
References

- AM78. Abraham, R., Marsden, J.: Foundations of Mechanics. Benjamin, Reading, (1978)
- AMR88. Abraham, R., Marsden, J., Ratiu, T.: Manifolds, Tensor Analysis and Applications. Springer, New York, (1988)
- AS92. Abraham, R., Shaw, C.: Dynamics: the Geometry of Behavior. Addison-Wesley, Reading, (1992)
- AGM97. Alekseevsky, D., Grabowski, J., Marmo, G., Michor, P.W.: Completely integrable systems: a generalization. Mod. Phys. Let. A, **12**(22), 1637–1648, (1997)
- AGM94. Alekseevsky, D.V., Grabowski, J., Marmo, G., Michor, P.W.: Poisson structures on the cotangent bundle of a Lie group or a principle bundle and their reductions. J. Math. Phys., **35**, 4909–4928, (1994)
- AAM76. Anderson, B.D., Arbib, M.A., Manes, E.G.: Foundations of System Theory: Finitary and Infinitary Conditions. Lecture Notes in Economics and Mathematical Systems Theory, Springer, New York, (1976)
- Arb98. Arbib, M. (ed.): Handbook of Brain Theory and Neural Networks (2nd ed.). MIT Press, Cambridge, (1998)
- Arn89. Arnold, V.I.: Mathematical Methods of Classical Mechanics (2nd ed). Springer, New York, (1989)
- Bae97. Baez, J.: An introduction to n -categories. 7th Conference on Category Theory and Computer Science, E. Moggi and G. Rosolini (eds), Lecture Notes in Computer Science, Springer, Berlin, (1997)
- BD98. Baez, J., Dolan, J.: Higher-Dimensional Algebra III: n -categories and the Algebra of Opetopes. Adv. Math. **135**(2), 145–206, (1998)
- BD95. Baez, J., Dolan, J.: Higher dimensional algebra and topological quantum field theory. J. Math. Phys. **36**, 6073–6105, (1995)
- Bah88. Bahri, A.: Pseudo-orbits of contact forms. Pitman Research Notes in Mathematics Series, **173**, Longman Scientific and Technical, (1988)

- BH96. Banaszuk, A., Hauser, J.: Approximate feedback linearization: a homotopy operator approach. *SIAM J. Cont. & Optim.*, **34**(5), 1533–1554, (1996)
- Bar93. Barry Jay, C. : Matrices, Monads and the Fast Fourier Transform. Univ. Tech., Sidney, (1993)
- BO95. Basar, T., Olsder, G.J.: *Dynamic Noncooperative Game Theory* (2nd ed.), Academic Press, (1995)
- BGG89. Batlle, C., Gomis, J., Gràcia, X., Pons, J.M.: Noether's theorem and gauge transformations: application to the bosonic string and CP_2^{n-1} model. *J. Math. Phys.* **30**, 1345, (1989)
- Bau00. Baum, H.: Twistor and Killing spinors on Lorentzian manifolds and their relations to CR and Kaehler geometry. *International Congress on Differential Geometry in memory of Alfred Gray, Bilbao, Spain*, (2000)
- BK92. Berleant, D., Kuipers, B.: Qualitative–Numeric Simulation with Q3, in *Recent Advances in Qualitative Physics*. eds. Boi Faltings and Peter Struss, MIT Press, Cambridge, (1992)
- Ben67. Bénabou, J. : Introduction to bicategories. In: *Lecture Notes in Mathematics*. Springer, New York, (1967)
- BR78. Birkhoff, G., Rota, G.C.: *Ordinary Differential Equations* (3rd ed.) Wiley, New York, (1978)
- BL81. Bishop, R.L., Goldberg, S.I.: *Tensor Analysis on Manifolds*. Dover, (1981)
- BL92. Blackmore, D., Leu, M.C.: Analysis of swept volumes via Lie group and differential equations. *Int. J. Rob. Res.*, **11**(6), 516–537, (1992)
- BPS98. Blackmore, D.L., Prykarpatsky, Y.A., Samulyak, R.V.: The Integrability of Lie-invariant Geometric Objects Generated by Ideals in the Grassmann Algebra. *J. Nonlin. Math. Phys.*, **5**(1), 54–67, (1998)
- Bon95. Bontempi, G.: Modelling with uncertainty in continuous dynamical systems: the probability and possibility approach. *IRIDIA - ULB Technical Report*, 95–16, (1995)
- Boo86. Boothby, W.M.: *An Introduction to Differentiable Manifolds and Riemannian Geometry*, Academic Press, New York, (1986)
- Bro01. Brockett, R.: New Issues in the Mathematics of Control. In *Mathematics Unlimited – 2001 and Beyond*, Springer, New York, (2001)
- BGG03. Bryant, R., Griffiths, P., Grossman, D.: *Exterior Differential Systems and Euler–Lagrange Partial differential Equations*. Univ. Chicago Press, Chicago, (2003)
- CCC97. Caiani, L., Casetti, L., Clementi, C., Pettini, M.: Geometry of dynamics, Lyapunov exponents and phase transitions. *Phys. Rev. Lett.* **79**, 4361 (1997)
- CC99. Cao, H.D., Chow, B.: Recent Developments on the Ricci Flow. *Bull. Amer. Math. Soc.* **36**, 59–74, (1999)
- CHP96. Channon, P., Hopkins, S. and Pham, D.: A variational approach to the optimization of gait for a bipedal robot. *J. Mech. Eng. Sci.*, **210**, 177–186, (1996)

- CD98. Chen, G., Dong, X.: From Chaos to Order: Methodologies, Perspectives and Application. World Scientific, Singapore, (1998)
- CL84. Cheng, T.-P., Li, L.-F.: Gauge Theory of Elementary Particle Physics. Clarendon Press, Oxford, (1984)
- Che55. Chevalley, C.: Theorie differential equations groupes de Lie. vol. 1–3. Hermann D.C., Paris, (1955)
- BM82. Choquet-Bruhat, Y., DeWitt-Morete, C.: Analysis, Manifolds and Physics (2nd ed). North-Holland, Amsterdam, (1982)
- BM00. Choquet-Bruhat, Y., DeWitt-Morete, C.: Analysis, Manifolds and Physics, Part II: 92 Applications (rev. ed). North-Holland, Amsterdam, (2000)
- CP02. Clementi, C. Pettini, M.: A geometric interpretation of integrable motions. *Celest. Mech. & Dyn. Astr.*, **84**, 263–281, (2002)
- CH64. Conway, E.D., Hopf, E.: Hamilton’s Theory and Generalized Solutions of the Hamilton–Jacobi Equation. *J. Math. Mech.* **13**, 939–986, (1964)
- Cox92. Cox, E.: Fuzzy Fundamentals, *IEEE Spectrum*, 58–61, (1992)
- Cox94. Cox, E.: The Fuzzy Systems Handbook. AP Professional, (1994)
- CF94. Crane, L., Frenkel, I.: Four dimensional topological quantum field theory, Hopf categories, and the canonical bases. *Jour. Math. Phys.* **35**, 5136–5154, (1994)
- Dar. Dariush, B.: Forward dynamics solutions to multi-modal inverse dynamics problems. In *Proc. ISB’03*, Univ. Otago, Dunedin, NZ, (2003)
- Dav89. Davies, E.B.: Heat Kernels and Spectral Theory. Cambridge Univ. Press, Cambridge, (1989)
- Dav81. Davydov, A.S.: Biology and Quantum Mechanics, Pergamon Press, New York, (1981)
- Dav91. Davydov, A.S.: Solitons in Molecular Systems. (2nd ed), Kluwer, Dordrecht, (1991)
- DEF99. Deligne, P., Etingof, P., Freed, D.S., Jeffrey, L.C., Kazhdan, D., Morgan, J.W., Morrison, D.R., Witten, E.: Quantum Fields and Strings: A Course for Mathematicians, *Am. Math. Soc.*, (1999)
- DRh84. De Rham, G.: Differentiable Manifolds. Springer, Berlin, (1984)
- Die69. Dieudonne, J.A.: Foundations of Modern Analysis (in four volumes). Academic Press, New York, (1969)
- Die88. Dieudonne, J.A.: A History of Algebraic and Differential Topology 1900–1960. Birkhäuser, Basel, (1988)
- Dir30. Dirac, P.A.M.: The Principles of Quantum Mechanics, Oxford Univ. Press, Oxford, (1930)
- Dir50. Dirac, P.A.M.: Generalized Hamiltonian dynamics. *Can. J. Math.*, **2**, 129–148, (1950)
- Dir58. Dirac, P.A.M.: Generalized Hamiltonian dynamics. *Proc. Roy. Soc. A* **246**, 326–332, (1958)

- DP97. Dodson, C.T.J., Parker, P.E.: A User's Guide to Algebraic Topology. Kluwer, Dordrecht, (1997)
- DG03. Dragovic, V., Gajic, B.: The Wagner Curvature Tensor in Nonholonomic Mechanics. *Reg. Chaot. Dyn.*, **8**(1), 105–124, (2003)
- DP80. Dubois, D., Prade, H.: Fuzzy Sets and Systems. Academic Press, New York, (1980)
- EG91. Eastwood, M.G., Graham, C.R.: Invariants of conformal densities. *Duke Math. Jour.* **63**, 633–671, (1991)
- Eas02. Eastwood, M.: Higher symmetries of the Laplacian. *arXiv hep-th/0206233*, (2002)
- Ecc64. Eccles, J.C.: The Physiology of Synapses. Springer, Berlin, (1964)
- EIS67. Eccles, J.C., Ito M., Szentagothai J.: The Cerebellum as a Neuronal Machine. Springer, Berlin, (1967)
- Elk99. Elkin, V.I.: Reduction of Nonlinear Control Systems. A Differential Geometric Approach, Kluwer, Dordrecht, (1999)
- Elw82. Elworthy, K.D. Stochastic Differential Equations on Manifolds. Cambridge Univ. Press, Cambridge, (1982)
- Fey48. Feynman, R.P.: Space-time Approach to Nonrelativistic Quantum Mechanics. *Rev. Mod. Phys.* **20**, 367–387, (1948)
- Fey51. Feynman, R.P.: An Operator Calculus having Applications in Quantum Electrodynamics. *Phys. Rev.* **84**, 108–128, (1951)
- FH65. Feynman, R.P., Hibbs, A.R.: Quantum Mechanics and Path Integrals, McGraw-Hill, New York, (1965)
- Fey72. Feynman, R.P.: Statistical Mechanics, A Set of Lectures. WA Benjamin, Inc., Reading, Massachusetts, (1972)
- Fey98. Feynman, R.P.: Quantum Electrodynamics. Advanced Book Classics, Perseus Publishing, (1998)
- Fla63. Flanders, H.: Differential Forms: with Applications to the Physical Sciences. Acad. Press, (1963)
- Flo88. Floer, A.: Morse theory for Lagrangian intersections. *J. Diff. Geom.*, **28**(9), 513–517, (1988)
- For60. Forsyth, A.R.: Calculus of Variations. Dover, New York, (1960)
- Gar85. Gardiner, C.W.: Handbook of Stochastic Methods for Physics, Chemistry and Natural Sciences (2nd ed). Springer, Berlin, (1985)
- Ghe90. Ghez, C.: Introduction to motor system. In: Kandel, E.K. and Schwarz, J.H. (eds.) Principles of neural science. 2nd ed. Elsevier, Amsterdam, 429–442, (1990)
- GM97. Giachetta, G., Mangiarotti, L., Sardanashvily, G.: New Lagrangian and Hamiltonian Methods in Field theory. World Scientific, Singapore, (1997)
- Gol80. Goldstein, H.: Classical mechanics. Addison-Wesley, Reading, (1980)
- Gom94. Gómez, J.C.: Using symbolic computation for the computer aided design of nonlinear (adaptive) control systems. Tech. Rep. EE9454, Dept. Electr. and Comput. Eng., Univ. Newcastle, Callaghan, NSW, AUS, (1994)

- Goo98. Goodwine, J.W.: Control of Stratified Systems with Robotic Applications. PhD thesis, California Institute of Technology, Pasadena, California, (1998)
- Gre96. Greene, B.R. : String Theory on Calabi-Yau Manifolds. Lectures given at the TASI-96 summer school on Strings, Fields and Duality, (1996)
- Gri83a. Griffiths, P.A.: Exterior Differential Systems and the Calculus of Variations, Birkhauser, Boston, (1983)
- Gri83b. Griffiths, P.A.: Infinitesimal variations of Hodge structure. III. Determinantal varieties and the infinitesimal invariant of normal functions. *Compositio Math.*, **50**(2-3), 267–324, (1983)
- GJ94. van Groesen, E., De Jager E.M.: (Editors) Mathematical Structures in Continuous Dynamical Systems. Studies in Mathematical Physics, vol. 6 North-Holland, Amsterdam, (1994)
- Gro82. Grossberg, S.: Studies of Mind and Brain. Dordrecht, Holland, (1982)
- Gun03. Gunion, J.F.: Class Notes on Path-Integral Methods. U.C. Davis, 230B, 2003.
- Hak93. Haken, H.: Advanced Synergetics: Instability Hierarchies of Self-Organizing Systems and Devices (3rd ed.). Springer, Berlin, (1993)
- Hak02. Haken, H.: Brain Dynamics, Synchronization and Activity Patterns in Pulse-Coupled Neural Nets with Delays and Noise, Springer, New York, (2002)
- Ham82. Hamilton, R.S.: Three-manifolds with positive Ricci curvature, *J. Differential Geom.* **17**, 255–306, (1982)
- Has98. Has, S.: Humanoid robots in Waseda University: Hadaly-2 and Wabian. In IARP First International Workshop on Humanoid and Human Friendly Robotics, 1–2, Waseda Univ., Waseda, (1998)
- Hat02. Hatcher, A. Algebraic Topology. Cambridge Univ. Press, Cambridge, (2002)
- Hat77a. Hatze, H.: A myocybernetic control model of skeletal muscle. *Biol. Cyber.* **25**, 103–119, (1977)
- Hat77b. Hatze, H.: A complete set of control equations for the human musculoskeletal system. *J. Biomech.* **10**, 799–805, (1977b)
- Hat78. Hatze, H.: A general myocybernetic control model of skeletal muscle. *Biol. Cyber.*, **28**, 143–157, (1978)
- HSK92. Hauser, J., Sastry, S., Kokotovic, P.: Nonlinear control via approximate input–output linearization: The ball and beam example, *IEEE Trans. Aut. Con.*, AC–37, 392–398, (1992)
- Heb49. Hebb, D.O.: The Organization of Behaviour. Wiley, New York, (1949)
- Hel01. Helgason, S.: Differential Geometry, Lie Groups and Symmetric Spaces. (2nd ed.) American Mathematical Society, Providence, RI, (2001)
- Hil38. Hill, A.V.: The heat of shortening and the dynamic constants of muscle, *Proc. R. Soc. B*, **76**, 136–195, (1938)

- Hir76. Hirsch, M.W.: Differential Topology. Springer, New York, (1976)
- HH52. Hodgkin, A.L., Huxley, A.F.: A quantitative description of membrane current and application to conduction and excitation in nerve. *J. Physiol.*, **117**, 500–544, (1952)
- Hod64. Hodgkin, A.L.: The Conduction of the Nervous Impulse. Liverpool Univ. Press, Liverpool, (1964)
- Hou79. Houk, J.C.: Regulation of stiffness by skeletomotor reflexes. *Ann. Rev. Physiol.*, **41**, 99–114, (1979)
- HBB96. Houk, J.C., Buckingham, J.T., Barto, A.G.: Models of the cerebellum and motor learning. *Behavioral and Brain Sciences*, **19**(3), 368–383, (1996)
- Hux57. Huxley, A.F.: Muscle structure and theories of contraction. *Progr. Biophys. Chem.*, **7**, 255–328, (1957)
- HN54. Huxley, A.F., Niedergerke, R.: Changes in the cross-striations of muscle during contraction and stretch and their structural interpretation. *Nature*, **173**, 973–976, (1954)
- HT93. Hunt, L, Turi, J.: A new algorithm for constructing approximate transformations for nonlinear systems. *IEEE Trans. Aut. Con.*, AC-38, 1553–1556, (1993)
- Hur93. Hurmuzlu, Y.: Dynamics of bipedal gait. *J. Appl. Mech.*, **60**, 331–343, (1993)
- IN92. Igarashi, E., Nogai, T.: Study of lower level adaptive walking in the sagittal plane by a biped locomotion robot. *Advanced Robotics*, **6**, 441–459, (1992)
- Ing97. Ingber, L.: Statistical mechanics of neocortical interactions: Applications of canonical momenta indicators to electroencephalography, *Phys. Rev. E*, **55**(4), 4578–4593, (1997)
- Ing98. Ingber, L.: Statistical mechanics of neocortical interactions: Training and testing canonical momenta indicators of EEG, *Mathl. Computer Modelling* **27**(3), 33–64, (1998)
- Isi89. Isidori, A.: Nonlinear Control Systems. An Introduction, (2nd ed) Springer, Berlin, (1989)
- Ito60. Ito, K.: Wiener Integral and Feynman Integral. *Proc. Fourth Berkeley Symp. Math., Stat., Prob.*, **2**, 227–238, (1960)
- IS01. Ivancevic, V., Snoswell, M.: Fuzzy-stochastic functor machine for general humanoid-robot dynamics. *IEEE Trans. on Sys, Man, Cyber. B*, **31**(3), 319–330, (2001)
- Iva02. Ivancevic, V.: Generalized Hamiltonian biodynamics and topology invariants of humanoid robots. *Int. J. Mat. Mat. Sci.*, **31**(9), 555–565, (2002)
- Iva04. Ivancevic, V.: Symplectic Rotational Geometry in Human Biomechanics. *SIAM Rev.*, **46**(3), 455–474, (2004)
- IB05. Ivancevic, V., Beagley, N.: Brain-like functor control machine for general humanoid biodynamics. *Int. J. Math. Math. Sci.* (to appear) (2005)
- Iva05. Ivancevic, V.: Dynamics of Humanoid Robots: Geometrical and Topological Duality. To appear in *Biomathematics: Modelling and simulation* (ed. J.C. Misra), World Scientific, Singapore, (2005)

- IP01a. Ivancevic, V., Pearce, C.E.M.: Poisson manifolds in generalised Hamiltonian biomechanics. *Bull. Austral. Math. Soc.* **64**, 515–526, (2001)
- IP01b. Ivancevic, V., Pearce, C.E.M.: Topological duality in humanoid robot dynamics. *ANZIAM J.* **43**, 183–194, (2001)
- IP05b. Ivancevic, V., Pearce, C.E.M.: Hamiltonian dynamics and Morse topology of humanoid robots. *Gl. J. Mat. Math. Sci.* (to appear) (2005)
- Iva91. Ivancevic, V.: *Introduction to Biomechanical Systems: Modelling, Control and Learning* (in Serbian). Scientific Book, Belgrade, (1991)
- ILI95. Ivancevic, V., Lukman, L., Ivancevic, T.: *Selected Chapters in Human Biomechanics. Textbook* (in Serbian). Univ. Novi Sad Press, Novi Sad, (1995)
- IS00. Ivancevic, V., Snoswell, M.: *Torson Sports Cybernetics*. Torson Group. Inc., Adelaide, (2000)
- IJB99a. Ivancevic, T., Jain, L.C., Bottema, M.: New Two-feature GBAM–Neurodynamical Classifier for Breast Cancer Diagnosis, *Proc. from KES’99*, IEEE Press, (1999)
- IJB99b. Ivancevic, T., Jain, L.C., Bottema, M.: A New Two-Feature FAM–Matrix Classifier for Breast Cancer Diagnosis, *Proc. from KES’99*, IEEE Press, (1999)
- Kac51. Kac, M.: On Some Connection between Probability Theory and Differential and Integral Equations. *Proc. 2nd Berkeley Sympos. Math. Stat. and Prob.*, 189–215, (1951)
- KE83. Kadic, A., Edelen, D.G.B.: *A Gauge theory of Dislocations and Disclinations*, New York, Springer, (1983)
- Kal60. Kalman, R.E.: A new approach to linear filtering and prediction problems. *Transactions of the ASME, Ser. D, J. Bas. Eng.*, **82**, 34–45, (1960)
- Kan58. Kan, D.M.: Adjoint Functors. *Trans. Am. Math. Soc.* **89**, 294–329, (1958)
- KV98. Katic, D., Vukobratovic, M.: A neural network-based classification of environment dynamics models for compliant control of manipulation robots. *IEEE Trans. Syst., Man, Cybern., B*, **28**(1), 58–69, (1998)
- KV03a. Katic, D., Vukobratovic, M.: *Advances in Intelligent Control of Robotic Systems*, Book series: Microprocessor-Based and Intelligent Systems Engineering, Kluwer Acad. Pub., Dordrecht, (2003)
- KV03b. Katic, D., Vukobratovic, M.: Survey of intelligent control techniques for humanoid robots. *J. Intel. Rob. Sys*, **37**, 117–141, (2003)
- Kla97. Klauder, J.R.: Understanding Quantization. *Found. Phys.* **27**, 1467–1483, (1997)
- Kla00. Klauder, J.R.: *Beyond Conventional Quantization*, Cambridge Univ. Press, Cambridge, (2000)
- Koc81. Kock, A.: *Synthetic Differential Geometry*, London Math.Soc. Lecture Notes Series No. 51, Cambridge Univ. Press, Cambridge, (1981)

- KR03. Kock, A., Reyes, G.E.: Some calculus with extensive quantities: wave equation. *Theory and Applications of Categories*, **11**(14), 321–336, (2003)
- KMS93. Kolar, I., Michor, P.W., Slovak, J.: *Natural Operations in Differential Geometry*. Springer, Berlin, (1993)
- KM97. Koon, W.S., Marsden, J.E.: The Hamiltonian and Lagrangian approaches to the dynamics of nonholonomic systems. *Reports on Math Phys.* **40**, 21–62, (1997)
- Kos92. Kosko, B.: *Neural Networks and Fuzzy Systems, A Dynamical Systems Approach to Machine Intelligence*. Prentice–Hall, New York, (1992)
- Kos96. Kosko, B.: *Fuzzy Engineering*. Prentice Hall, New York, (1996)
- Kre84. Krener, A.: Approximate linearization by state feedback and coordinate change, *Systems Control Lett.*, **5**, 181–185, (1984)
- LP94. Langer, J., Perline, R.: Local geometric invariants of integrable evolution equations, *J. Math. Phys.*, **35**(4), 1732–1737, (1994)
- LC03. Lebedev, L.P., Cloud, M.J.: *Tensor Analysis*. World Scientific, Singapore, (2003)
- Lee00. Lee, J.M.: *Introduction to Topological Manifolds*. Springer, New York, (2000)
- Lee02. Lee, J.M.: *Introduction to Smooth Manifolds*. New York, Springer, (2002)
- LR94. Leimkuhler, B.J., Reich, S.: Symplectic integration of constrained Hamiltonian systems. *Math. Comp.* **63**, 589–605, (1994)
- Lei02. Leinster, T.: A survey of definitions of n -category. *Theor. Appl. Categ.* **10**, 1–70, (2002)
- Lei03. Leinster, T.: *Higher Operads, Higher Categories*, London Mathematical Society Lecture Notes Series, Cambridge Univ. Press, Cambridge, (2003)
- Lei04. Leinster, T.: Operads in higher-dimensional category theory. *Theor. Appl. Categ.* **12**, 73–194, (2004)
- Lew95. Lewis, A.D.: *Aspects of Geometric Mechanics and Control of Mechanical Systems*. Technical Report CIT-CDS 95-017 for the Control and Dynamical Systems Option, California Institute of Technology, Pasadena, CA, (1995)
- LM97. Lewis, A. D. and Murray, R. M.: Controllability of simple mechanical control systems, *SIAM J. Con. Opt.*, **35**(3), 766–790, (1997)
- Lew98. Lewis, A.D.: Affine connections and distributions with applications to nonholonomic mechanics, *Reports on Mathematical Physics*, **42**(1/2), 135–164, (1998)
- Lew99. Lewis, A.D.: When is a mechanical control system kinematic?, in *Proceedings of the 38th IEEE Conf. Decis. Con.*, 1162–1167, IEEE, Phoenix, AZ, (1999)
- LM99. Lewis, A. D. and Murray, R. M.: Configuration controllability of simple mechanical control systems, *SIAM Review*, **41**(3), 555–574, (1999)

- Lew00a. Lewis, A.D.: Simple mechanical control systems with constraints, *IEEE Trans. Aut. Con.*, **45**(8), 1420–1436, (2000)
- LM87. Libermann, P., Marle, C.M.: *Symplectic Geometry and Analytical Mechanics*, Reidel, Dordrecht, (1987)
- Lie94. Lieh, J.: Computer oriented closed-form algorithm for constrained multibody dynamics for robotics applications. *Mechanism and Machine Theory*, **29**, 357–371, (1994)
- LR89. Lovelock, D., Rund, H.: *Tensors, Differential Forms, and Variational Principles*. Dover, (1989)
- Lu90. Lu, J.-H.: Multiplicative and affine Poisson structures on Lie groups. PhD Thesis, Berkeley Univ., Berkeley, (1990)
- Lu91. Lu, J.-H.: Momentum mappings and reduction of Poisson actions. in *Symplectic Geometry, Groupoids, and Integrable Systems*, eds.: P. Dazord and A. Weinstein, 209–225, Springer, New York, (1991)
- MacK86. MacKay, R.S.: Stability of equilibria of Hamiltonian systems. In *Nonlinear Phenomena and Chaos* (S. Sarkar, ed.), 254–270, Hilger, Bristol, (1986)
- MacL71. MacLane, S.: *Categories for the Working Mathematician*. Springer, New York, (1971)
- MS98. Mangiarotti, L., Sardanashvily, G.: *Gauge Mechanics*. World Scientific, Singapore, (1998)
- Man98. Manikonda, V.: Control and Stabilization of a Class of Nonlinear Systems with Symmetry. PhD Thesis, Center for Dynamics and Control of Smart Structures, Harvard Univ., Cambridge, (1998)
- Mar98. Marieb, E.N.: *Human Anatomy and Physiology*. (4th ed.), Benjamin/Cummings, Menlo Park, CA, (1998)
- MS95. Marmo, G., Simoni, A., Stern, A.: Poisson Lie group symmetries for the isotropic rotator. *Int. J. Mod. Phys. A* **10**, 99–114, (1995)
- MR99. Marsden, J.E., Ratiu, T.S.: *Introduction to Mechanics and Symmetry: A Basic Exposition of Classical Mechanical Systems*. (2nd ed), Springer, New York, (1999)
- Mas02. Mascalchi, M. *et al.*: Proton MR Spectroscopy of the Cerebellum and Pons in Patients with Degenerative Ataxia, *Radiology*, **223**, 371 (2002)
- May81. Mayer, P.A.: *A Differential Geometric Formalism for the Ito Calculus*. *Lecture Notes in Mathematics*, vol. 851, Springer, New York, (1981)
- McC60. McConnell, A.J.: *Applications of Tensor Analysis* (2nd ed). Dover, (1960)
- MS00. Meyer, K.R., Schmidt, D.S.: From the restricted to the full three-body problem. *Trans. Amer. Math. Soc.*, **352**, 2283–2299, (2000)
- MH92. Meyer, K.R., Hall, G.R.: *Introduction to Hamiltonian Dynamical Systems and the N-body Problem*. Springer, New York, (1992)
- Mic01. Michor, P.W.: *Topics in Differential Geometry*. Lecture notes of a course in Vienna, (2001)

- Mil99. Milinković, D.: Morse homology for generating functions of Lagrangian submanifolds. *Trans. Amer. Math. Soc.* **351**(10), 3953–3974, (1999)
- Mil65. Milnor, J.: *Lectures on the H–Cobordism Theorem*. Math. Notes. Princeton Univ. Press, Princeton, (1965)
- Mil63. Milnor, J.: *Morse Theory*. Princeton Univ. Press, Princeton, (1963)
- MTW73. Misner, C.W., Thorne, K.S., Wheeler, J.A.: *Gravitation*. Freeman, San Francisco, (1973)
- MS78. Modugno, M., Stefani, G.: Some results on second tangent and cotangent spaces. *Quadern dell’ Istituto di Matematica dell’ Universit a di Lecce Q.*, **16**, (1978)
- MS03. Moroianu, A., Semmelmann, U.: Twistor forms on Kähler manifolds. *Ann. Scuola Norm. Sup. Pisa Cl. Sci.* **2**(4), 823–845, (2003)
- Mor34. Morse, M.: *The Calculus of Variations in the Large*. Amer. Math. Soc. Coll. Publ. No. 18, Providence, RI, (1934)
- Mou80. Mountcastle, V.N.: *Medical physiology* (XIV ed.), C.V. Mosby Comp., St. Louis, (1980)
- Mur97. Murray, R.M.: *A Brief Introduction to Feedback Control*, CDS 110, California Institute of Technology, San Diego, (1997)
- MLS94. Murray, R.M., Li, X., Sastry, S.: *Robotic Manipulation*, CRC Press, Boca Raton, FL, (1994)
- Mus99. Mustafa, M.T.: Restrictions on harmonic morphisms. *Conformal Geometry and Dynamics* (AMS), **3**, 102–115, (1999)
- Nas83. Nash, C., Sen, S.: *Topology and Geometry for Physicists*. Academic Press, London, (1983)
- Nay73. Nayfeh, A.H., *Perturbation Methods*, Wiley, New York, (1973)
- NP77. Nicolis, G., Prigogine, I.: *Self–Organization in Nonequilibrium Systems: From Dissipative Structures to Order through Fluctuations*. Wiley Europe, (1977)
- NS90. Nijmeijer, H., Van der Schaft, A.J.: *Nonlinear Dynamical Control Systems*. Springer, New York, (1990)
- Nob62. Noble, D.: A modification of the Hodgkin–Huxley equations applicable to Purkinie fibre action and pace-maker potentials. *J. Physiol.*, **160**, 317–330, (1962)
- Olv86. Olver, P.J.: *Applications of Lie Groups to Differential Equations* (2nd ed.) Graduate Texts in Mathematics, vol. 107, Springer, New York, (1986)
- Pen67. Penrose, R.: Twistor algebra. *J. Math. Phys.*, **8**, 345–366, (1967)
- PR86. Penrose, R., Rindler, W.: *Spinors and Space-time II*. Cambr. Univ. Press, Cambridge, (1986)
- Pen89. Penrose, R.: *The Emperor’s New Mind*, Oxford Univ. Press, Oxford, (1989)
- Pet99. Petersen, P.: Aspects of Global Riemannian Geometry. *Bull. Amer. Math. Soc.*, **36**(3), 297–344, (1999)
- Pet98. Petersen, P.: *Riemannian Geometry*. Springer, New York, (1998)

- PI03. Pearce, C.E.M., Ivancevic, V.: A generalised Hamiltonian model for the dynamics of human motion. In *Differential Equations and Applications*, Vol. 2, Eds. Y.J. Cho, J.K. Kim and K.S. Ha, Nova Science, New York, (2003)
- PI04. Pearce, C.E.M., Ivancevic, V.: A qualitative Hamiltonian model for the dynamics of human motion. In *Differential Equations and Applications*, Vol. 3, Eds. Y.J. Cho, J.K. Kim and K.S. Ha, Nova Science, New York, (2004)
- PSS96. Pons, J.M., Salisbury, D.C., Shepley, L.C.: Gauge transformations in the Lagrangian and Hamiltonian formalisms of generally covariant theories. *arXiv gr-qc/9612037*, (1996)
- Pos86. Postnikov, M.M.: *Lectures in Geometry V, Lie Groups and Lie Algebras*, Mir Publ., Moscow, (1986)
- PV05. Potkonjak, V., Vukobratovic, M.: A generalized approach to modelling dynamics of human and humanoid motion, *Int. J. Adv. Robot. Sys.*, **2**(1), pp. 21-45, (2005)
- PP98. Pratt, J., Pratt, G.: Exploiting natural dynamics in the control of a planar bipedal walking robot. In *Proceedings of the 36 Annual Allerton Conference on Communication, Control, and Computing*, 739–748, Allerton, (1998)
- Pry96. Prykarpatsky, A.K.: Geometric models of the Blackmore's swept volume dynamical systems and their integrability, In: *Proc. of the IMACS-95, Hamburg 1995*, ZAMP, **247**(5), 720–724, (1996)
- Put93. Puta, M.: *Hamiltonian Mechanical Systems and Geometric Quantization*, Kluwer, Dordrecht, (1993)
- Ram90. Ramond, P.: *Field Theory: a Modern Primer*. Addison-Wesley, Reading, (1990)
- REB03. Rani, R., Edgar, S.B., Barnes, A.: Killing Tensors and Conformal Killing Tensors from Conformal Killing Vectors. *Class.Quant.Grav.*, **20**, 1929–1942, (2003)
- Ric93. Ricca, R.L.: Torus knots and polynomial invariants for a class of soliton equations, *Chaos*, **3**(1), 83–91, (1993)
- RV05. Rodic A., Vukobratovic M.: Contribution to the Integrated Control of Biped Locomotion Mechanisms Interacting With Dynamic Environment, *Int. J. Adv. Robot. Sys.*, (in press), (2005)
- Ryd96. Ryder, L.: *Quantum Field Theory*. Cambridge Univ. Press, (1996)
- SRB99. Sardain, P., Rostami, M., Bessonnet, G.: An anthropomorphic biped robot: dynamic concepts and technological design. *IEEE Trans. Syst. Man, Cyber. A*, **28**, 823–838, (1999)
- SI89. Sastry, S.S., Isidori, A.: Adaptive control of linearizable systems. *IEEE Trans. Aut. Con.*, **34**(11), 1123–1131, (1989)
- LGS. Lygeros, J., Godbole, D.N., Sastry, S.: Verified hybrid controllers for automated vehicles, *IEEE Trans. Aut. Con.*, **43**, 522–539, (1998)
- Sch98. Schaal, S.: Robot learning. In M. Arbib (ed). *Handbook of Brain Theory and Neural Networks* (2nd ed.), MIT Press, Cambridge, (1998)

- SA98. Schaal, S., Atkeson, C.G.: Constructive incremental learning from only local information. *Neural Comput.*, **10**, 2047–2084, (1998)
- Sch99. Schaal, S.: Is imitation learning the route to humanoid robots?. *Trends Cogn. Sci.*, **3**, 233–242, (1999)
- Sch93. Schwarz, M.: *Morse Homology*, Birkhäuser, Basel, (1993)
- ST95. Seiler, W.M., Tucker, R.W.: Involution and constrained dynamics I: The Dirac approach, *J. Phys. A*, **28**, 4431–4451, (1995)
- Sei95. Seiler, W.M.: Involution and constrained dynamics II: The Faddeev-Jackiw approach, *J. Phys. A*, **28**, 7315–7331, (1995)
- Sei99. Seiler, W.M.: Numerical integration of constrained Hamiltonian systems using Dirac brackets. *Math. Comp.*, **68**, 661–681, (1999)
- Sem02. Semmelmann, U.: Conformal Killing forms on Riemannian manifolds. *arXiv math.DG/0206117*, (2002)
- Ser89. Seraji, H.: Configuration control of redundant manipulators: theory and implementation. *IEEE Trans. Rob. Aut.*, **5**, 437–443, (1989)
- SBM96. Seward, D., Bradshaw, A. and Margrave, F.: The anatomy of a humanoid robot. *Robotica*. **14**, 437–443, (1996)
- SK98. Shabanov, S.V., Klauder, J.R.: Path Integral Quantization and Riemannian-Symplectic Manifolds. *Phys.Lett. B* **435**, 343–349, (1998)
- SGL93. Shih, C.L., Gruver, W. and Lee, T.: Inverse kinematics and inverse dynamics for control of a biped walking machine. *J. Robot. Syst.*, **10**, 531–555, (1993)
- SK93. Shih, C.L. and Klein, C.A.: An adaptive gait for legged walking machines over rough terrain. *IEEE Trans. Syst. Man, Cyber. A*, **23**, 1150–1154, (1993)
- SM71. Siegel, C.L., Moser, J.K.: *Lectures on Celestial Mechanics*, Springer, Berlin, (1971)
- Sma60. Smale, S.: The generalized Poincaré conjecture in higher dimensions, *Bull. Amer. Math. Soc.*, **66**, 373–375, (1960)
- Sma67. Smale, S.: Differentiable dynamical systems, *Bull. Amer. Math. Soc.*, **73**, 747–817, (1967)
- SMO02. Spooner, J.T., Maggiore, M., Ordóñez, R., Passino, K.M.: *Stable Adaptive Control and Estimation for Nonlinear Systems: Neural and Fuzzy Approximator Techniques*. Wiley, New York, (2002)
- Sti51. Steenrod, N.: *The Topology of Fibre Bundles*. Princeton Univ. Press, Princeton, (1951)
- Sto68. Stong, R.E.: *Notes on Cobordism Theory*. Princeton Univ. Press, Princeton, (1968)
- Stu99. Stuart, J.: *Calculus* (4th ed.). Brooks/Cole Publ., Pacific Grove, CA, (1999)
- Sun82. Sundermeyer, K.: *Constrained Dynamics*. Lecture Notes in Physics 169, Springer, New York, (1982)

- SW72. Sulanke, R., Wintgen P.: Differential geometry und faserbündel; bound 75, Veb. Deutscher Verlag der Wissenschaften, Berlin, (1972)
- Sus83. Sussmann, H.J.: Lie brackets and local controllability: a sufficient condition for scalar-input systems, *SIAM J. Con. Opt.*, **21**(5), 686–713, (1983)
- Sus87. Sussmann, H.J.: A general theorem on local controllability, *SIAM J. Con. Opt.*, **25**(1), 158–194, (1987)
- Swi75. Switzer, R.K.: Algebraic Topology – Homology and Homotopy. (in *Classics in Mathematics*), Springer, New York, (1975)
- SS78. Synge, J.L., Schild, A.: Tensor Calculus. Dover, (1978)
- Thi79. Thirring, W.: A Course in Mathematical Physics (in four volumes). Springer, New York, (1979)
- Tho79. Thorpe, J.A.: Elementary Topics in Differential Geometry. Springer, New York, (1979)
- TPS98. Tomlin, C., Pappas, G.J., Sastry, S.: Conflict resolution for air traffic management: A case study in multi-agent hybrid systems, *IEEE Trans. Aut. Con.*, **43**, 509–521, (1998)
- Sma99. Van der Smagt, P.: (ed.) Self-Learning Robots. Workshop: Brainstyle Robotics, IEE, London, (1999)
- Voi02. Voisin, C.: Hodge Theory and Complex Algebraic Geometry I. Cambridge Univ. Press, Cambridge, (2002)
- VJ69. Vukobratovic, M., Juricic, D.: Contribution to the synthesis of biped gait. *IEEE Trans. Biom. Eng.*, **16**(1), (1969)
- VJF70. Vukobratovic, M., Juricic, D., Frank, A.: On the control and stability of one class of biped locomotion systems. *ASME J. Basic Eng.*, **3**, 328–332, (1970)
- VFJ70. Vukobratovic, M., Juricic, D., Frank, A.: On the stability of biped locomotion. *IEEE Trans. Biom. Eng.*, **17**(1), 25–36, (1970)
- VS72. Vukobratovic, M., Stepanenko, Y.: On the stability of anthropomorphic systems. *Math. Biosci.* **15**, 1–37, (1972)
- VS73. Vukobratovic, M., Stepanenko, Y.: Mathematical models of general anthropomorphic systems. *Math. Biosci.* **17**, 191–242, (1973)
- Vuk75. Vukobratovic, M.: Legged Locomotion Robots and Anthropomorphic Mechanisms (in English). Mihailo Pupin, Belgrade, (1975); also published in Japanese, Nikkan Shimbun Ltd. Tokyo, (1975); in Russian, “MIR”, Moscow, (1976); in Chinese, Beijing, (1983)
- Vuk78. Vukobratovic, M.: Dynamics of Robots (in Japanese). Nikkan Shimbun Ltd, Tokyo, (1978)
- VP82. Vukobratovic, M., Potkonjak, V.: Scientific Fundamentals of Robotics, Vol. 1, Dynamics of Manipulation Robots: Theory and Application (in English), Springer-Verlag, (1982); also published in Japanese, extended version, Japanese Springer-Verlag, (1986); and in Chinese, Beijing, (1991)
- VS82. Vukobratovic, M., Stokic, D.: Scientific Fundamentals of Robotics, Vol. 2, Control of Manipulation Robots: Theory and

- Application (in English), Springer-Verlag, (1982); also published in Russian, "Nauka", Moskow, (1985); and in Chinese, Beijing, (1991)
- VK85a. Vukobratovic, M., Kircanski, M.: Scientific Fundamentals of Robotics, Vol. 3, Kinematics and Trajectories Synthesis of Manipulation Robots (in English), Springer-Verlag, (1985); also published in Chinese, Beijing, (1992)
- VK85b. Vukobratovic, M., Kircanski, N.: Scientific Fundamentals of Robotics, Vol. 4, Real-Time Dynamics of Manipulation Robots (in English), Springer-Verlag, (1985); also published in Chinese, Beijing, (1992)
- VSK85. Vukobratovic, M., Stokic, D., Kircanski, N.: Scientific Fundamentals of Robotics, Vol. 5, Non-Adaptive and Adaptive Control of Manipulation Robots (in English), Springer-Verlag, (1985); also published in Russian, "Mir", Moskow, (1988); and in Chinese, Beijing, (1993)
- VP85. Vukobratovic, M., Potkonjak, V.: Scientific Fundamentals of Robotics, Vol. 6, Applied Dynamics and CAD of Manipulation Robots, Springer-Verlag, (1985)
- VHI87. Vukobratovic, M., Hristic, D., Ivancevic, V.: DC-muscular hybrid joint control system. Proc. IX Int. Symp. External Control of Human Extremities, Dubrovnik, (1987)
- VBS89. Vukobratovic, M., Borovac, B., Surla, D., Stokic, D.: Scientific Fundamentals of Robotics, Vol. 7, Biped Locomotion: Dynamics, Stability, Control, and Applications. Springer-Verlag, Berlin, (1989)
- VPM03. Vukobratovic, M., Potkonjak, V., Matijevic, V.: Dynamics of Robots in Contact Tasks, Book series: Microprocessor-Based and Intelligent Systems Engineering, Kluwer Acad. Pub., Dordrecht, (2003)
- VB04. Vukobratovic, M., Borovac, B.: Zero-Moment Point – Thirty Five Years of its Life, *Int. J. Humanoid Robotics*, **1**(1), 157–173, (2004)
- VPR. Vukobratovic, M., Potkonjak, V., Rodic, A.: Contribution to the Dynamic Study of Humanoid Robots Interacting with Dynamic Environment. *Int. J. Robotica*, **22**, 439–447, (2004)
- VPT04. Vukobratovic, M., Potkonjak, V., Tzafestas, S.: Human and Humanoid Dynamics – From the Past to the Future, *J. Intel. Robot. Sys.*, **41**, 65–84, (2004)
- VAB04. Vukobratovic, M., Andric, D., Borovac, B.: How to achieve various gait patterns from single nominal, *Int. J. Adv. Robot. Sys.*, **1**(2), 99–108, (2004)
- VBB05. Vukobratovic M., Borovac B., Babkovic K.: Contribution to the Study of Anthropomorphism of Humanoid Robots, *International Journal of Advanced Robotic Systems*, in press, *Int. J. Adv. Robot. Sys.*, (in press), (2005)
- Wei90. Weinstein, A.: Affine Poisson structures. *Internat. J. Math.*, **1**, 343–360, (1990)

- WF45. Wheeler, J.A., Feynman, R.P.: Interaction with the Absorber as the Mechanism of Radiation. *Rev. Mod. Phys.* **17**, 157–181 (1945)
- WF49. Wheeler, J.A., Feynman, R.P.: Classical Electrodynamics in Terms of Direct Interparticle Action. *Rev. Mod. Phys.* **21**, 425–433, (1949)
- WZ98. Whiting, W.C., Zernicke, R.F.: *Biomechanics of Musculoskeletal Injury*, Human Kinetics, Champaign, IL, (1998)
- Whi87. Whitney, D.E.: Historical perspective and state of the art in robot force control. *Int. J. Robot. Res.*, **6**(1), 3–14, (1987)
- Wig90. Wiggins, S.: *Introduction to Applied Dynamical Systems and Chaos*. Springer, New York, (1990)
- Wil56. Wilkie, D.R.: The mechanical properties of muscle. *Brit. Med. Bull.*, **12**, 177–182, (1956)
- Wil93. Willmore, T.J.: *Riemannian Geometry*. Oxford Univ. Press, Oxford, (1993)
- Wil00. Wilson, D.: *Nonlinear Control*, Advanced Control Course (Student Version), Karlstad Univ., (2000)
- Wit82. Witten, E.: Supersymmetry and Morse theory. *J. Diff. Geom.*, **17**, 661–692, (1982)
- XH94. Xu, Z., Hauser, J.: Higher order approximate feedback linearization about a manifold, *J. Math. Sys. Est. Con.*, **4**, 451–465, (1994)
- XH95. Xu, Z., Hauser, J.: Higher order approximate feedback linearization about a manifold for multi-input systems, *IEEE Trans. Aut. Con*, AC-40, 833–840, (1995)
- Yag87. Yager, R.R.: *Fuzzy Sets and Applications: Selected Papers by L.A. Zadeh*, Wiley, New York, (1987)
- Yan52. Yano, K.: Some remarks on tensor fields and curvature. *Ann. of Math.* **55**(2), 328–347, (1952)
- Yos84. Yoshikawa, T.: Analysis and Control of Robot Manipulators with Redundancy. In *Robotics Research*, Eds. M. Brady and R. Paul, 735–747, MIT Press, Cambridge, (1984)

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