The Matlab Source Code of a Health Evaluation Method of Multicopters Modeled by Stochastic Hybrid System

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INTRODUCTION

This file set is a supporting material for our paper [1]. This paper proposes an stochastic hybrid system based (SHS-based) health evaluation method for multicopters under the framework of safety decision-making, where different health states and corresponding dynamic behaviors are modeled by SHS. Then, the health of the multicopter is defined with the concept of health degree which is a probability measure describing an extent of degradation from an expected normal condition. On this basis, the problem of multicopter's health evaluation is transformed to a hybrid estimation problem. For state estimation, a modified interacting-multiple-model (IMM)-based algorithm is proposed to estimate real-time distribution of hybrid states, and the health degree is further calculated. Finally, a case study of a multicopter with sensor anomalies is simulated to validate the effectiveness of the proposed method. Comparisons with the model without health state transitions and the classic IMM algorithm [2] are also made to show the advantages of the proposed method.

Please use Matlab to run all of the files in the file set. All the M-files have been checked availability on Matlab R2011b.

FILE LIST AND USAGE

1. "Modified_IMM_algorithm.m": Use the modified IMM algorithm to estimate multicopter's hybrid states based on SHS. The results are saved.

Input: None

Output: "modifieddata.mat"

2. "Expected_trajectory_generation.m": Assume the multicopter is fully healthy. The expected trajectory is generated.

Input: None

Output: "expecteddata.mat"

3. "Classic_IMM_algorithm.m": Use the classic IMM algorithm to estimate multicopter's hybrid states based on SHS.

Input: None

Output: "classicdata.mat"

4. “nonSHS_model.m”: Use the extended Kalman filter to estimate multicopter’s states based on “model without health state transitions”.

Input: None

Output: “nonSHSdata.mat”

5. “Health_evaluation_depict.m”: Depicts Figs. 1&2, and calculate health degree as shown in Fig. 6.

Input: “expecteddata.mat”, “modifieddata.mat”

Output: Figs. 1, 2 & 6

6. “Compare_with_nonSHS_depict.m”: Compares the performance of “SHS-based model” and “model without health state transition”, and depicts Fig. 3.

Input: “nonSHSdata.mat”, “modifieddata.mat”

Output: Fig. 3

7. “Compare_with_classicIMM_depict.m”: Compares the performance of the modified IMM algorithm and the classic IMM algorithm, and depicts Figs. 4&5.

Input: “classicdata.mat”, “modifieddata.mat”

Output: Figs. 4&5

8. “Kalman4IMM.m”: Function of Kalman filter.

function [X_posterior,P_posterior,e,S]=Kalman4IMM(X_prior,Y,Y_e,P_prior,A,C,tau_w,Q,tau_r,R)

Input:

X_prior: prior estimate of $\boldsymbol{x}$

Y: real system measurement

Y_e: estimated system measurement

P_prior: prior estimate of covariance matrix P

A, C: model parameter matrices

tau_w: system noise driven matrix

Q: system noise covariance

tau_r: measurement noise driven matrix

R: measurement noise covariance

Output:

X_posterior: posterior estimate of $\boldsymbol{x}$

P_posterior: posterior estimate of covariance matrix P

e: residual

NOTICE

Please read the specification in the files to get the further information. If you have any questions, then please feel free to contact Zhiyao Zhao (zzy_buaa@buaa.edu.cn) or QuanQuan (qq_buaa@buaa.edu.cn). If you use these files or results in your paper, please cite it as: Zhiyao Zhao, Quan Quan, Kai-Yuan Cai, “The Matlab Source Code of a Health Evaluation Method of Multicopters Modeled by Stochastic Hybrid System”, http://rfly.buaa.edu.cn/, January, 2016.

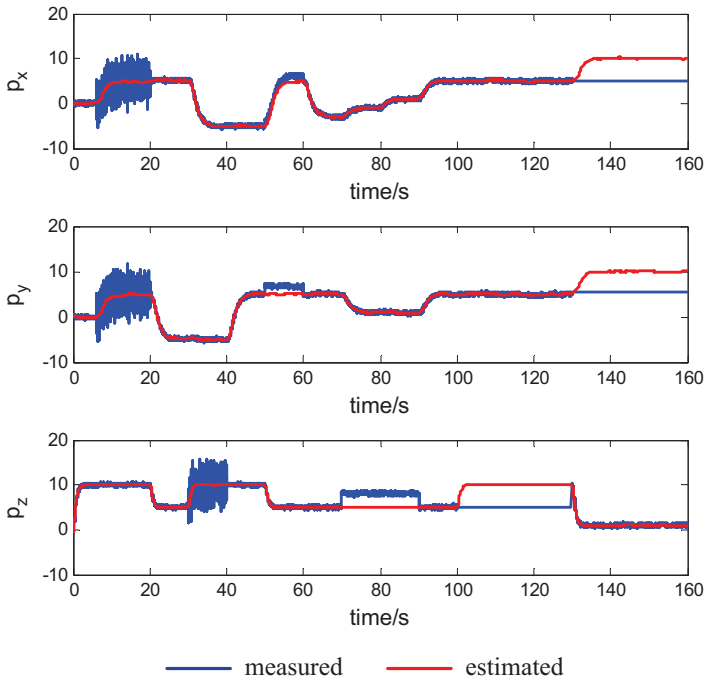

Fig. 1. Measurements and estimates of $\{p_x, p_y, p_z\}$

REFERENCES

[1] Zhao Z, Quan Q, Cai K-Y. (2016). A Health Evaluation Method of Multicopters Modeled by Stochastic Hybrid System (Submitted).

[2] Zhang, Y., & Li, X. R. (1998). Detection and diagnosis of sensor and actuator failures using IMM estimator. Aerospace and Electronic Systems, IEEE Transactions on, 34(4), 1293-1313.

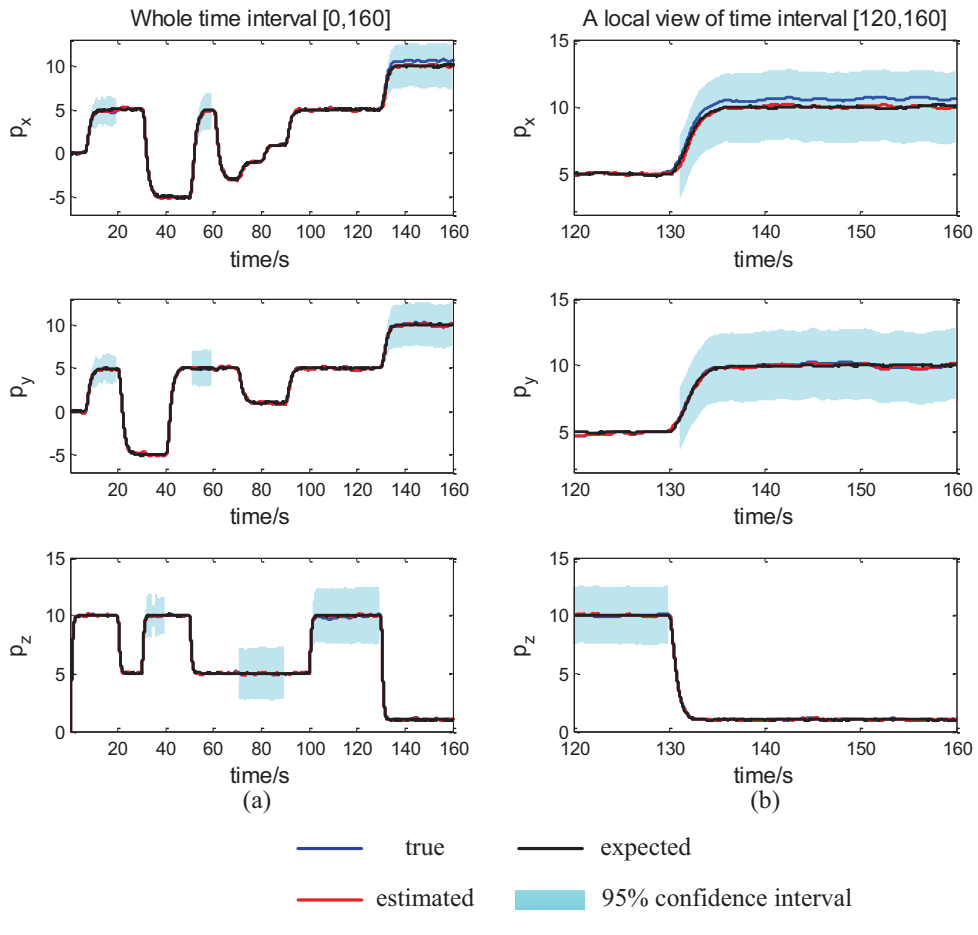

Fig. 2. True values, expected values, and estimates with 95% confidence interval of $\{p_x, p_y, p_z\}$.

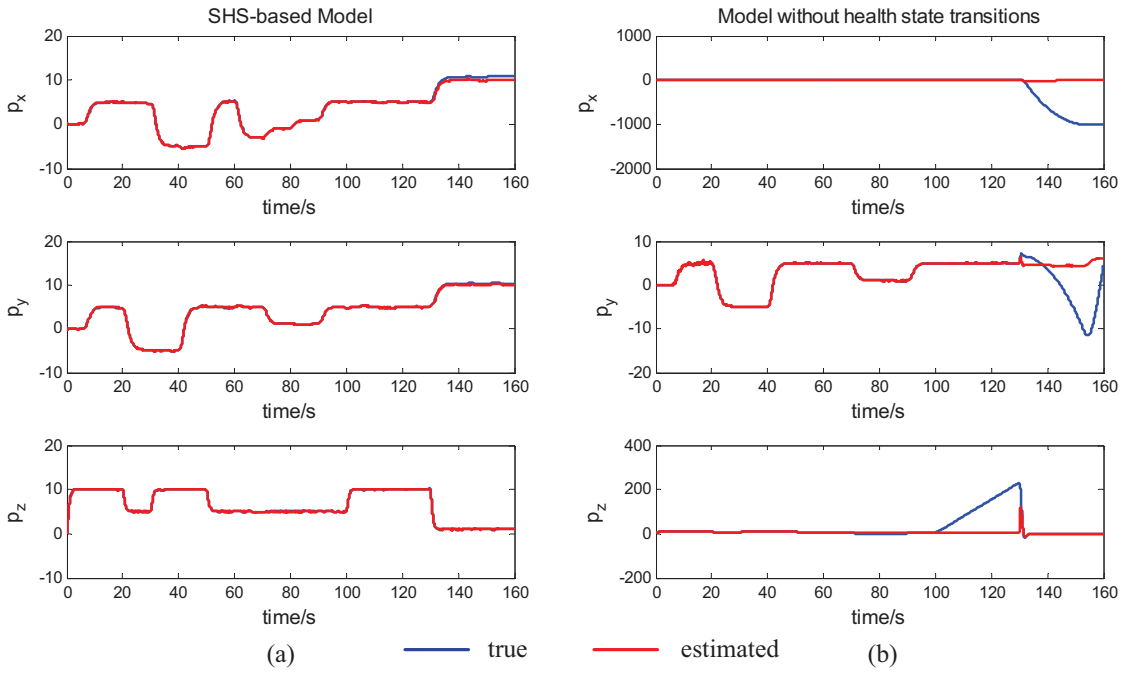

Fig. 3. Comparison of SHS-based model and model without health state transition

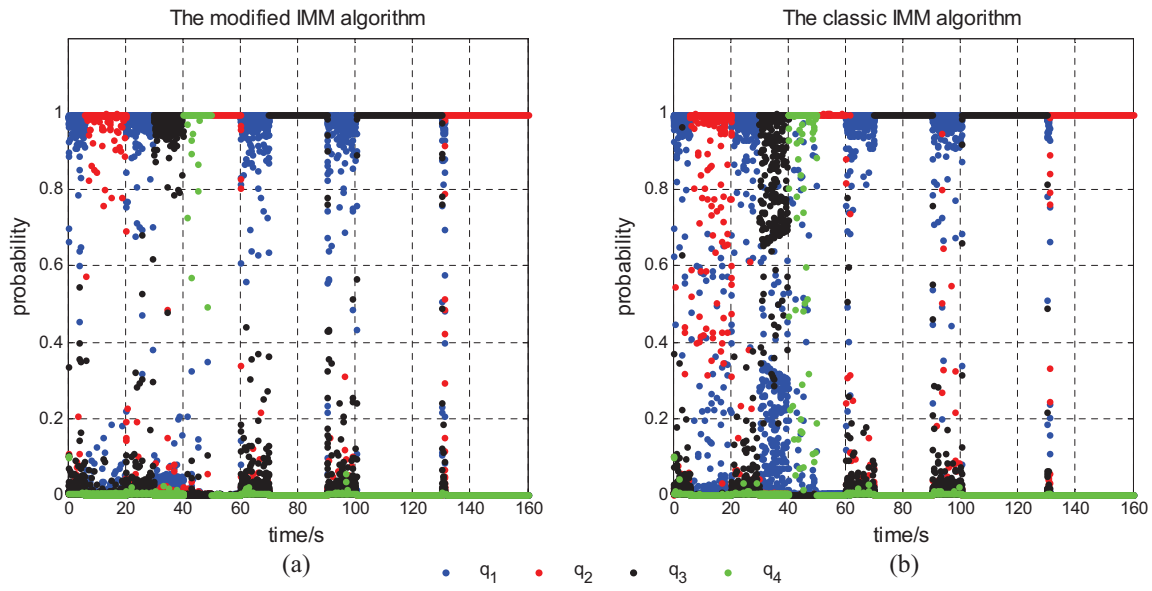

Fig. 4. Health state probability comparison with the classic IMM algorithm

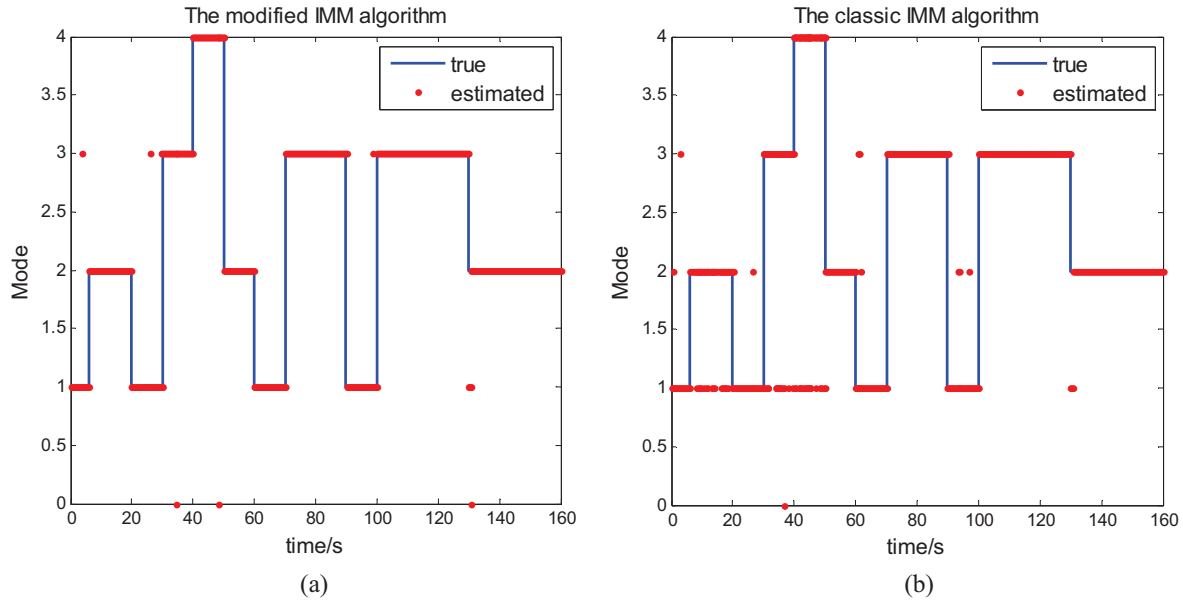

Fig. 5. Health state identification results and comparison with the classic IMM algorithm

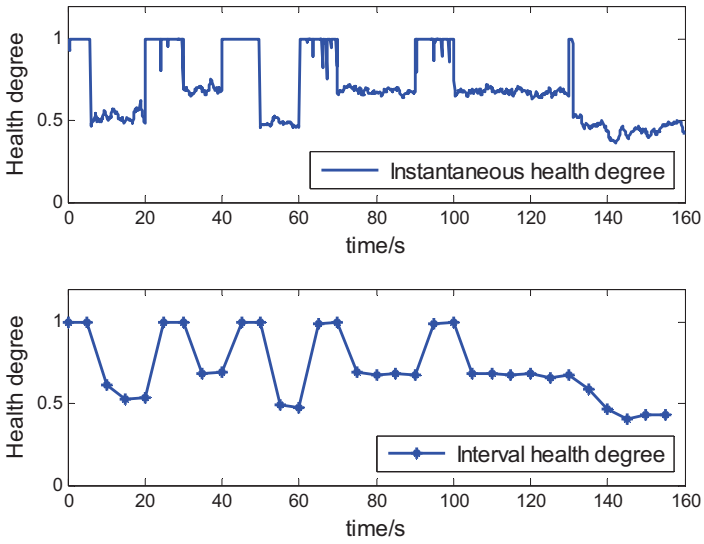

Fig. 6. Instantaneous health degree and interval health degree