in Padova, April 28th, 1958; married with five children.
- 1977, degree in flute, Padova Conservatory of music; concert activity until 1981.

- 1983, degree in Mathematics, University of Padua, 110/110 *cum laude*.
- 1984, military service (mandatory).
- fall 1985, enrolled at SISSA (International School of Advanced Studies), Trieste, as graduate student in functional analysis.
- March 1988: "Doctor Philosophiae", (SISSA); advisor: prof. A.Cellina.
- March 1988 - March 1990: post doctoral position, SISSA, Trieste.
- April 1990 - October 1992: researcher position, mathematical analysis, SISSA, Trieste.
- November 1992 - October 1994: associate professor, mathematical analysis, Engineering School, University of L'Aquila (Italy).
- November 1994 - 2004: associate professor, mathematical analysis, Engineering School, University of Padova.
- December 2004 - present time: full professor, mathematical analysis, Department of Mathematics, University of Padova.

Research projects and visits

- 1993: collaboration with V. Křivan (Czech Academy of Sciences): funded with 8,000 ECU from EU (ERB-CIPA-CT-93-1554); research program: analysis of uncertain systems.
- 1999-2000: Local coordinator of a national project on Ordinary differential equations (PI A. Cellina)
- 2000: collaboration with P. Wolenski (LSU, Baton Rouge, USA), funded by Istituto Nazionale di Alta Matematica; research program: regularity of the minimum time function;
- 2001: collaboration with M. Monteiro Marques (CMAF, Lisbon): funded by Istituto Nazionale di Alta Matematica; research program: analysis of the Moreau process.
- 2002-2003: sabbatical year. Invited visits to Baton Rouge (LSU), Schauder Center for Nonlinear Analysis (Toruń, Poland), Technical University of Budapest.
- 2004-2005: PI of a Padova University research project.
- 2004: invited visit to CMAF, Lisbon.
- 2009: collaboration with V. Goncharov (Univ. of Évora, Portugal), funded by INdAM.
- 2010-2013: member of the Padova University research project "Nonlinear Partial Differential Equations: models, analysis, and control-theoretic problems", funded by CARIPARO
- 2010-2013: member of the research project VARIANT, funded by the Portuguese Ministry of Education
- 2011-2013: member of the Padova University research project "Some analytic and differential geometric aspects in Nonlinear Control Theory, with applications to Mechanics", funded by Padova University.
- 2010-2014: member of EU Marie Curie Project "SADCO".
- 2015-2017: PI of the Padova University research project "Control of dynamics with active constraints".
- 2018: collaboration with P. Bettiol (Brest) funded by Université de Bretagne Occidentale.

Editorial Boards

- Set Valued and Variational Analysis
- Discussiones Mathematicae – Differential Inclusions

Organization of international conferences

Control of state constrained dynamical systems, Padova, September 2017.
Analysis and Geometry in Control Theory and its Applications, INdAM Workshop, Roma, June 2014.
Nonlinear differential equations and control, celebrating A. Cellina's 70th birthday, Milano, September 2011.
Variational and differential problems with constraints, Venezia, September 2006.

Educational activities.

2017: PhD course "An introduction to the mathematical control theory and to set-valued analysis".
2015, 2016, 2017: Master courses on Advanced functional analysis.
1990, 1991, 2001: graduate courses (introduction to differential inclusions; set-valued and nonsmooth analysis).
1996, 1997, 2000: advanced undergraduate courses (introduction to Calculus of Variations and to Optimal Control)
1996, 1997: master course (introduction to partial differential equations)
1992 - present: courses on Mathematical Analysis for the Engineering School (various levels)
1999 - present: member of various Faculty boards for teaching and research organization.

– Supervisor of research Master thesis (1989, 1994, 2014).

– Supervisor of the following PhD students:

- A. Marigonda, 2002 - 2006; tenured at Verona University.
- Khai T. Nguyen, 2008 - 2010; tenure track at North Carolina State University.
- Luong V. Nguyen, 2011 - 2014; post doc at Polish Academy of Sciences, Warsaw; currently tenured at Hong Duc University, Viet Nam.
- Thuy T.T. Le, 2013 - 2016; currently post doc at Otto von Guericke University, Magdeburg; from Jan 1, 2018 Research Associate at NIH Bethesda Lab. in the USA.
- Chems Eddine Arroud (2015 - 2016); in collaboration with. T. Haddad, University of Jijel, Algeria.
- Nathalie Khalil (2015 - 2016); partial supervision in collaboration with F. Rampazzo (Padova) and P. Bettiol (Brest) [supervisor].

Selected invited talks

- Krasiczyn (Poland), 1988 (international conference)
- Warsaw, 1989, "Mini-Semester on Differential Inclusions"
- Pamporovo (Bulgaria), 1990 (international conference)
- Warsaw, 1993, "Mini-Semester on Differential Inclusions",
- Fontevraud (France), 1994, "Viability and Control" (international conference)
- World Congress of Nonlinear Analysts, Athens, 1996, (in a session)
- Viability and Control II, 1997, Levico.
- Second Symposium on Nonlinear Analysis, Toruń, 1999.
- CDC, Las Vegas, 2002 (in a session).
- Nonsmooth analysis and Mathematical control Theory, Baton Rouge, 2003 (international conference).
- SISSA, 1993 (invited seminar);
- Firenze, 1996 (invited seminar);
- SISSA, 1997 (invited seminar);

- Roma II, 1997 (invited seminar);
- Politecnico di Torino, 1998 (invited seminar);
- *Schauder lecture*, Toruń (Poland), 2003;
- Technical University, Budapest, 2003 (invited seminar);
- World Congress of Nonlinear Analysts, Orlando, 2004 (contributed talk);
- Geometric Control Theory and Nonsmooth Analysis, INDAM, Rome, 2006: invited talk;
- Differential equations and topology (Pontryagin's centennial conference), Moscow, 2008 (contributed talk);
- Control Theory and nonsmooth analysis, INDAM, Rome, June 2009: invited talk.
- ICIAM, Dresden, May 2010: invited talk.
- ENSTA, Paris, March 2011: Kick-off meeting of the Marie Curie project "SADCO": invited talk.
- IFIP, Berlin, September 2011: invited talk.
- Oberwolfach, Variational Methods for Evolution, December 2011: invited talk.
- Brescia University, March 2012: invited talk.
- International school "G. Stampacchia", Erice, May 2012: invited talk.
- Conference in memoriam Francesco De Blasi, Rome, October 2012: invited talk.
- New trends in optimal control, Tours, June 2014.
- SIAM Conference on Applications of Dynamical Systems, Snowbird (Utah), May 2015: invited session.
- SIAM conference on Control, Paris, July 2015: invited session.
- Conference for the 60th birthday of A. Bressan, SISSA, June 2016.
- Conference for the 60th birthday of A. Arutyunov, Porto, April 2017.
- Conference for the 60th birthday of P. Cannarsa, INdAM, Roma, July 2017.

Research topics.

- Set-valued analysis (continuous selections, papers # 1, 2, 4, 14, 29)
- Differential inclusions (existence of solutions, papers # 3, 5, 6, 7, 8, 10, 11, 12, 16, 18, 23, 45)
- Optimal control (existence of minimizers, papers # 9, 21, 22)
- Nonsmooth analysis (regularity properties of some value functions of optimal control problems, and of some non-Lipschitz functions, papers # 27, 30, 32, 33, 34, 36, 37, 39)
- Viability theory and Moreau's sweeping process (existence of solutions of differential inclusions with state constraints, papers # 13, 26, 31, 42, 47)
- Analysis of uncertain systems (deterministic perturbation: papers # 15, 19, 24; probabilistic approach for deterministic perturbations: papers # 25, 28)
- The regularity of the minimum time function and its numerical approximation (# 35, 38, 44, 46, 48, 49).
- Control of the sweeping process (papers # 42, 50, 51, 52, F).

Other activities

- Referee for several international journals, including *Proc. Amer. Math. Soc., SIAM J. Contr., Set-Val. Var. Anal., Nonlin. Anal., J. Convex Anal., J. Diff. Equat., J. Math. Anal. Appl., J. London Math. Soc., Zeitschr. Anal. Anwend., Topol. Meth. Nonlin. Anal., J. Dynamics Control Sys., JOTA, IEEE TAC*; reviewer for *Mathematical Reviews.*

List of publications.

52) Ch. E. Arroud, G. Colombo, A Pontryagin maximum principle for the controlled sweeping process, *Set-Val. Variat. Anal.*, in print, DOI 10.1007/s11228-017-0400-4.

51) G. Colombo, M. Palladino, The minimum time function for the controlled Moreau's sweeping process, *SIAM J. Control* 54 (2016), 2036-2062.

50) G. Colombo, R. Henrion, Nguyen D. Hoang, B. S. Mordukhovich, Optimal control of the sweeping process: the polyhedral case, *J. Differential Eqs.* 260 (2016), 3397-3447.

49) G. Colombo, Luong V. Nguyen, Differentiability properties of the minimum time function for normal linear systems, *J. Math. Anal. Appl.* 429 (2015), 143-174.

48) G. Colombo, Thuy T.T. Le, Higher order discrete controllability and the approximation of the minimum time function, *Discr. Cont. Dyn. Systems Ser. A* 35 (2015), 4293-4322.

47) G. Colombo, R. Henrion, Nguyen D. Hoang, B. S. Mordukhovich, Discrete approximations of a controlled sweeping process, *Set-Valued Variat. Anal.* 23 (2015), 69-86.

46) G. Colombo, Khai T. Nguyen, Luong V. Nguyen, Non-Lipschitz points and the SBV regularity of the minimum time function, *Calc. Var. PDE's* DOI 10.1007/s00526-013-0682-9 (2013), 51 (2014), 439-463.

45) G. Colombo, V. V. Goncharov, Brownian motion and exposed solutions of differential inclusions (Dedicated to A. Cellina for his 70th birthday), *NoDEA* 20 (2013), 323-343.

44) G. Colombo, Khai T. Nguyen, On the minimum time function around the origin, *Mathematics of Control and Related Fields* 3 (2013), 51-82.

43) G. Colombo, A. Marigonda, P. Wolenski, The Clarke generalized gradient for functions whose epigraph has positive reach, *Mathematics of Operations Research* 38 (2013), 451-468.

42) G. Colombo, R. Henrion, Nguyen D. Hoang, B. S. Mordukhovich, Optimal control of the sweeping process, *Dynamics of Continuous, Discrete and Impulsive Systems – B* 19 (2012), 117-159.

41) G. Colombo, M. Fečkan, B. M. Garay, Inflated deterministic chaos and Smale's horseshoe, *J. Difference Eq. Applic.* iFirst article (2011), 1-18, DOI: 10.1080/10236198.2010.510139.

40) G. Colombo, V. Goncharov, B. Mordukhovich, Well-posedness of minimal time problems with constant dynamics in Banach spaces, *Set-Valued Variat. Anal.* 18 (2010), 349-372.

39) G. Colombo, L. Thibault, Prox-regular sets and applications, in *Handbook of Nonconvex Analysis*, D.Y. Gao, D. Motreanu eds., International Press (2010), ISBN: 978-1-57146-200-8.

38) G. Colombo, Khai T. Nguyen, On the structure of the minimum time function, *SIAM J. Control* 48 (2010), 4776-4814.

37) G. Colombo, Khai T. Nguyen, Quantitative isoperimetric inequalities for a class of nonconvex sets, *Calc. Var. PDE's* 37 (2010), 141-166, DOI: 10.1007/s00526-009-0256-z.

36) G. Colombo, M. Fečkan, B. Garay, Multivalued perturbations of a saddle dynamics, *Diff. Eq. Dyn. Syst.* 18 (2010), 29-56.

35) G. Colombo, A. Marigonda, Singularities for a class of non-convex sets and functions, and viscosity solutions of some Hamilton-Jacobi equations, *J. Convex Anal.* 15 (2008), 105-129.

34) G. Colombo, A. Marigonda, P. Wolenski, Some new regularity properties for the minimal time function, *Siam J. Control* 44 (2006), 2285-2299.

33) G. Colombo, A. Marigonda, Differentiability properties for a class of non-Lipschitz functions, *Calc. Var. PDE's* 25 (2006), 1-31.

32) G. Colombo, P. R. Wolenski, Variational analysis for a class of minimal time functions in Hilbert spaces, *J. Convex Analysis* 11 (2004), 335-361.

31) G. Colombo, P.R. Wolenski, The subgradient formula for the minimal time function in the case of constant dynamics in Hilbert space, *J. Global Optimization* 3-4 (2004) 269-282.

30) G. Colombo, P. Dai Pra, V. Křivan, I. Vrkoč, Stochastic processes for bounded noise, *Mathematics of Control, Signals, and Systems (MCSS)* 16 (2003), 95-119.

29) G. Colombo, M. D.P. Monteiro Marques, Sweeping by a continuous φ-convex set, *J. Differ. Equations* 187 (2003), 46-72.

28) G. Colombo, V. Goncharov, Continuous selections via geodesics, *Topological Methods in Nonlin. Anal.* 18 (2001), 171-182.

27) G. Colombo, P. Dai Pra, A class of piecewise deterministic Markov processes, *Markov Processes and Related Fields*, 7 (2001), 251-287.

26) G. Colombo, V. Goncharov, Variational inequalities and regularity properties of closed sets in Hilbert spaces, *J. Convex Anal.* 8 (2001), 197-222.

25) G. Colombo, V. Goncharov, The sweeping processes without convexity, *Set-Valued Anal.* 7 (1999), 357-374.

24) V. Křivan, G. Colombo, A non-stochastic approach for modeling uncertainty in population dynamics, *Bull. Math. Biol.* 60 (1998), 721-751.

23) T. Cardinali, G. Colombo, F. Papalini, M.Tosques, On a class of evolution equations without convexity, *Nonlinear Analysis: Theory, Meth. Appl.* 28 (1997), 217-234.

22) G. Colombo, V. Goncharov, E. Ramazzina, On a class of nonconvex and nonlinear optimal control problems, *Nonlinear Diff. Equations and Appl. (NoDEA)* 3 (1996), 115-126.

21) G. Colombo, V. Goncharov, Existence for a non-convex optimal control problem with a nonlinear dynamics, *Nonlinear Analysis: Theory, Meth. Appl.* 24 (1995), 795-800.

20) G. Colombo, B. Garay, Existence results for infinite dimensional differential equations without compactness, *Rend. Sem. Mat. Univ. Padova* XCII (1994), 127-133.

19) G. Colombo, V. Křivan, Robustness of viability controllers under small perturbations, *J. of Optimization Theory and Appl.* 83 (1994), 207-215.

18) A. Bressan, G. Colombo, Boundary value problems for lower semicontinuous differential inclusions, *Funkcial. Ekvac.* 36 (1993), 359-373.

17) G. Colombo, V. Křivan, A viability algorithm, *J. Diff. Equations* 102 (1993), 236-243.

16) G. Colombo, On extremal solutions of differential inclusions, *Bull. Polish Acad. Sci.*, 40 (1992), 97-109.

15) G. Colombo, V. Křivan, Fuzzy differential inclusions and nonprobabilistic likelihood, *Dynamic Systems and Applications* 1 (1992), 419-440.

14) A. Bressan, G. Colombo, Selections and representations of multifunctions in paracompact spaces, *Studia Math.* 103 (1992), 209-216.

13) G. Colombo, Weak flow-invariance for non-convex differential inclusions, *Differential and Integral Equations* 5, (1992), 173-180.

12) G. Colombo, M. Tosques, Multivalued perturbations for a class of nonlinear evolution equations, *Ann. di Mat. Pura Appl.* CLX (1991).

11) F. Ancona, G. Colombo, Existence of solutions for a class of non-convex differential inclusions, *Rend. Sem. Mat. Univ. Padova* 83 (1990), 71-76.

10) A. Bressan, G. Colombo, Existence and continuous dependence for discontinuous O.D.E.'s, *Boll. Un. Mat. Ital.* (7) 4-B (1990), 295-311.

9) A.Cellina, G. Colombo, On a classical problem of the calculus of variations without convexity assumptions, *Ann. Inst. H. Poincaré, Analyse Nonlinéaire* 7 (1990), 97-106.

8) A.Cellina, G. Colombo, An existence result for differential inclusions with non-convex right-hand side, *Funkcial. Ekvac.* 32 (1989), 407-416.

7) A.Bressan, A. Cellina, G. Colombo, Upper semicontinuous differential inclusions without convexity, *Proc. Am. Math Soc.* 106 (1989), 771-775.

6) G. Colombo, Approximate and relaxed solutions of differential inclusions, *Rend. Sem. Matem. Univ. Padova* 81 (1989), 229-238.

5) A. Bressan, G. Colombo, Generalized Baire category and differential inclusions in Banach spaces, *Journal Differ. Equat.* 76 (1988),135-158.

4) A. Bressan, G. Colombo, Extensions and selections of maps with decomposable values, *Studia Mathematica* 90 (1988), 69-86.

3) G. Colombo, A. Fonda, A. Ornelas, Lower semicontinuous perturbations of maximal monotone differential inclusions, *Isr. J. Mathematics* 61 (1988), 211-218.

2) A. Cellina, G. Colombo, A. Fonda, A continuous version of Liapunov's convexity theorem, *Ann. Inst. H. Poincaré, Analyse Nonlinéaire* 5 (1988), 23-36.

1) A. Cellina, G. Colombo, A. Fonda, Approximate selections and fixed points for upper semicontinuous maps with decomposable values, *Proc. Am. Math. Soc.* 98 (1986), 663- 666.

PROCEEDINGS

A) G. Colombo, Directionally continuous selections and lower semicontinuous differential inclusions, ottobre 1991, in "Set-valued analysis and differential inclusions", ed. A. B. Kurzhanski e V. M. Veliov, Birkhäuser, Basel (1993), 61-73.

B) G. Colombo, A class of upper semicontinuous differential inclusions without convexity, in "Proceedings of World Congress of Nonlinear Analysts", ed. V. Lakshmikantham, De Gruyter (1996), 2107-2113.

C) G. Colombo, V. Goncharov, The sweeping processes without convexity, in "International Conference on Differential Equations, Vol. 1, 2 (Berlin, 1999)" (Proceedings of EQUADIFF 99), World Sci. Publ., River Edge, NJ (2000), 494-496.

D) G. Colombo, P.R. Wolenski, Subdifferential and regularity properties of the minimum time function: an analysis for a constant dynamics in finite dimensions, Proceedings of the Conference on Decision and Control, Las Vegas (2002), 1117-1122.

E) G. Colombo, P.R. Wolenski, The subgradient formula for the minimal time function with linear dynamics and convex target, Proceedings of the IFAC Conference on Intelligent control systems and signal processing, Faro (2003), 6 pp.

F) Ch.E. Arroud and G. Colombo, Necessary conditions for a nonclassical control problem with state constraints, IFAC PAPERSONLINE Proceeding of 20th IFAC World Congress, Toulouse (2017), 6 pp.

LECTURE NOTES:

I) G. Colombo, Notes on differential equations under Carathéodory conditions (from the lectures delivered at S.I.S.S.A., academic year 1989-90), S.I.S.S.A., SEPTEMBER 1990 (62 pp.).

OTHER PUBLICATIONS:

I) G. Colombo, C. Mariconda, F. Rampazzo, G. Treu, Preface *NoDEA* 20 (2013), 149-150.