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Controllability in nonlinear dynamical systems: a compartmental model

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Abstract
Controlling nonlinear systems and steering the system to a stable state is a significant issue in complex systems. Controllability is our ability to steer a dynamic system to a desired final state in finite time. A compartmental model is general mathematical modeling used to predict the time evolution of complex systems. We consider a three-dimensional nonlinear system with a transition threshold. It has only one steadystate (equilibrium fixed point) which it reachs a long period. Our goal is to drive this system towards the desired stable fixed point at the beginning of the dynamics (finite time). The nonlinear system was investigated as a compartmental model. We used the control strategy of multidimensional dynamical systems and proposed the canonical transformation from which the control function was obtained. In order to show that the fixed points of the system are stable, we used the linear stability method and the Gershgorin circle theorem. By numerically solving the differential equations after control, the system reached the desired fixed points in a finite time. We plotted the state space for different fixed points, and four regions were obtained. We found the points where the control function can steer the system to a stable state in a finite time. We found fixed points that are non-physical.

Keywords: complex systems, non-linear dynamical systems, controllability, Gershgorin circle theorem, compartmental model

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