## List of Figures


| | | Page No. |
|---|---|---|
| Fig. 1.1 | Stability. | 12 |
| Fig. 1.2 | Asymptotic stability. | 12 |
| Fig. 2.1 | Projections of phase portraits of Qi attractor: (a) in x-y-z space (b) in x-y plane (c) in y-z plane (d) in x-z plane for $\alpha = 0.93$ and $(p,q,r)=(35,8/3,80)$. | 45 |
| Fig. 2.2 | Projections of phase portraits of Genesio-Tesi attractor: (a) in x-y-z space (b) in x-y plane (c) in y-z plane (d) in x-z plane for $\alpha = 0.96$ at $(a,b,c,m)=(6,2.92,1.2,1)$. | 46 |
| Fig. 2.3 | State trajectories of drive system (2.3) and response system (2.4) between state vectors and evolution of error vectors for the fractional-order $\alpha = 0.92$. | 49-50 |
| Fig. 2.4 | State trajectories of systems (2.9) and (2.10) between state vectors and evolution of error vectors for the fractional-order $\alpha = 0.96$. | 52-53 |
| Fig. 2.5 | Plots of state trajectories of systems (2.9) and (2.4) between state vectors and evolution of error vectors for the fractional-order $\alpha = 0.96$. | 55-56 |
| Fig. 3.1.1 | The chaotic attractors of the generalized SIR model (3.1.4): (a) for fractional order $\alpha = 0.99$; (b) for $\alpha = 0.975$. | 65 |
| Fig. 3.1.2 | The state trajectories of systems (3.1.11) and (3.1.12) between state vectors and evolution of error vectors for the fractional- | 69-70 |

order $\alpha$=0.99 .

Fig. 3.1.3 The state trajectories of systems (3.1.11) and (3.1.12) between state vectors and evolution of error vectors for the fractional-order $\alpha$=0.975 70-71

Fig. 3.2.1 The trajectories of susceptible, infected and pathogen concentration with respect to time $t$ for $\mu = 2, \beta_W = 0.6217, \beta_I = 0.6217,$ and $\alpha = 0.8, 0.9, 1.$ 81-82

Fig. 3.2.2 The trajectories of susceptible, infected and pathogen concentration with respect to time $t$ for $\mu = 1, \beta_W = 0.6217, \beta_I = 0.6217, \gamma = 0.1340, \xi = 0.333, T = 0.7$ and $\alpha = 0.8, 0.9, 1.$ 83-84

Fig. 4.1 Phase portraits of Advanced Lorenz system in *x*-*y*-*z* space. 93

Fig. 4.2 Phase portraits of Multiple delay Rössler system in *x*-*y*-*z* space 94

Fig. 4.3 Phase portrait of time-delayed feedback Chua's oscillator in *x*-*y*-*z* space for different sets of parameters: (a) $\varepsilon = 0.07$ and $\sigma = 0.4$, (b) $\varepsilon = 0.2$ and $\sigma = 2$, (c) $\varepsilon = 0.5$ and $\sigma = 3$ and (d) $\varepsilon = 1$ and $\sigma = 1.$ 95-96

Fig. 4.4 State trajectories of drive system (4.9) and response system (4.10) between state vectors and evolution of error vectors. 98-99

Fig. 4.5 The estimated parameter vectors of time-delayed advanced Lorenz systems. 100

| | | |
|---|---|---|
| Fig. 4.6 | State trajectories of drive system (4.11) and response system (4.12) between state vectors and evolution of error vectors. | 102-103 |
| Fig. 4.7 | State trajectories of estimated parameter vectors drive system (4.11) and response system (4.12). | 104 |
| Fig. 4.8 | State trajectories of drive system (4.13) and response system (4.14) between state vectors and evolution of error vectors. | 107-108 |
| Fig. 4.9 | State trajectories of estimated parameter vectors of drive system (4.13) and response system (4.14). | 108 |
| Fig. 5.1 | Phase portraits of Rössler system in $x_1(t)-x_2(t)-x_3(t)$ space. | 114 |
| Fig. 5.2 | (a) State trajectories of errors system and (b) The estimated parameters obtained by using the proposed method for the initial conditions of drive and response systems as (0.5, 1, 1.5) and (2.5, 2, 2.5) respectively. | 118 |
| Fig. 5.3 | (a) State trajectories of errors system and (b) The estimated parameters obtained by using the method described by Sudheer and Sabir (2011) for the initial conditions of drive and response systems as (0.5, 1, 1.5) and (2.5, 2, 2.5) respectively. | 119 |
| Fig. 5.4 | (a) State trajectories of errors system and (b) The estimated parameters obtained by using the proposed method for the initial conditions of drive and response systems as (1, 1, 1) and (1.5, 1.5, 1.5) respectively. | 120 |
| Fig. 5.5 | (a) State trajectories of errors system and (b) The estimated | 121 |

parameters obtained by using the method described by Sudheer and Sabir (2011) for the initial conditions of drive and response systems as (1, 1, 1) and (1.5, 1.5, 1.5) respectively.

Fig. 5.6 (a) State trajectories of errors system and (b) The estimated parameters obtained by using the proposed method for scaling functions $\lambda_1(t) = 1 + \cos(0.05t)$, $\lambda_2(t) = 2 - \sin(t)$ and $\lambda_3(t) = 3 + \cos(t + 10)$ and the initial conditions of drive and response systems as (2.5, 2, 2.5) and (0.5, 1, 1.5) respectively. 122

Fig. 5.7 (a) State trajectories of errors system and (b) The estimated parameters obtained by using the method described by Sudheer and Sabir (2011) for scaling functions $\lambda_1(t) = 1 + \cos(0.05t)$, $\lambda_2(t) = 2 - \sin(t)$ and $\lambda_3(t) = 3 + \cos(t + 10)$ and the initial conditions of drive and response systems as (2.5, 2, 2.5) and (0.5, 1, 1.5) respectively. 123

Fig. 6.1 Phase portraits of the fractional-order T-system for commensurate fractional orders (a) $(\alpha_1, \alpha_2, \alpha_3) = (0.95, 0.95, 0.95)$ (b) $(\alpha_1, \alpha_2, \alpha_3) = (0.92,\ 0.92,\ 0.92)$ in x-y-z space. 130

Fig. 6.2 Phase portraits of the fractional-order T-system system with incommensurate fractional orders at (a) $(\alpha_1, \alpha_2, \alpha_3) = (1, 1, 0.90)$ (b) $(\alpha_1, \alpha_2, \alpha_3) = (0.93, 0.99, .91)$ (c) $(\alpha_1, \alpha_2, \alpha_3) = (0.93, 0.95, 0.96)$ and (d) asymptotic stable at $(\alpha_1, \alpha_2, \alpha_3) = (1, 1, 0.70)$. 132

| | | |
|---|---|---|
| Fig. 6.3 | State trajectories of the controlled chaotic system (6.3). | 134 |
| Fig. 6.4 | The error states of the FPS between the systems (6.4) and (6.5) for $\alpha = 0.96$ and $\beta = 0.97$. | 136 |
| Fig. 6.5 | Root mean square error (RMSE) for $\alpha = 0.96$ and $\beta = 0.97$. | 136 |
| Fig. 6.6 | The error states of the FPS between the systems (6.4) and (6.5) for $\alpha = 1$ and $\beta = 1$. | 137 |
| Fig. 6.7 | Root mean square error (RMSE) for $\alpha = 1$ and $\beta = 1$. | 137 |
| Fig. 6.8 | The error states of the FPS between the systems (6.4) and (6.9) for $\alpha = 0.96$ and $\beta = 0.995$. | 139 |
| Fig. 6.9 | Root mean square error (RMSE) for $\alpha = 0.96$ and $\beta = 0.995$. | 139 |
| Fig. 6.10 | The error states of the FPS between the systems (6.4) and (6.9) for $\alpha = 1$ and $\beta = 1$. | 140 |
| Fig. 6.11 | Root mean square error (RMSE) for $\alpha = 1$ and $\beta = 1$. | 140 |
| Fig. 7.1 | Phase portrait of Qi system for $\alpha = 0.915$. | 146 |
| Fig. 7.2 | Phase portrait of Genesio-Tesi system for $\alpha = 0.93$. | 147 |
| Fig. 7.3 | Phase portrait of uncertain Genesio-Tesi system for $\alpha = 0.95$. | 150 |
| Fig. 7.4 | Phase portrait of uncertain chaotic Qi system for $\alpha = 0.93$. | 151 |
| Fig. 7.5 | Phase synchronization for fractional order $\alpha = 0.95$. | 153 |
| Fig. 7.6 | The evolution of the error functions of uncertain chaotic systems. | 154 |

Fig. 7.7 The evolution of the error functions of chaotic systems. 154

Fig. 7.8 Anti-phase synchronization for fractional order $\alpha = 0.95$. 156

Fig. 7.9 The evolution of the error functions of uncertain chaotic systems. 157

Fig. 7.10 The evolution of the error functions of chaotic systems. 157