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Aircraft safety analysis based on differential manifold theory and bifurcation method

Key words: Loss of control; Safety envelope; Aircraft dynamic; Bifurcation analysis; Differential manifold theory

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Motivation

1. Loss of control (LOC) is considered one of the leading contributors to aircraft accidents, as a result of aircraft exceeding the flight safety envelope. Reducing LOC is critical to improve flight safety.

2. The flight envelope developed by the traditional method cannot take upset conditions into account and has much conservative.

Main idea

1. The bifurcation analysis method can be used to study the non-linear characteristics of aircraft and to observe the change of equilibrium state.

2. By introducing the differential manifold theory, an accurate safe flight envelope can be determined.

3. A combination of the bifurcation analysis method and the differential manifold theory has properties capable of guiding operation and determining the flight safety envelope.

Method

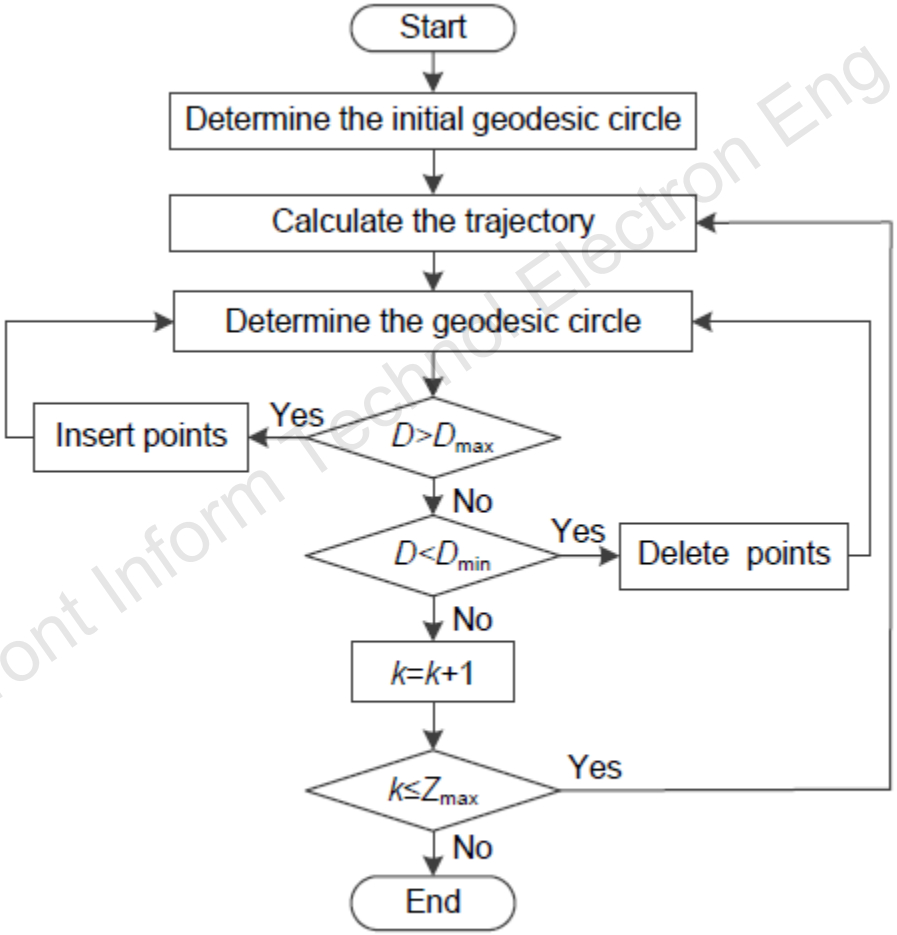
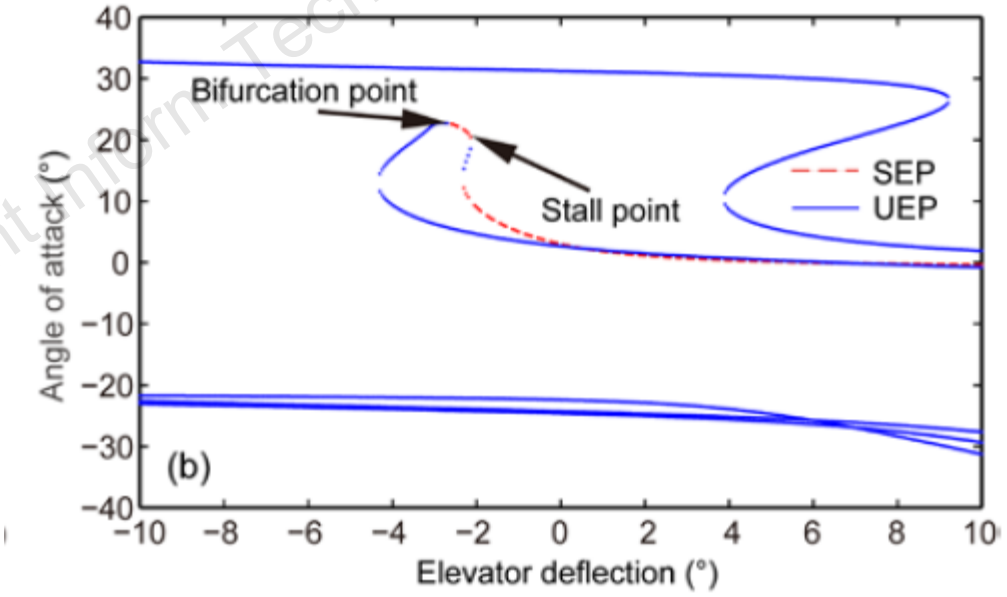


Fig. 1 Flow chart of envelope determination in the geodesic circles method

Major results

1. The bifurcation analysis method can be used to study the flight state changes of the aircraft under different maneuvers.



Major results

2. An accurate safety flight envelope can be determined by the differential manifold theory.

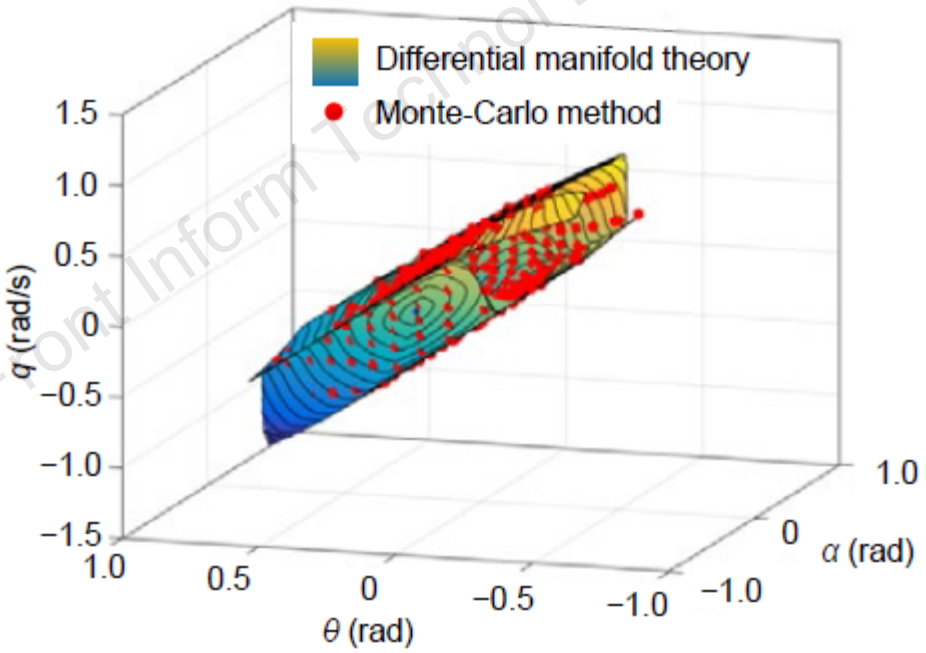


Fig. 6 Envelopes under different methods

Major results

3. A combination of the bifurcation analysis method and the differential manifold theory can be used to guide pilot operation.

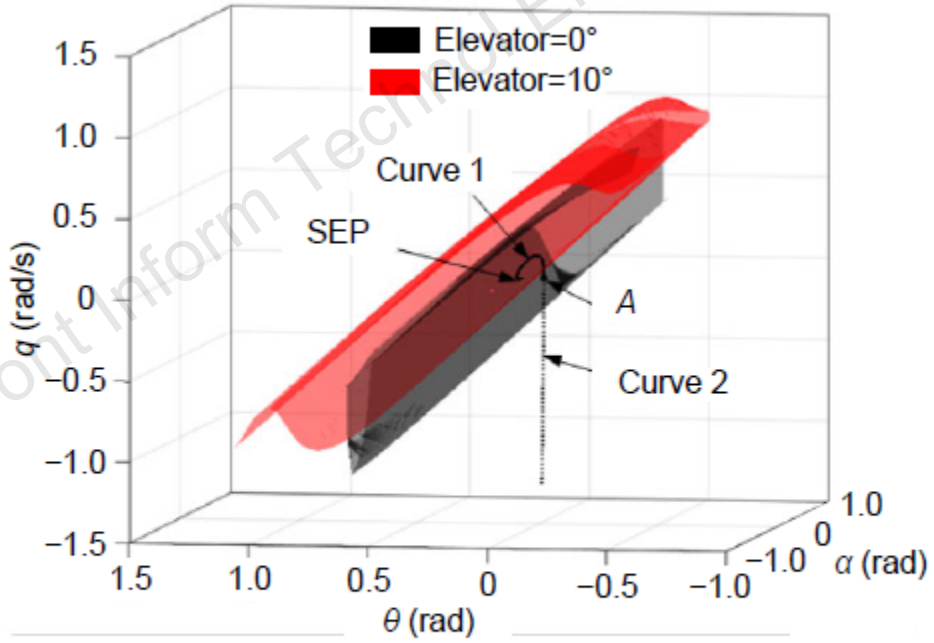


Fig. 7 Change of envelope with the pilot operation

References to color refer to the online version of this figure

Conclusions

1. Using the bifurcation analysis results for the research of GTM, the relationship between elevator deflections and equilibrium points has been shown in this paper.

2. Compared with the Monte Carlo method, the feasibility and accuracy of the differential manifold theory are justified.

3. The bifurcation analysis method and differential manifold theory complement each other well. The simultaneous use of these two methods can greatly improve the operating safety of the aircraft.