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**Allee optimal control of a system in ecology.** (English) Zbl 1411.93198

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**MSC:**

[93E20](#) Optimal stochastic control  
[93E03](#) Stochastic systems in control theory (general)  
[92D40](#) Ecology  
[35K57](#) Reaction-diffusion equations  
[90C15](#) Stochastic programming

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**Keywords:**

diffusion-reaction equation; interacting particle system; stochastic process; travelling wave; optimal control; ecological system; Allee effect; piecewise control strategy; direct computational method

**Software:**

SQLab; PLCP; FreeFem++; Chemotaxis; AMPL

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**References:**

- [1] Albi, G.; Pareschi, L.; Toscani, G.; Zanella, M., Active Particles, 1, Recent advances in opinion modeling: control and social influence, 49-98, (2017), Birkhäuser
- [2] Annunziato, M.; Borzi, A., A Fokker-Planck control framework for multidimensional stochastic processes, J. Comput. Appl. Math., 237, 487-507, (2013) · [Zbl 1251.35196](#)
- [3] Aronson, D. G.; Weinberger, H. F., Partial Differential Equations \& Related Topics, 446, Nonlinear diffusion in population genetics, combustion, and nerve pulse propagation, 5-49, (1975), Springer
- [4] Aronson, D. G.; Weinberger, H. F., Multidimensional nonlinear diffusions arising in population genetics, Adv. Math., 30, 33-76, (1978) · [Zbl 0407.92014](#)
- [5] Arrieta, J. M.; López-Fernández, M.; Zuazua, E., Approximating travelling waves by equilibria of non-local equations, Asymptot. Anal., 3, 145-186, (2012) · [Zbl 1248.35038](#)
- [6] Aydogdu, A.; Caponigro, M.; McQuade, S.; Piccoli, B.; Duteil, N. P.; Rossi, F.; Trélat, E., Active Particles, 1, Interaction network, state space, and control in social dynamics, 99-140, (2017), Birkhäuser
- [7] Barthel, W.; John, C.; Tröltzsch, F., Optimal boundary control of a system of reaction diffusion equations, J. Appl. Math. Mech., 12, 966-982, (2010) · [Zbl 1375.49030](#)
- [8] Barton, N.; Turelli, M., Spatial waves of advance with bistable dynamics: cytoplasmic and genetic analogues of allee effects, Am. Nat., 178, E48-E75, (2011)
- [9] K. Beauchard and M. Morancey, Local controllability of 1D Schrödinger equations with bilinear control and minimal time, arXiv:1208.5393. · [Zbl 1281.93016](#)
- [10] Bellomo, N.; Bellouquid, A.; Knopoff, D., From the microscale to collective crowd dynamics, Multiscale Model. Simul., 11, 943-963, (2013) · [Zbl 1280.90019](#)
- [11] Bellomo, N.; Preziosi, L., Modelling and mathematical problems related to tumor evolution and its interaction with the immune system, Math. Comput. Modelling, 32, 413-452, (2000) · [Zbl 0997.92020](#)
- [12] Bellomo, N.; Winkler, M., A degenerate chemotaxis system with flux limitation: maximally extended solutions and absence of gradient blow-up, Comm. Partial Differential Equations, 42, 436-473, (2017) · [Zbl 1430.35166](#)
- [13] Bellouquid, A.; Delitala, M., Mathematical Modeling of Complex Biological Systems, (2006), Birkhäuser · [Zbl 1178.92002](#)
- [14] Bertsekas, D. P., Nonlinear Programming, 1-60, (1999), Athena Scientific
- [15] Bisi, M.; Desvillettes, L., From reactive Boltzmann equations to reaction-diffusion systems, J. Statist. Phys., 124, 881-912, (2006) · [Zbl 1134.82323](#)
- [16] Bliman, P. A.; Vauchelet, N., Establishing traveling wave in bistable reaction-diffusion system by feedback, IEEE Control Syst. Lett., 1, 62-67, (2017)
- [17] Bonnans, J. F.; Gilbert, J. C.; Lemaréchal, C.; Sagastizábal, C. A., Numerical Optimization: Theoretical and Practical Aspects, (2006), Springer Science & Business Media · [Zbl 1108.65060](#)
- [18] Burini, D.; Gibelli, L.; Outada, N., Active Particles, 1, A kinetic theory approach to the modeling of complex living systems,

229-258, (2017), Birkhäuser

- [19] Cannarsa, P.; Floridia, G.; Khapalov, A. Y., Multiplicative controllability for semilinear reaction-diffusion equations with finitely many changes of sign, *J. Math. Pures Appl.*, 108, 425-458, (2017) · [Zbl 1370.93140](#)
- [20] Carrillo, J. A.; Choi, Y. P.; Perez, S. P., *Active Particles*, 1, A review on attractive-repulsive mean fields for consensus in collective behavior, 259-298, (2017), Birkhäuser
- [21] Casas, E.; Ryll, C.; Tröltzsch, F., Sparse optimal control of the Schlögl and Fitzhugh-Nagumo systems, *Comput. Methods Appl. Math.*, 1, 1-29, (2013) · [Zbl 1393.49019](#)
- [22] Chalub, F. A.; Markowich, P. A.; Perthame, B.; Schmeiser, C., Kinetic models for chemotaxis and their drift-diffusion limits, *Monatsh. Math.*, 142, 123-141, (2004) · [Zbl 1052.92005](#)
- [23] Coron, J. M., *Control and Nonlinearity*, (2007), Amer. Math. Soc.
- [24] Coron, J.-M.; Trélat, E., Global steady-state controllability of one-dimensional semilinear heat equations, *SIAM J. Control Optim.*, 43, 549-569, (2004) · [Zbl 1101.93011](#)
- [25] Coron, J.-M.; Trélat, E., Global steady-state stabilization and controllability of 1D semilinear wave equations, *Commun. Contemp. Math.*, 8, 535-567, (2006) · [Zbl 1101.93039](#)
- [26] Cristiani, E.; Piccoli, B.; Tosin, A., Multiscale modeling of granular flows with application to crowd dynamics, *Multiscale Model. Simul.*, 9, 155-182, (2011) · [Zbl 1221.35232](#)
- [27] Durrett, R., Crabgrass, measles, and gypsy moths: an introduction to modern probability, *Bull. Amer. Math. Soc.*, 18, 117-143, (1988) · [Zbl 0653.60095](#)
- [28] Durrett, R., *Lectures on Probability Theory, Ten lectures on particle systems*, 97-201, (1995), Springer · [Zbl 0840.60088](#)
- [29] Engl, H. W.; Hanke, M.; Neubauer, A., *Regularization of Inverse Problems*, (1996), Springer Science & Business Media · [Zbl 0859.65054](#)
- [30] Erneux, T.; Nicolis, G., Propagating waves in discrete bistable reaction-diffusion systems, *Phys. D*, 67, 237-244, (1993) · [Zbl 0787.92010](#)
- [31] Fernández, L. A.; Khapalov, A. Y., Controllability properties for the one-dimensional heat equation under multiplicative or non-negative additive controls with local mobile support, *ESAIM Control Optim. Calc. Var.*, 4, 1207-1224, (2012) · [Zbl 1262.35119](#)
- [32] Fife, P. C.; McLeod, J. B., The approach of solutions of nonlinear diffusion equations to travelling front solutions, *Arch. Ration. Mech. Anal.*, 65, 335-361, (1977) · [Zbl 0361.35035](#)
- [33] Filbet, F.; Laurennot, P.; Perthame, B., Derivation of hyperbolic models for chemosensitive movement, *J. Math. Biol.*, 50, 189-207, (2005) · [Zbl 1080.92014](#)
- [34] Fisher, R. A., The wave of advance of advantageous genes, *Ann. Eugen.*, 7, 355-369, (1937) · [Zbl 63.1111.04](#)
- [35] Fleming, W. H.; Rishel, R. W., *Deterministic and Stochastic Optimal Control*, (1975), Springer-Verlag · [Zbl 0323.49001](#)
- [36] Forsgren, A.; Gill, P. E.; Wright, M. H., Interior methods for nonlinear optimization, *SIAM Rev.*, 4, 525-597, (2002) · [Zbl 1028.90060](#)
- [37] R. Fourer, D. M. Gay and B. W. Kernighan, *AMPL: A mathematical programming language*, Technical Report, AT&T Bell Laboratories, Murray Hill (1987). · [Zbl 0701.90062](#)
- [38] Francesco, M. D.; Fagioli, S.; Rosini, M. D.; Russo, G., *Active Particles*, 1, Follow-the-leader approximations of macroscopic models for vehicular and Pedestrian flows, 333-378, (2017), Birkhäuser
- [39] F. Hecht, O. Pironneau, A. Le Hyaric and K. Ohtsuka, *FreeFem++ Manual* (2005), <http://www.freefem.org/>.
- [40] Hillen, T.; Othmer, H. G., The diffusion limit of transport equations derived from velocity jump processes, *SIAM J. Appl. Math.*, 61, 751-775, (2000) · [Zbl 1002.35120](#)
- [41] Hodgkin, A. L.; Huxley, A. F., A quantitative description of membrane current and its application to conduction and excitation in nerve, *J. Physiol.*, 117, 500-544, (1952)
- [42] Iriberry, N.; Uriarte, J.-R., Minority language and the stability of bilingual equilibria, *Ration. Soc.*, 24, 442-462, (2012)
- [43] Itô, Y.; Kawamoto, H., Number of generations necessary to attain eradication of an insect pest with sterile insect release method: A model study, *Res. Popul. Ecol. (Kyoto)*, 20, 216-226, (1979)
- [44] Kanarek, A. R.; Webb, C. T., Allee effects, adaptive evolution, and invasion success, *Evol. Appl.*, 2, 122-135, (2010)
- [45] Karn'ý, M., Towards fully probabilistic control design, *Automatica*, 32, 1719-1722, (1996) · [Zbl 0868.93022](#)
- [46] Keener, J. P.; Sneyd, J., *Mathematical Physiology*, (1998), Springer · [Zbl 0913.92009](#)
- [47] Klassen, W.; Curtis, C. F., *Sterile Insect Technique, History of the sterile insect technique*, 3-36, (2005), Springer
- [48] Knipling, E. F., Sterile-male method of population control, *Science*, 130, 902-904, (1959)
- [49] Laplante, J. P.; Erneux, T., Propagation failure in arrays of coupled bistable chemical reactors, *J. Phys. Chem.*, 96, 4931-4934, (1992)
- [50] Lewis, M. A.; Kareiva, P., Allee dynamics and the spread of invading organisms, *Theor. Popul. Biol.*, 2, 141-158, (1993) · [Zbl 0769.92025](#)
- [51] Liebhold, A. M.; Tobin, P. C., Population ecology of insect invasions and their management, *Annu. Rev. Entomol.*, 53, 387-408, (2008)
- [52] Lions, J. L., *Contrôle Optimal de Systemes Gouvernés par des Équations aux Dérivées Partielles*, (1968), Gauthier-Villars ·

[Zbl 0179.41801](#)

- [53] Masi, A. D.; Ferrari, P. A.; Lebowitz, J., Reaction-diffusion equations for interacting particle systems, *J. Statist Phys.*, 44, 589-644, (1986) · [Zbl 0629.60107](#)
- [54] Masi, A. D.; Presutti, E.; Vares, M. E., Escape from the unstable equilibrium in a random process with infinitely many interacting particles, *J. Statist Phys.*, 44, 645-696, (1986) · [Zbl 0652.60110](#)
- [55] Murray, J. D., *Mathematical Biology. II Spatial Models and Biomedical Applications*, 18, 1-43, (2001), Springer-Verlag
- [56] Nagumo, J.; Yoshizawa, S.; Arimoto, S., Bistable transmission lines, *IEEE Trans. Circuit Theory*, 3, 400-412, (1965)
- [57] Neuhauser, C., Mathematical challenges in spatial ecology, *Notices Amer. Math. Soc.* 48, 11, 1304-1314, (2002) · [Zbl 1128.92328](#)
- [58] Okubo, A.; Levin, S. A., *Diffusion and Ecological Problems, Modern Perspectives*, 10-30, (2001), Springer
- [59] Perthame, B., Mathematical tools for kinetic equations, *Bull. Amer. Math. Soc.*, 41, 2, 205-244, (2004) · [Zbl 1151.82351](#)
- [60] Perthame, B., *Parabolic Equations in Biology*, *Parabolic equations in biology*, 1-21, (2015), Springer International Publishing
- [61] Phillips, D. L., A technique for the numerical solution of certain integral equations of the first kind, *J. Assoc. Comput. Mach.*, 9, 84-97, (1962) · [Zbl 0108.29902](#)
- [62] C. Pouchol, E. Trélat and E. Zuazua, Phase portrait control 1D monostable and bistable reaction-diffusion equations, preprint, arXiv:1805.10786v1 (2018), 30 pp.
- [63] Raymond, J.-P.; Zidani, H., Hamiltonian pontryagin's principles for control problems governed by semilinear parabolic equations, *Appl. Math. Optim.*, 2, 143-177, (1999) · [Zbl 0922.49013](#)
- [64] Ruszczyński, A. P., *Nonlinear Optimization*, (2006), Princeton Univ. Press
- [65] Ryll, C.; Löber, J.; Martens, S.; Engel, H.; Tröltzsch, F., Control of Self-Organizing Nonlinear Systems, Analytical, optimal, and sparse optimal control of traveling wave solutions to reaction-diffusion systems, 189-210, (2016), Springer International Publishing
- [66] Stevens, A., The derivation of chemotaxis equations as limit dynamics of moderately interacting stochastic many-particle systems, *SIAM J. Appl. Math.*, 61, 183-212, (2000) · [Zbl 0963.60093](#)
- [67] Strikwerda, J. C., *Finite Difference Schemes and Partial Differential Equation*, (2004), Society for Industrial and Applied Mathematics · [Zbl 1071.65118](#)
- [68] Strugarek, M.; Vauchelet, N., Reduction to a single closed equation for 2-by-2 reaction-diffusion systems of Lotka-Volterra type, *SIAM J. Appl. Math.*, 76, 2060-2080, (2016) · [Zbl 1355.35108](#)
- [69] Taylor, C. R., Determining optimal sterile male release strategies, *Environ. Entomol.*, 5, 87-95, (1976)
- [70] Tits, A. L.; Wächter, A.; Bakhtiari, S.; Urban, T. J.; Lawrence, C. T., A primal-dual interior-point method for nonlinear programming with strong global and local convergence properties, *SIAM J. Optim.*, 1, 173-199, (2003) · [Zbl 1075.90078](#)
- [71] Tröltzsch, F., Optimal Control of Partial Differential Equations, 265-312, (2010), Amer. Math. Soc.
- [72] A. Wächter, An interior point algorithm for large-scale nonlinear optimization with applications in process engineering, PhD thesis, Carnegie Mellon University (2002).
- [73] Winkler, M.; Bellomo, N., Finite-time blow-up in a degenerate chemotaxis system with flux limitation, *Trans. Amer. Math. Soc. Ser. B*, 4, 31-67, (2017) · [Zbl 1367.35044](#)
- [74] Ycart, B., *Modèles et Algorithmes Markoviens*, (2002), Springer Science & Business Media
- [75] Zuazua, E., *Handbook of Differential Equations: Evolutionary Equations, Controllability and observability of partial differential equations: some results and open problems*, 527-621, (2007), North-Holland · [Zbl 1193.35234](#)

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