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2. Study of Linear Differential-Algebraic Equations of Higher-Order and Characteristics of Matrix Polynomials

Ramesh D. Lashkare, Dr. Jaya Kushwah

Dept. of Mathematics,

Himalayan University, Arunachal Pradesh.

ABSTRACT

This proposition adds to the hypothetical investigation of linear Differential Algebraic Equations of higher order just as of the regularity and singularity of matrix polynomials. Begin with ODE system: y' (=dy/dt) = f(y, t), y(0) = y0

Here we anticipate a development of y in time and there are various methods that guarantee a precise and stable advancement. A few invariant and dense structure under fitting proportionate transformation are given for systems of linear higher order Differential Algebraic EquationsS with constants and variable coefficients. Inductively, in view of dense structure the first Differential Algebraic EquationsS system can changed by differentiation and elimination ventures into an equql oddness free system, From which the arrangement conduct (counting consistency of starting conditions and remarkable resolvability) of the first Differential Algebraic EquationsS system and related beginning quality problem can be legitimately perused off. It is demonstrated that the accompanying identicalness hold foe a Differential Algebraic Equations system oddness record ^and square and constant coefficient.

For any reliable starting condition any right side $f(t) = C^{\mu}(|t_0, t_1|)C^{\eta}$

The related beginning worth problem has an interesting arrangement if and just if the matrix polynomial related with the system is normal. It is demonstrated that this proximity problem is identical to a rank insufficiency problem for a specific class of organized and obliged irritation. Likewise a portrayal as far as the particular estimations of matrices, of the separation to singularity for matrix pencil is gotten At long last, som lower limits for the separation of a matrix polynomial to singularity are set up.

KEYWORDS:

Differential, Algebraic, Equations, Problem, Uniqueness, Linear.

Introduction:

Variable Coefficients Linear Higher-Order Differential-Algebraic Equations

Consider the (linear implicit) DAE system:

$$Ey' = A\,y + g(t)$$

with steady starting conditions and apply implicit Euler:

$$E(y_{n+1} - y_n)/h = A\,y_{n+1} + g(t_{n+1})$$

and rearrangement gives:

$$y_{n+1} = (E - A\,h)^{-1}\,[E\,y_n + h\,g(t_{n+1})]$$

Now the true solution, y(tn), satisfies:

$$E[(y(t_{n+1}) - y(t_n))/h + h\,y''(x)/2] = A\,y(t_{n+1}) + g(t_{n+1})$$

and defining en = $y(t_n) - y_n$, we have:

$$e_{n+1} = (E - A\,h)^{-1}\,[E\,e_n - h^2\,y''(x)/2]$$

$e_0 = 0$, known initial conditions

Where the segments of Aa relate to the voltage, resistive and capacitive branches separately. The rows speak to the system's hub, so that i1 and 1 demonstrate the hubs that are associated by each branch under thought. In this manner Aa relegates an extremity to each branch.

Lemma:

Let $M(t), C(t), K(t) \in \mathcal{C}([t_0, t_1], \mathbb{C}^{m\times n})$ be adequately smooth, and sup¬ represent that the regularity conditions (3.12) hold for the nearby trademark values of (M(t), C(t), K(t)). At that point, (M(t),C(t),K(t)) is internationally identical to a triple $(\tilde{M}(t), \tilde{C}(t), \tilde{K}(t))$ of matrix-valued functions of the accompanying consolidated structure

$$(M, C, K)$$

$$\sim \left(\begin{bmatrix} I & 0 \\ 0 & 0 \end{bmatrix}, \begin{bmatrix} C & C \\ C & C \end{bmatrix}, \begin{bmatrix} K & K \\ K & K \end{bmatrix} \right)$$

$$\sim \left(\begin{bmatrix} I & 0 \\ 0 & 0 \end{bmatrix}, \begin{bmatrix} C & C \\ C & U_1^H C V_1 \end{bmatrix} + 2 \begin{bmatrix} I & 0 \\ 0 & U_1^H \end{bmatrix} \begin{bmatrix} I & 0 \\ 0 & 0 \end{bmatrix} \begin{bmatrix} 0 & 0 \\ 0 & \dot{V}_1 \end{bmatrix}, \begin{bmatrix} K & K \\ K & K \end{bmatrix} \right)$$

$$\sim \left(\begin{bmatrix} I & 0 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & 0 \end{bmatrix}, \begin{bmatrix} C & C & C \\ C & I & 0 \\ C & 0 & 0 \end{bmatrix}, \begin{bmatrix} K & K & K \\ K & K & K \\ K & K & K \end{bmatrix} \right)$$

$$\sim \left(\begin{bmatrix} I & 0 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & 0 \end{bmatrix}, \begin{bmatrix} C & 0 & C \\ C & I & 0 \\ C & 0 & 0 \end{bmatrix}, \begin{bmatrix} K & K & K \\ K & K & K \\ K & K & K \end{bmatrix} \right)$$

$$\sim \left(\begin{bmatrix} I & 0 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & 0 \end{bmatrix}, \begin{bmatrix} C & 0 & C \\ 0 & I & 0 \\ C & 0 & 0 \end{bmatrix} + 2 \begin{bmatrix} I & 0 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & 0 \end{bmatrix} \begin{bmatrix} 0 & 0 & 0 \\ -\dot{C} & 0 & 0 \\ 0 & 0 & 0 \end{bmatrix}, \begin{bmatrix} K & K & K \\ K & K & K \\ K & K & K \end{bmatrix} \right)$$

$$\sim \left(\begin{bmatrix} V_2 & 0 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & 0 \end{bmatrix}, \begin{bmatrix} C & 0 & C \\ 0 & I & 0 \\ U_2^H C V_2 & 0 & 0 \end{bmatrix}, \begin{bmatrix} K & K & K \\ K & K & K \\ K & K & K \end{bmatrix} \right)$$

$$\sim \left(\begin{bmatrix} V_{11} & V_{12} & 0 & 0 \\ V_{21} & V_{22} & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix}, \begin{bmatrix} C & C & 0 & C \\ C & C & 0 & C \\ 0 & 0 & I & 0 \\ I & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix}, \begin{bmatrix} K & K & K & K \\ K & K & K & K \\ K & K & K & K \\ K & K & K & K \\ K & K & K & K \end{bmatrix} \right)$$

$$\sim \left(\begin{bmatrix} V_{11} & V_{12} & 0 & 0 \\ V_{21} & V_{22} & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix}, \begin{bmatrix} 0 & C & 0 & C \\ 0 & C & 0 & C \\ 0 & 0 & I & 0 \\ I & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix}, \begin{bmatrix} K & K & K & K \\ K & K & K & K \\ K & K & K & K \\ K & K & K & K \\ K & K & K & K \end{bmatrix} \right)$$

$$\sim \left(\begin{bmatrix} I & 0 & 0 & 0 \\ 0 & I & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix}, \begin{bmatrix} 0 & C & 0 & C \\ 0 & C & 0 & C \\ 0 & 0 & I & 0 \\ I & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix}, \begin{bmatrix} K & K & K & K \\ K & K & K & K \\ K & K & K & K \\ K & K & K & K \\ K & K & K & K \end{bmatrix} \right)$$

$$\sim \left(\begin{bmatrix} I & 0 & 0 & 0 \\ 0 & Q_1 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix}, \begin{bmatrix} 0 & C & 0 & C \\ 0 & CQ_1 + 2\dot{Q}_1 & 0 & C \\ 0 & 0 & I & 0 \\ I & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix}, \begin{bmatrix} K & K & K & K \\ K & K & K & K \\ K & K & K & K \\ K & K & K & K \\ K & K & K & K \end{bmatrix} \right)$$

(where pointwise nonsingular matrix-valued function $Q_1(t)$ is chosen as the solution of the initial value problem $\dot{Q}_1(t) = -\frac{1}{2} C_{2,2}(t) Q_1(t),\ t \in [t_0, t_1],\ Q_1(t_0) = \mathrm{I}$)

$$\sim\left(\begin{bmatrix} I & 0 & 0 & 0 & 0 \\ 0 & I & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \end{bmatrix}, \begin{bmatrix} 0 & C & 0 & C & C \\ 0 & 0 & 0 & C & C \\ 0 & 0 & I & 0 & 0 \\ I & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \end{bmatrix}, \begin{bmatrix} K & K & K & K & K \\ K & K & K & K & K \\ K & K & K & 0 & K \\ K & K & K & 0 & K \\ K & K & 0 & I & 0 \\ K & K & K & 0 & 0 \end{bmatrix}\right)$$

$$\sim\left(\begin{bmatrix} I & 0 & 0 & 0 & 0 \\ 0 & I & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \end{bmatrix}, \begin{bmatrix} 0 & C & 0 & C & C \\ 0 & 0 & 0 & C & C \\ 0 & 0 & I & 0 & 0 \\ I & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \end{bmatrix}, \begin{bmatrix} K & K & K & 0 & K \\ K & K & K & 0 & K \\ K & K & K & 0 & K \\ K & K & K & 0 & K \\ K & K & 0 & I & 0 \\ K & K & K & 0 & 0 \end{bmatrix}\right)$$

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+2\begin{bmatrix}
\dot{V}_{11} & \dot{V}_{12} & 0 & 0 & 0 & 0 & 0 & 0\\
\dot{V}_{21} & \dot{V}_{22} & 0 & 0 & 0 & 0 & 0 & 0\\
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0 & 0 & 0 & 0 & 0 & 0 & 0 & 0\\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0\\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0\\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0\\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0\\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0\\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0\\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0\\
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0 & 0 & 0 & 0 & 0 & 0 & 0 & 0
\end{bmatrix},
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K & K & 0 & K & 0 & K & 0 & K\\
K & K & 0 & K & 0 & K & 0 & K\\
K & K & 0 & K & 0 & K & 0 & K\\
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K & K & 0 & K & 0 & K & 0 & K\\
K & K & 0 & K & 0 & K & 0 & K\\
K & K & 0 & K & 0 & K & 0 & K\\
0 & 0 & 0 & 0 & 0 & 0 & I & 0\\
0 & 0 & 0 & 0 & I & 0 & 0 & 0\\
0 & 0 & I & 0 & 0 & 0 & 0 & 0\\
I & 0 & 0 & 0 & 0 & 0 & 0 & 0\\
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\end{bmatrix}
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+\begin{bmatrix}
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\end{bmatrix}\Bigg)
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0 & 0 & 0 & 0 & 0 & 0 & 0 & 0\\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0\\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0\\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0\\
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0 & 0 & 0 & 0 & 0 & 0 & 0 & 0\\
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0 & 0 & 0 & 0 & 0 & 0 & 0 & 0
\end{bmatrix},
\begin{bmatrix}
C & C & C & C & 0 & 0 & C & C\\
C & C & C & C & 0 & 0 & C & C\\
0 & 0 & C & C & 0 & 0 & C & C\\
0 & 0 & C & C & 0 & 0 & C & C\\
0 & 0 & 0 & 0 & I & 0 & 0 & 0\\
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I & 0 & 0 & 0 & 0 & 0 & 0 & 0\\
0 & I & 0 & 0 & 0 & 0 & 0 & 0\\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0\\
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\begin{bmatrix}
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K & K & 0 & K & 0 & K & 0 & K\\
K & K & 0 & K & 0 & K & 0 & K\\
K & K & 0 & K & 0 & K & 0 & K\\
K & K & 0 & K & 0 & K & 0 & K\\
K & K & 0 & K & 0 & K & 0 & K\\
K & K & 0 & K & 0 & K & 0 & K\\
0 & 0 & 0 & 0 & 0 & 0 & I & 0\\
0 & 0 & 0 & 0 & I & 0 & 0 & 0\\
0 & 0 & I & 0 & 0 & 0 & 0 & 0\\
I & 0 & 0 & 0 & 0 & 0 & 0 & 0\\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0
\end{bmatrix}\right)
$$

$$
\sim\left(\begin{bmatrix}
I & 0 & 0 & 0 & 0 & 0 & 0 & 0\\
0 & I & 0 & 0 & 0 & 0 & 0 & 0\\
0 & 0 & I & 0 & 0 & 0 & 0 & 0\\
0 & 0 & 0 & I & 0 & 0 & 0 & 0\\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0\\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0\\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0\\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0\\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0\\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0\\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0\\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0\\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0
\end{bmatrix},
\begin{bmatrix}
0 & 0 & C & C & 0 & 0 & C & C\\
0 & 0 & C & C & 0 & 0 & C & C\\
0 & 0 & C & C & 0 & 0 & C & C\\
0 & 0 & C & C & 0 & 0 & C & C\\
0 & 0 & 0 & 0 & I & 0 & 0 & 0\\
0 & 0 & 0 & 0 & 0 & I & 0 & 0\\
I & 0 & 0 & 0 & 0 & 0 & 0 & 0\\
0 & I & 0 & 0 & 0 & 0 & 0 & 0\\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0\\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0\\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0\\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0\\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0
\end{bmatrix},
\begin{bmatrix}
0 & K & 0 & K & 0 & K & 0 & K\\
0 & K & 0 & K & 0 & K & 0 & K\\
0 & K & 0 & K & 0 & K & 0 & K\\
0 & K & 0 & K & 0 & K & 0 & K\\
0 & K & 0 & K & 0 & K & 0 & K\\
0 & K & 0 & K & 0 & K & 0 & K\\
0 & K & 0 & K & 0 & K & 0 & K\\
0 & K & 0 & K & 0 & K & 0 & K\\
0 & 0 & 0 & 0 & 0 & 0 & I & 0\\
0 & 0 & 0 & 0 & I & 0 & 0 & 0\\
0 & 0 & I & 0 & 0 & 0 & 0 & 0\\
I & 0 & 0 & 0 & 0 & 0 & 0 & 0\\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0
\end{bmatrix}\right).
$$

Regular and Singular characterization of Matrix Polynomials:

Definition:

Given standard $\|\cdot\|$ on $\mathbb{C}^{m\times n}$,it is unitarily invariant if for any $A\epsilon\mathbb{C}^{m\times n}$, and any unitary $U\epsilon\,\mathbb{C}^{m\times n}$ and $V\epsilon\,\mathbb{C}^{m\times n}$ it fulfills $\|U^HAV\| = \|A\|$.

LEMMA:

Let ||.|| be a group of unitarilyinvariant atandards, and let $A \epsilon \mathbb{C}^{m \times n}$ and $B \epsilon \mathbb{C}^{m \times n}$ where m.n,qϵN then

$$||AB|| \leq ||A|| \, ||B||_2 \text{ and}$$

$$||AB|| \leq ||A||_2 \, ||B||$$

Proposition:

Let $\hat{S} := (n-1)l + 1$.Then

$$\frac{1}{\sqrt{\hat{S}}} \max \{\delta_{min}(W_{\hat{S}}(A_t, A_{t-1}, \ldots\ldots\ldots A_0) , \delta_{min}(\hat{W}_{\hat{S}}(A_t, A_{t-1}, \ldots\ldots\ldots A_0) \} \leq \delta_F(A(\lambda)),$$

Where $(W_{\hat{S}}(A_t, A_{t-1}, \ldots\ldots\ldots A_0)$ and $\delta_{min}(\hat{W}_{\hat{S}}(A_t, A_{t-1}, \ldots\ldots\ldots A_0) \}$ are defined as in respectively.

Since it appears that we can not get a " $\leq$ " relation of $|| W_{\hat{S}}(A_t, A_{t-1}, \ldots\ldots\ldots A_0||_2$

$|| \hat{W}_{\hat{S}}(A_t, A_{t-1}, \ldots\ldots\ldots A_0||_2$ to c. $\delta_2(A(\lambda))$ (where c is a constant)

We do not, at this writing obtain a reasonable lower bound on $\delta_2(A(\lambda))$ which is similar to that on $\delta_F(A(\lambda))$,.

EXAMPLE:

We research the regular matrix pencil.

$$A(\lambda) = \lambda A_1 + A_0 := \lambda \begin{matrix} 1 & 0 \\ 0 & -1 \end{matrix} + \begin{matrix} 1 & 0 \\ 0 & 1 \end{matrix}$$

By Proposition, We have

$$\lambda_A(A(\lambda)) = \min \{\sigma_{min}(\begin{matrix} A_1 \\ A_0 \end{matrix}) , \sigma_{min}(A_1 \quad A_0)\}$$

$$= \min \{\sqrt{2}, \sqrt{2}\} = \sqrt{2}.$$

For any $(\alpha, \beta) \epsilon = \{(\alpha, \beta) \epsilon \mathbb{C} \times \mathbb{C} | |\alpha|^2 + |\beta|^2 = 1\}$,

We have

$$\sigma_{min}(\alpha A_1 + \beta A_0) = \sigma_{min}(\begin{bmatrix} \alpha + \beta & 0 \\ 0 & \beta - \alpha \end{bmatrix})$$

$$= \min \ \{ \beta - \alpha| \ , |\beta - \alpha| \}$$

Since $|\beta + \alpha|.|\beta - \alpha| = \beta^2 - \alpha^2| \leq |\alpha^2| + |\beta^2| = 1$

Conclusions:

In this paper we have shown the theoretical examination of two interrelated focuses: straight differential mathematical conditions of higher request and the normality and peculiarity of network polynomials.

By virtue of square gird polynomials, we have investigated the issues of recognizing the consistency and peculiarity and of vicinity to peculiarity for customary framework polynomials. We have acquainted an estimation with check whether a given network polynomials is customary through the rank of information of its lattice coefficients. Subsequently in our examination, we have moreover given attainable lower constrains on the arithmetical assortment of eigenvalues T0 and) of a polynomials

eigenvalue issue $\left(\sum_{i=0}^{l} \lambda^i A_i\right) x = 0$ if the relating matrix polynomial $\sum_{i=0}^{l} \lambda^i A_i$ is regular.

For square and normal lattice polynomials, we have given a meaning of the detachment, to the extent the extraordinary and Fresenius framework guidelines, to the nearest solitary grid polynomials. A couple of fundamental and captivating properties of the detachment have been shown. In light of the sufficient and basic conditions of the consistency of framework polynomials got , a general theoretical depiction of the nearest division to peculiarity has been in like manner presented. From thedepiction all things being equal, the closeness issue is fundamentally a disturbance composed and constrained position deficiency issue, for which to choose an unequivocal measurable condition has every one of the reserves of being an open issue. Regardless, by virtue of framework pencils we have built up an accommodating depiction, to the extent the solitary estimations of lattices, of the nearest partition, which honestly concurs with the got geometrical depiction for particular network pencils. We have furthermore inspected the closeness issue for two extraordinary occasions of lattice polynomials, and explicitly, presented a model wherein the nearest partition to peculiarity to the extent the spooky standard isn't as much as that to the extent the Fresenius standard. At long last, two sorts of lower constrains on the nearest division for general ordinary framework polynomials have been shown.

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