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Review

of the doctoral thesis :"Spatially invariant systems: modelling, analysis and control via polynomial approach" by Petr Augusta

1.Scope and aim of the thesis

Kalman , Kamen and Sontag belong to the pioneers who started in the late 1960 and early 1970 to investigate the linear spatially distributed linear systems as the linear systems over rings. Kamen in his book [36] has proposed a comprehensive methodology for analysis and synthesis of spatially distributed systems. The Ricatti equation with non-constant matrices has been investigated by Melzer and Kuo in [48].The finite differences methods have been used to discretise a partial differential equation describing the systems in [39,50,70]. The modelling, analysis and control of systems with more than one spatial variable have been addressed in many papers, for example in [39,13,25,23,65]

The topic of the thesis is very actual and many problems of the analysis ,synthesis and control of spatially distributed systems are difficult and still open.

The thesis is devoted to the modeling ,analysis and control of spatially distributed linear time-invariant and spatially-invariant systems. The partial differential equations describing the systems are spatially and in time discretised and after application of the z-transform and Laplace-transform the transfer functions of the systems are obtained. In the thesis the fractions of multivariate polynomials are used for modeling, analysis and control of the systems. A heat conduction in a rod described by the parabolic equation (3.2) is used to illustrate the considerations.

The thesis consists of 9 chapters and it is organised as follows.

A short review of the existing approaches to analysis and synthesis of spatially distributed linear systems is given in Chapter 2.The partial differential equations and their finite difference methods are briefly discussed in Chapter 3.The difference methods are used for modeling of the spatially distributed linear systems and the modeling of the systems by the use of transfer functions is addressed in Chapter 4.The stability analysis of the systems by polynomial approach is presented in Chapter 5. Chapter 6 is devoted to the control design techniques. An overview of tools used in Chapter 6 is given in Chapter 7. A comparison of the methods proposed in the thesis to the existing approaches is presented in Chapter 8.Conclusions are given in Chapter 9.

2.Main results and contribution of the thesis

The main new original results of the thesis are presented in chapters 5 and 6:

1.In Chapter 5 a method of BIBO stability analysis of multidimensional linear systems is proposed. The method is based on the well-known Shanks theorem , Schur-Cohn theorem and Siljak theorem.

2.In Section 6.1 the positive polynomial approach to stabilization of the discrete-time and spatially discretised linear systems is proposed. The approach is based on the theorem 6.2 which gives the necessary and sufficient stability conditions for the polynomial (6.3) for n=1.

3.In Section 6.2 this approach has been extended for continuous-time case.

4.A procedure for design of LQG optimal controller minimizing the quadratic criterion (6.15) for the spatially distributed linear systems is given in Section 6.3.The main result of this Section is Theorem 6.13 and Algorithm 6.14.

5.In Section 6,4 the parametrisation of all stabilizing controllers is given and among these stabilising controllers a controller minimizing H_2 norm of the closed-loop system transfer function is selected. An algorithm for the synthesis of H_2-optimal controller is proposed and illustrated by a numerical example. This is an extension of the Kucera and Sebek results.

6.In Section 6.5 a design algorithm for the dead-beat controller which drives the control error to zero in a minimal number of steps is proposed and illustrated a numerical example

The thesis is well organized and well written.

3.Comments and remarks

1.The theory of the spatially distributed systems is quite closely related to the theory of 2D linear systems and the continuous-discrete linear systems(called also 2D hybrid systems). In my book: Two-Dimensional Linear Systems, Springer-Verlag 1985 it is shown that he partially differential equations describing the distributed parameter linear systems can be reduced by discretisation to 2D linear systems described by the Roesser model or by the Fornasimi-Marchesini models. Similarly, the spatially discretised systems are equivalent to the continuous-discrete linear systems.

2.It will be interesting to show that for example the equations (3.5),(3.6) can be (or not) reduced to the form of Roesser model or to the general 2D model.

3.It is assumed that the time variable is limited and the spatial variable is infinite. This assumption is never valid for a real physical system. It will be interesting to show at least on simple example how work the proposed approaches when the special variable is also limited.

4.Some additional comments are desired how the matrix M is chosen in (5.2).

5.A proof of Lemma 6.6 is desired.

6.page 36-Amethod for the choice of the matrix S_3 is desired.

7.In (6.23) and (6.24) Z is not defined.

8.The letters M and s are used in Chapter 5 and Chapter 7 in different meanings.

9.Some evident mistakes (for example page 20 upper (4.4) is z instead of s, page 21 line 6-is cab instead of can etc.) should be corrected

4. Conclusion

The thesis contains new original results concerning the modeling, analysis and control of spatially distributed linear systems. Some results of the thesis have been published by the author in few papers. The thesis is well organized and clearly written. It shows good knowledge of the author of the theory of the automatic control systems, specially on the parameters distributed linear systems and its literature. It also shows that the author of the thesis proved to have an ability to perform research and to achieve scientific results. I do recommend the thesis for presentation with the aim of receiving the degree of Ph.D.