Term paper

SYNTHESIS OF AN ADAPTIVE OBSERVER OF THE STATE OF A LINEAR PLANT WITH IMPROVED PARAMETRIC CONVERGENCE

Problem statement. Consider the asymptotically stable plant:

$$\begin{cases} \dot{x} = Ax + bu, \quad x(0), \\ y = Cx, \end{cases}$$

where x is the unmeasurable state vector, u and y are the measurable input and output signals respectively,

$$A = \begin{bmatrix} -a_{n-1} & 1 & \cdots & 0 \\ -a_{n-2} & 0 & & 0 \\ \vdots & & \ddots & 1 \\ -a_0 & 0 & & 0 \end{bmatrix}, \quad b = \begin{bmatrix} 0 \\ \vdots \\ 0 \\ b_m \\ \vdots \\ b_0 \end{bmatrix}, \quad C = \begin{bmatrix} 1 & 0 & \cdots & 0 \end{bmatrix},$$

$a_i, i = \overline{0, n-1}$, $b_j, j = \overline{0, m}$ are the unknown coefficients.

The problem is to design an observer providing the boundaries of all the signals in the closed-loop system and generating state vector estimates $\hat{x}$ such that the following equality holds

$$\lim_{t \to \infty} \|x(t) - \hat{x}(t)\| = 0,$$

and ensure improved parametric convergence with the use of special modified adaptation algorithm.

Implementation steps

1. Perform the work N°6, in which an adaptive observer of the state of a linear system is synthesized with the basic adaptation algorithm.
2. Design an adaptive observation system with the scheme with improved parametric convergence.
3. Simulate an adaptive observation system with the standard adaptation algorithm and modified adaptation algorithm. Compare the simulation results for systems with different adaptation algorithms.

Contents of the report

1. Plant and input signal parameters.

2. List of the systems components.
3. Simulation schemes with listings.
4. Transients in the adaptive observation system with gradient-based adaptation algorithm (plots with output signal, observation error, identification (parametric) error, state vector, state vector estimates, regressor).
5. Transients in the adaptive observation system with modified adaptation algorithm.
6. Conclusions.

Assignment variations

№	a_1	a_0	b_1	b_0	$u(t)$
1	1	2	1	7	$7\sin(8t + 1)\cos(7t + 6)$
2	2	2	1	8	$4\cos(6t + 11)\sin(3t + 7)$
3	3	2	1	9	$2\sin(t - 5)\cos(6t + 5)$
4	4	2	2	3	$3\cos(5t + 2)\sin(2t - 7)$
5	5	2	2	4	$5\sin(2t - 3)\cos(9t + 2)$
6	1	3	2	5	$6\sin(7t - 4)\sin(4t + 7)$
7	2	3	2	6	$9\cos(3t + 7)\sin(2t - 5)$
8	3	3	2	7	$\sin(4t - 5)\cos(5t + 3)$
9	4	3	2	8	$8\cos(t - 6)\sin(3t - 5)$
10	5	3	2	9	$11\sin(5t - 1)\cos(7t - 6)$
11	1	4	3	4	$3\cos(7t + 8)\sin(t + 4)$
12	2	4	3	5	$4\cos(2t + 1)\sin(3t + 7)$
13	3	4	3	6	$6\sin(4t + 1)\cos(2t + 6)$
14	4	4	3	7	$4\cos(6t + 11)\cos(7t + 7)$
15	5	4	3	8	$2\sin(7t + 5)\cos(3t - 1)$
16	1	5	3	9	$7\cos(3t - 9)\sin(t + 4)$
17	2	5	4	5	$7\sin(7t - 2)\cos(3t + 8)$
18	3	5	4	6	$4\sin(3t + 2)\sin(2t + 2)$
19	4	5	4	7	$9\cos(3t + 7)6\sin(2t - 5)$
20	5	5	4	8	$\sin(4t - 5)2\cos(5t + 3)$
21	1	6	4	9	$8\cos(6t + 3)\cos(9t - 2)$
22	2	6	5	6	$\sin(3t - 1)\cos(8t + 2)$
23	3	6	5	7	$8\cos(4t + 2)3\cos(3t + 1)$
24	4	6	5	8	$\cos(2t + 4)\sin(7t + 2)$
25	5	6	5	9	$4\sin(3t + 12)\cos(7t - 3)$
26	3	4	2	1	$6\cos(4t - 11)\sin(3t + 7)$
27	4	5	3	2	$11\cos(t - 3)\cos(4t + 1)$
28	1	2	4	1	$2\cos(6t + 2)\sin(7t - 1)$
29	2	3	4	2	$7\sin(8t - 1)\cos(3t + 2)$
30	3	4	5	3	$3\cos(3t - 2)\sin(4t + 5)$
31	4	5	5	2	$4\cos(2t + 4)\sin(6t - 3)$
32	5	6	6	4	$\sin(4t - 5)\cos(5t + 3)$
33	6	7	6	6	$3\sin(3t + 1)\sin(6t - 7)$
34	4	4	2	2	$3\sin(7t + 4)\cos(3t + 2)$
35	6	5	2	3	$5\cos(4t + 6)\sin(t + 3)$
36	8	6	5	5	$2\cos(8t + 3)\cos(3t + 7)$
37	9	6	2	8	$10\sin(4t + 5)\sin(3t + 2)$
38	12	7	3	1	$2\cos(10t - 2)\sin(2t + 1)$
39	15	8	3	4	$10\sin(t + 9)\cos(3t + 2)$
40	16	8	8	2	$4\cos(2t + 4)\sin(3t - 5)$
41	9	6	9	6	$2\sin(7t - 6)\cos(4t + 1)$

42	5	6	8	1	$5\sin(3t-2)\sin(6t+10)$
43	6	7	4	6	$\cos(t+9)\sin(8t-7)$
44	4	4	4	8	$8\sin(2t+3)\cos(4t+10)$
45	6	5	1	8	$3\cos(4t-3)\sin(5t-2)$
46	8	6	2	5	$\sin(4t-1)\cos(3t-6)$
47	10	7	8	8	$2\cos(6t-2)\sin(t-5)$
48	9	6	9	1	$5\sin(4t+2)\sin(3t+4)$
49	15	8	7	1	$7\sin(8t+1)\cos(7t+6)$
50	7	10	9	9	$4\cos(6t+11)\sin(6t+7)$
51	6	2	11	1	$2\sin(9t-5)\cos(6t+5)$
52	7	2	11	2	$3\cos(5t+2)\sin(5t-7)$
53	8	2	9	3	$5\sin(2t-3)\cos(9t+2)$
54	9	2	9	4	$6\sin(3t-4)\sin(7t+7)$
55	10	2	9	5	$9\cos(3t+7)\sin(2t-5)$
56	6	3	9	6	$\sin(4t-5)\cos(2t+3)$
57	7	3	9	7	$8\cos(t-6)\sin(3t-5)$
58	8	3	8	8	$11\sin(2t-1)\cos(5t-6)$
59	9	3	8	9	$3\cos(7t+8)\sin(t+4)$
60	10	3	8	10	$7\sin(8t+1)\cos(7t+6)$
61	6	4	8	11	$3\cos 4t+\sin 5t$
62	7	4	8	12	$3\sin 5t+7\cos(3t+2)$
63	8	4	7	1	$\sin(3t+2)+3\sin(2t+5)$
64	9	4	7	2	$\cos 2t+6\sin(t+2)$
65	10	4	7	3	$\sin t+5\sin(2t+3)$
66	6	5	7	4	$4\sin(2t+1)+9\sin(3t+2)$
67	7	5	7	5	$5\cos 3t+\sin(t+2)$
68	8	5	6	6	$2\sin t+3\cos 9t$
69	9	5	6	7	$15\sin 9t+6\sin 8t$
70	10	5	6	8	$2\sin(8t+1)+8\cos(5t+2)$
71	6	6	6	9	$6\cos(5t+3)+3\sin(4t+7)$
72	7	6	6	10	$10\cos(4t+1)+7\cos(3t+2)$
73	8	6	5	11	$7\cos 3t+2\cos(6t+3)$
74	9	6	5	12	$9\sin(6t+0,5)+2\sin(4t+4,2)$
75	10	6	5	1	$0,5\cos(6t+1)+4,3\sin(3t+5)$
76	6	7	5	2	$\cos(3t+1)+6\sin(8t+2)$
77	7	7	5	3	$4\cos 8t+8\sin(9t+4)$
78	8	7	4	4	$7\sin(9t+2,5)+5\cos(4t)$
79	9	7	4	5	$5\cos(4t+1,5)+4\sin 3t$
80	10	7	4	6	$\cos 3t+\cos 4t$
81	6	8	4	7	$\sin t+\cos 4t$
82	7	8	4	8	$\cos 2t+\sin 5t$
83	8	8	3	9	$\sin(5t+2)+7\cos(3t+2)$
84	9	8	3	10	$\cos(t+1)+3\sin(2t+5)$
85	10	8	3	11	$2\sin 2t+6\sin(t+2)$
86	6	9	3	12	$3\cos 4t+5\sin(2t+3)$
87	7	9	3	1	$4\sin(t+1)+9\sin(3t+2)$
88	8	9	2	2	$10\cos(8t+1)+2\sin(4t+2)$

89	9	9	2	3	$2\sin t + 3\cos 9t$
90	10	9	2	4	$5\cos 3t + 6\sin 4t$
91	6	10	2	5	$2\sin(8t+1) + 8\cos(5t+2)$
92	7	10	2	6	$6\cos(3t+3) + 3\sin(4t+7)$
93	8	10	1	7	$15\sin 9t + 7\cos(3t+2)$
94	9	10	1	8	$7\cos 3t + 2\cos(6t+3)$
95	10	10	1	9	$9\sin(t+0,5) + 2\sin(6t+4,2)$
96	6	1	1	10	$0,5\cos(t+1) + 3\sin(3t+5)$
97	7	1	1	11	$3\sin 5t + 6\sin(3t+2)$
98	8	1	11	12	$4\cos 8t + 8\sin(6t+4)$
99	9	1	11	1	$7\sin(9t+2) + 5\cos(4t)$
100	10	1	11	2	$5\cos(5t+1) + 4\sin 3t$