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Chaotic dynamics of a fractional order glucose-insulin regulatory system

Key words: Diabetes mellitus; Chaos; Bifurcation; Multistability; Antimonotonicity

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Motivation

- The total estimated 2017 cost of diagnosed diabetes of \$327 billion includes \$237 billion in direct medical costs and \$90 billion in reduced productivity. So, this cost motivates research about this disease.
- The number of people with diabetes has risen from 108 million in 1980 to 422 million in 2014. So, this prevalence motivates research about this disease.

Main idea

- Proposing mathematical models for biological phenomena can help scientists better understand and even control diseases.
- We want to propose a model considering different parameters, leading to different types of these diseases.
- Fractional systems can be used in modeling of biological phenomena which have shown some complex dynamics in experimental data.

Method

We consider nonlinear methods like stability of equilibria, Lyapunov exponents, bifurcation diagrams, and the basin of attraction of the system.

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Major results

- A novel fractional order glucose-insulin regulatory system is derived.
- Various biological disorders caused by an unregulated glucose-insulin system are studied in detail.
- We have revealed that the glucose-insulin regulatory system shows multistability and antimonotonicity in its fractional order form.

Conclusions

- Nonlinear methods like stability of equilibria, Lyapunov exponents, bifurcation diagrams, and the basin of attraction of the system are powerful methods to analyze the biological systems.

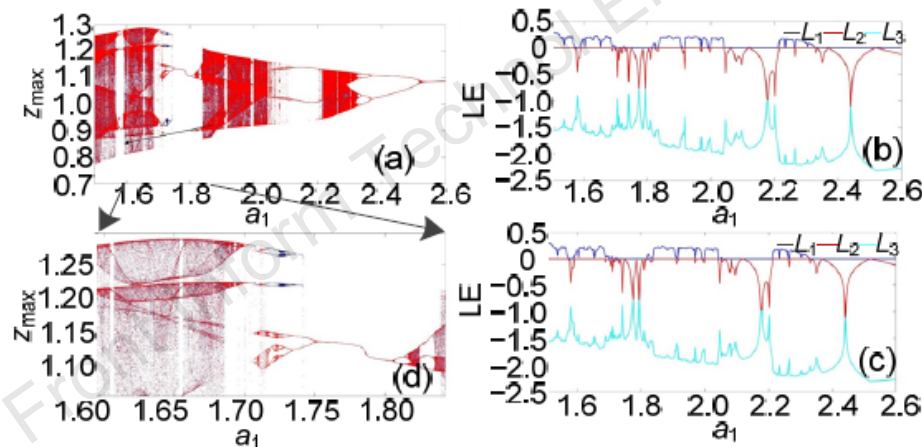


Fig. 5 Bifurcation diagram and Lyapunov exponents of FOGIRS as parameter a_1 changes: (a) forward and backward bifurcation diagrams of FOGIRS; (b) LEs of FOGIRS changing the parameter in forward continuation; (c) LEs of FOGIRS changing the parameter in backward continuation; (d) specified portion with multistability

Conclusions (Cont'd)

- The fractional order model exhibited the properties of coexisting attractors and antimonotonicity which have not been reported in the literature.

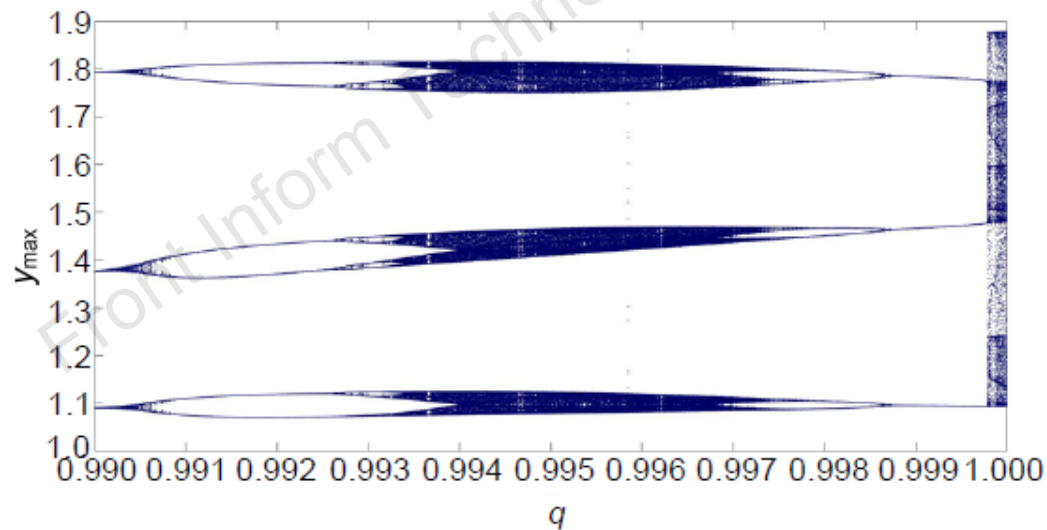


Fig. 9 Bifurcation diagram of FOGIRS for different values of the fractional order of the system