REDUCTION OF DISCRETE ALGEBRAIC RICCATI EQUATIONS: ELIMINATION OF GENERALIZED EIGENVALUES ON THE UNIT CIRCLE

AUGUSTO FERRANTE AND LORENZO NTOGRAMATZIDIS

Abstract. The purpose of this paper is to introduce a two-stage procedure that can be used to decompose a discrete-time algebraic Riccati equation into a trivial part, a part that is entirely arbitrary, and a part that can be obtained by computing the set of solutions of a reduced-order Riccati equation whose associated symplectic pencil has no generalized eigenvalues on the unit circle.

Mathematics subject classification (2010): 93C05, 93B27, 93B52.

Keywords and phrases: Discrete-time algebraic Riccati equations, symplectic pencil.

REFERENCES

[1] H. ABOU-KANDIL, G. FREILING, V. IONESCU AND G. JANK, it Matrix Riccati Equations in Control and Systems Theory, Birkhäuser, Basel, 2003.

[2] D. J. CLEMENTS AND B .D. O. ANDERSON, *Polynomial factorization via the Riccati equation*, SIAM Journal on Applied Mathematics, **31** (2004), 179–205.

[3] T. DAMM AND D. HINRICHSEN, *Newton's method for a rational matrix equation occurring in stochastic control*, Linear Algebra and its Applications, **332–334** (2001), 81–109.

[4] A. FERRANTE, *On the structure of the solution of discrete-time algebraic Riccati equation with singular closed-loop matrix*, IEEE Transactions on Automatic Control, **49** (2004), 2049–2054.

[5] A. FERRANTE AND L. NTOGRAMATZIDIS, *The generalized discrete algebraic Riccati equation in Linear-Quadratic optimal control*, Automatica, **49** (2013), 471–478.

[6] A. FERRANTE AND L. NTOGRAMATZIDIS, *The extended symplectic pencil and the finite-horizon LQ problem with two-sided boundary conditions*, IEEE Transactions on Automatic Control, **58** (2013), 2102–2107.

[7] A. FERRANTE AND L. NTOGRAMATZIDIS, *A note on finite-horizon LQ problems with indefinite cost*, Automatica, **52** (2015), 290–293.

[8] A. FERRANTE AND L. NTOGRAMATZIDIS, *Generalized finite-horizon linear-quadratic optimal control*, Encyclopedia of Systems and Control, DOI 10.1007/978-1-4471-5102-9_202-1, Springer-Verlag, London, 2014.

[9] A. FERRANTE AND H. K. WIMMER, *Order reduction of discrete-time algebraic Riccati equations with singular closed-loop matrix*, Operators and Matrices, **1** (2007), 61–70.

[10] G. FREILING AND A. HOCHHAUS, *On a class of rational matrix differential equations arising in stochastic control*, Linear Algebra and its Applications, **379** (2004), 43–68.

[11] T. FUJINAKA AND M. ARAKI, *Discrete-time optimal control of systems with unilateral time-delays*, Automatica, **23** (1987), 763–765.

[12] T. FUJINAKA, G. CHEN AND H. SHIBATA, *Discrete algebraic Riccati equation with singular coefficient matrix*, In Proc. *Systems and Networks: Mathematical Theory and Application (MTNS 98)*, Padova, Italy, 1999.

[13] A. HANSSON AND P. HAGANDER, *How to decompose semi-definite discrete-time algebraic Riccati equations*, European Journal of Control, **5** (1999), 245–258.

[14] V. IONESCU, C. OARĂ AND M. WEISS, *Generalized Riccati theory and robust control, a Popov function approach*, Wiley, 1999.

[15] P. LANCASTER AND L. RODMAN, *Algebraic Riccati equations*, Clarendon Press, Oxford, 1995.

[16] J. MEDANIC, *Geometric properties and invariant manifolds of the Riccati equation*, IEEE Transactions on Automatic Control, **27** (1985), 670–677.

[17] T. MITA, *Optimal digital feedback control systems counting computation time of control laws*, IEEE Transactions on Automatic Control, **30** (1985), 542–548.

[18] L. NTOGRAMATZIDIS AND A. FERRANTE, *The discrete-time generalized algebraic Riccati Equation: order reduction and solutions's structure*, Systems & Control Letters, **75** (2015), 84–93.

[19] D. RAPPAPORT AND L. M. SILVERMAN, *Structure and stability of discrete-time optimal systems*, IEEE Transactions on Automatic Control, **16** (1971), 227–233.

[20] W. T. REID, *Riccati differential equations*, Academic Press, 1972.

[21] J. C WILLEMS, S. BITTANTI AND A. LAUB, editors, *The Riccati Equation*, Springer Verlag, New York, 1991.

[22] H. K. WIMMER, *Normal forms of symplectic pencils and the discrete-time algebraic Riccati equation*, Linear Algebra and its Applications, **147** (1991), 411–440.

[23] M. ZORZI, *Robust Kalman filtering under model perturbations*, IEEE Transactions on Automatic Control, **62**, 6 (2017), 2902–2907.

[24] B. C. LEVY, M. ZORZI, *A contraction analysis of the convergence of risk-sensitive filters*, SIAM Journal on Control and Optimization, **54**, 4 (2016), 2154–2173.

[25] M. ZORZI, *Convergence analysis of a family of robust Kalman filters based on the contraction principle*, SIAM Journal on Control and Optimization, **55**, 5 (2017), 3116–3131.