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An algorithm for trajectory prediction of flight plan based on relative motion between positions

Key words: Velocity vector; Hidden Markov model; Gaussian mixture model; Machine learning; Plan path prediction; Relative motion between positions (RMBP)

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Motivations

1. Flight trajectory prediction is a basic technique in air traffic control. Existing methods have low accuracy and stability.

2. Developing an algorithm for accurate trajectory prediction is challenging because of the stochastic factors during flight.

3. Existing methods for trajectory prediction are with preset models and cannot capture the transition patterns of the flight trajectory.

4. A new trajectory prediction algorithm that can improve the applicability and performance is needed.

Main ideas

1. The historical routes of flight are proven safe and feasible. The environmental factors along the route are considered.

2. The transition patterns of the velocity vector during flight are the fundamental for trajectory prediction.

3. The transition patterns of the velocity vector during flight have high similarity among different executions; thus, the sequence of the velocity vector can be predicted before departure.

Methods

1. The motion state of aircraft is composed of two parts, motion trend and motion parameters under different trends.

2. The motion trend during flight depends on the flight phase, which can be regarded as a sequential decision. Hidden Markov models (HMMs) are introduced to describe the flight motion and capture the stochastic factors of the transition patterns.

3. The motion parameters under different motion trends are predicted using the Gaussian mixture models (GMMs).

Major results

1. Confirmation of the parameters for HMM

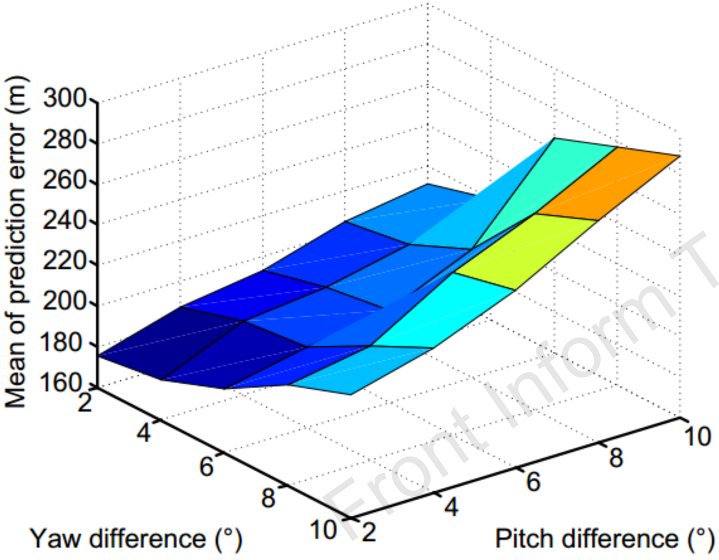

Fig. 3 Diagram of the prediction error with varied yaw and pitch when ς_v=12m/s

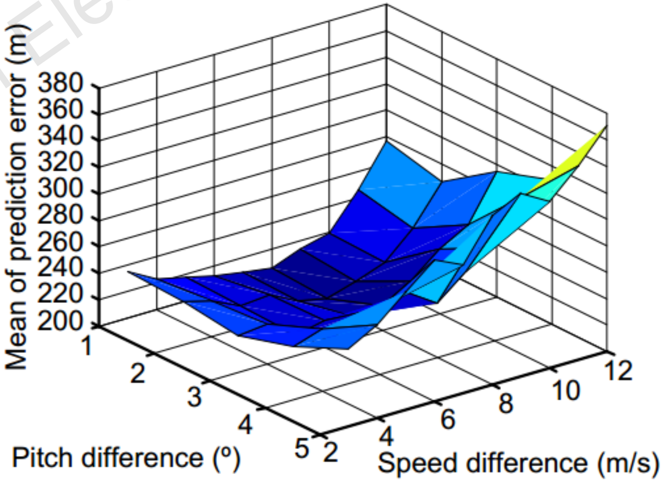

Fig. 4 Diagram of the prediction error with varied speed and pitch when ς_ϑ=4°

Major results

2. Predicted trajectory

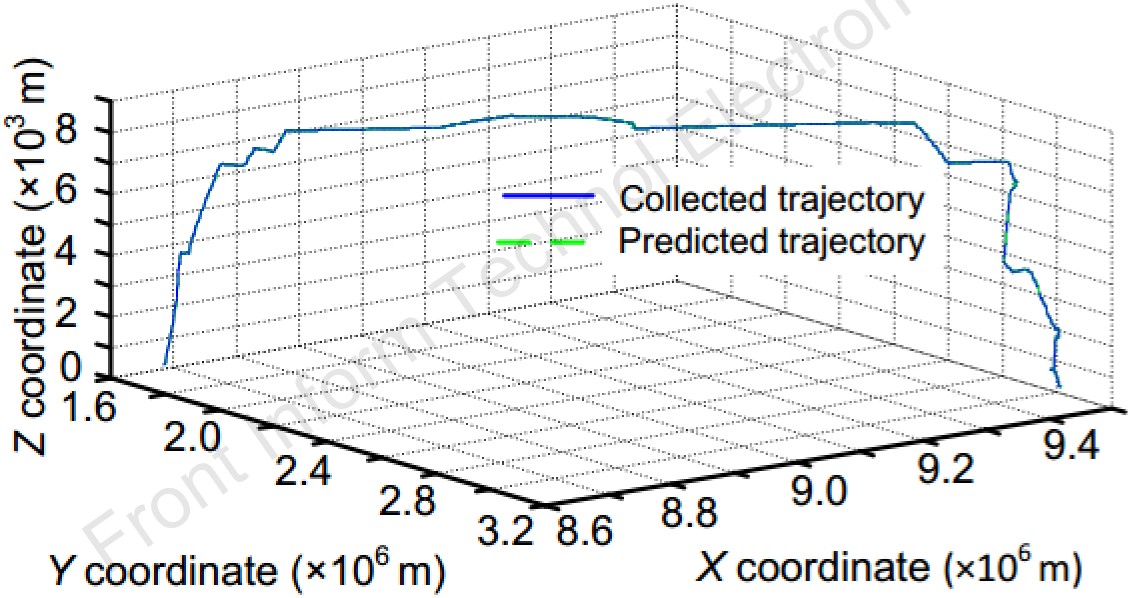

Fig. 6 Comparison between collected and predicted trajectories for a selected flight in the 3D space

Major results

3. Error distribution

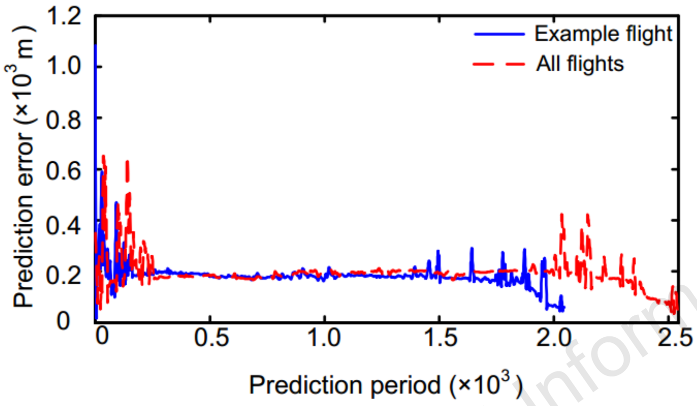

Fig. 7 Comparison of the prediction errors between a selected flight and all flights at different update periods

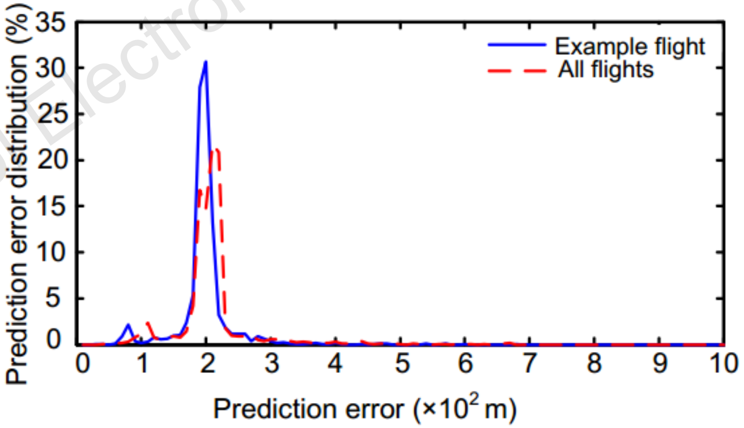

Fig. 8 Comparison of the prediction error distribution between a selected flight and all flights in different ranges

Major results

4. Comparison of results

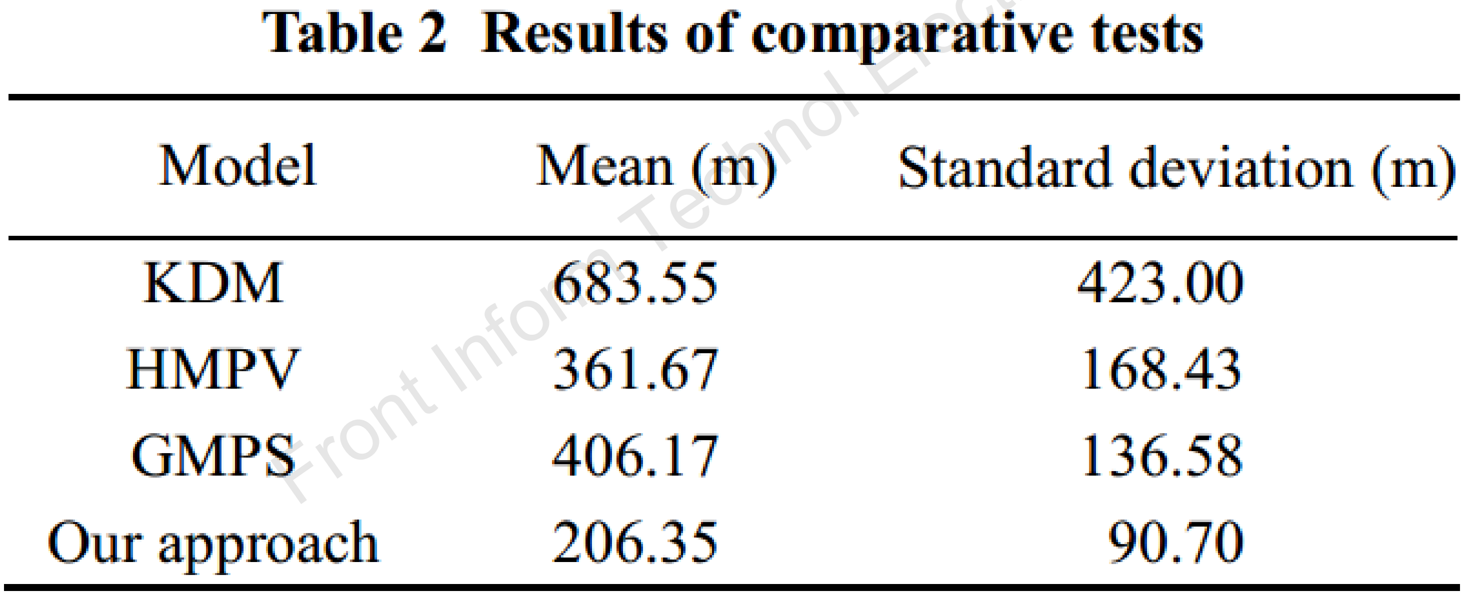

Table 2 Results of comparative tests

Model	Mean (m)	Standard deviation (m)
KDM	683.55	423.00
HMPV	361.67	168.43
GMPS	406.17	136.58
Our approach	206.35	90.70

Conclusions

1. The transition patterns of the motion trend are captured by the proposed HMMs.

2. The motion parameters under different motion trends are described by the proposed GMMs.

3. The trajectory prediction has good performance and shows superiority over the existing methods.