

Fuel Feed Control for Asymmetric Arranged Multi-tanks Aircraft: A Hybrid MPC Approach

Haoyu Miao¹, Mengfan Cao¹, Shibo Chen¹, Zaiyue Yang¹

1. Southern University of Science and Technology, Shenzhen 518055, P. R. China
E-mail: haoyumiao97@gmail.com, chensb@sustech.edu.cn, yangzy3@sustech.edu.cn

Abstract: Aircraft fuel system, which provides a continuous source of fuel to the engine, is an important component of the aircraft. Although the sequential fuel feed strategy for the symmetric arranged multi-tanks aircraft is widely used in today's aircraft, the fuel feed strategy of the asymmetric arranged multi-tanks is still a challenge. In this article, a two layer offline approach is developed to obtain the fuel feed strategy to minimize the difference between the actual center of gravity (CG) and the desired CG. The performance of the proposed approach is tested in a case study based on the test data of aircraft pitch movement. The result indicates that the proposed approach solves the problem with an offline manner from the optimization perspective.

Key Words: asymmetric arranged multi-tanks, fuel feed control, hybrid MPC, warm start

1 Introduction

To be completed.

2 System Model

The details of the model is referred to [1].

3 Problem Formulation

$$\begin{cases} x_c(t) = \frac{\mathbf{m}(t)^T \mathbf{x}_{co}(t)}{M + \mathbf{1}^T \mathbf{m}(t)} \\ y_c(t) = \frac{\mathbf{m}(t)^T \mathbf{y}_{co}(t)}{M + \mathbf{1}^T \mathbf{m}(t)} \\ z_c(t) = \frac{\mathbf{m}(t)^T \mathbf{z}_{co}(t)}{M + \mathbf{1}^T \mathbf{m}(t)} \end{cases} \quad (1)$$

$$\mathbf{u}_{t|\tau}^T = [\mathbf{x}_{t|\tau}^T, \mathbf{y}_{t|\tau}^T]^T \in \mathbb{R}^{2n} \quad (2)$$

$$\mathbf{x}_{t|\tau} = V_x \mathbf{u}_{t|\tau} \in \{0, 1\}^n \text{ and } \mathbf{y}_{t|\tau} = V_y \mathbf{u}_{t|\tau} \in \mathbb{R}_+^n, [T] = 0, 1, \dots, T$$

Constraints:

$$\mathbf{m}_{0|\tau} = \mathbf{m}_\tau \quad (3)$$

$$\mathbf{m}_{t+1|\tau} = \mathbf{A} \mathbf{m}_{t|\tau} + \mathbf{B} \mathbf{u}_{t|\tau}, t \in [T] \setminus T \quad (4)$$

$$\mathbf{0} \leq \mathbf{m}_{t|\tau} \leq \bar{\mathbf{m}}, \forall t \in [T] \quad (5)$$

$$\mathbf{0} \leq \mathbf{y}_{t|\tau} \leq \min\{K \mathbf{x}_{t|\tau}, \bar{\mathbf{y}}\}, \forall t \in [T] \setminus T \quad (6)$$

$$\sum_{i \in \mathcal{M}_m} y_i(t) \geq h(t), \forall t \in [T] \setminus T \quad (7)$$

$$[x_i(t+1) - x_i(t)] \times \left[\sum_{j=1}^L (x_i(t+j)) - L \right] \geq 0 \quad (8)$$

$$\begin{aligned} -M_1 \{1 - [x_i(t+1) - x_i(t)]\} &\leq \sum_{j=1}^L (x_i(t+j)) - L \\ &\leq M_1 \{1 - [x_i(t+1) - x_i(t)]\} \end{aligned} \quad (9)$$

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4 Methodology

5 Experimental Results

$$\begin{cases} m_{1,t+1|\tau} = m_{1,t|\tau} - y_{1,t|\tau} \\ m_{2,t+1|\tau} = m_{2,t|\tau} - y_{2,t|\tau} + y_{1,t|\tau} \\ m_{3,t+1|\tau} = m_{3,t|\tau} - y_{3,t|\tau} \\ m_{4,t+1|\tau} = m_{4,t|\tau} - y_{4,t|\tau} \\ m_{5,t+1|\tau} = m_{5,t|\tau} - y_{5,t|\tau} + y_{6,t|\tau} \\ m_{6,t+1|\tau} = m_{6,t|\tau} - y_{6,t|\tau} \end{cases} \quad (9)$$

A is an identity matrix.

$$B = \begin{bmatrix} \mathbf{0} & \begin{bmatrix} -1 & 0 & 0 & 0 & 0 & 0 \\ 1 & -1 & 0 & 0 & 0 & 0 \\ 0 & 0 & -1 & 0 & 0 & 0 \\ 0 & 0 & 0 & -1 & 0 & 0 \\ 0 & 0 & 0 & 0 & -1 & 1 \\ 0 & 0 & 0 & 0 & 0 & -1 \end{bmatrix} \end{bmatrix} \quad (10)$$

Table 1: Geometric Center Coordinates of Fuel Tanks

Fuel Tank	Geometric Center Coordinates (Unit:m)		
	x	y	z
#1	8.913043	1.20652174	0.61669004
#2	6.91304348	-1.39347826	0.21669004
#3	-1.68695652	1.20652174	-0.28330996
#4	3.11304348	0.60652174	-0.18330996
#5	-5.28695652	-0.29347826	0.41669004
#6	-2.08695652	-1.49347826	0.21669004

6 Conclusion

References

- [1] Haoyu Miao, Zikai Ouyang, Shunpeng Yang, Weichao Yan, Mengfan Cao, Shibo Chen, and Zaiyue Yang. Optimal fuel feed strategy for asymmetric arranged multi-tanks aircraft. In *2021 3rd International Conference on Industrial Artificial Intelligence (IAI)*, pages 1–6. IEEE, 2021.