Flight reliability of multi rotor UAV Based on genetic algorithm

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Abstract. In the disturbed case, since the parameter tuning method is imperfect, there have been issues of excessive overshoot and adjusting time in MFAC. To optimize MFAC controller, a MFAC-ABC is proposed, with ITAE criterion as the fitness function, and key parameters of $\eta_k$and μ are optimized and tuned using ABC, and MFAC simulation model is established using Matlab Simulink platform, with written ABC control algorithm. Simulation results show that, compared with traditional MFAC and MFAC-PSO, MFAC-ABC control method is effective in reducing the response time and the overshoot, with good robustness, which has improved the adaptability and effectiveness of MFAC in the disturbed case.

Introduction

MFAC is a new method of data-driven control established based on the new non-parametric time-varying dynamic linearization, and its essence is to replace the general nonlinear system with a series of dynamic linear time-varying model nearby trajectory of controlled system by using the newly introduced concept of pseudo-partial-derivative and pseudo order, and only the input and output data of the controlled system is used to estimate pseudo-partial-derivative of system online, and on this basis, self-adaptive control is re-designed to meet the performance indicators.

MFAC

We assuming that there are N cities in total, M is the total number of ants, let us suppose that M ants are put into N randomly selected cities, $d_{ij}\left(i,j=1,2,3\cdots,n\right)$ represents the distance between city i and city j , $\tau_{ij}\left(t\right)$ represents the amount of remaining information on the t time between the city of i and the city of j , at the initial time, the amount of information on each path is equal, assuming that $\tau_{ij}\left(0\right)=c$ (c is the constant), when ant $k\left(k=1,2,3\cdots,m\right)$ is in the process of movement, they will choose the next city that has not yet been visited on the basis of the amount of information on each path, at the same time, after they complete a step or a cycle, in other words, from a city to another city or complete the access to all cities, they will update the residual information on all paths. The basis for choosing the next city is mainly as follows [15]: residual amount of information was left between city of i and city of j on the time of $\tau_{ij}\left(t\right)$, that is, the information was provided by ant colony algorithm, as to the aspirational information the η_{ij} ants transfer form city of I to city of J, this heuristic information can be given by the problem which were waiting to be solved, and it can be realized by a certain algorithm, in the problem of TSP, generally we get the value $\eta_{ij}=\frac{1}{d_{ij}}$, η_{ij} here can be called a priori knowledge, and then we can get the probability that $p_{ij}^{t}\left(t\right)$ on the t time ants k transfer from city i to the target city j .

$$p_{ij}^{t}(t)=\begin{cases}\dfrac{\tau_{ij}\bullet\eta_{ij}^{\beta}(t)}{\sum\limits_{s\in allowed_k}\tau_s^{\alpha}\bullet\eta_{ij}^{\beta}(t)} & j\in allowed_k\\ 0 & otherwise\end{cases} \quad (1)$$

$allowed_k=\{1,2,3,\cdots n\}-tabu_k$ —Represents the optional cities which ants k can choose on time t, that is, these cities haven't yet visited by ants. Compared with the real ant colony system, there is a difference that the artificial ant colony system has a certain memory function, here we use $tabu_k\ (k=1,2,3,\cdots m)$ to record the cities which has been passed through by ants;

α —The relative importance of residual information;

β — The relative importance of the expected value.

Through n moments, the ant completes a cycle [16], before the next round of the cycle, the new information must be added to the τ_{ij} in which the latest ants have been visited. The amount of information should be adjusted according to the following formula:

$$\tau_{ij}(t+n)=\rho\tau_{ij}(t)+\Delta\tau_{ij} \quad (2)$$

$$\Delta\tau_{ij}=\sum_{k=1}^{m}\Delta\tau_{ij}^{k} \quad (3)$$

ρ is the information residual coefficient, to imitate the characteristics of human memory, the old information will be gradually weakened as time goes by, the information that was left behind will fade away, and we use the parameter 1-ρ to represent the degree of information disappearing (the volatile degree).

$\Delta\tau_{ij}^{k}$ —The amount of information on the path i to the path j of the first ant k in this cycle (during the time period T to $(t+n)$ within the access process).

Structural Style

Four rotor aircraft motor 3 and 1 counter clockwise rotation at the same time, the motor 4 and motor 2 clockwise rotation, so when the aircraft balance flight, the gyro effect and aerodynamic torque effects are offset.

As shown in the figure above, motor and motor 3 reverse clockwise rotation, the motor and the motor 4 clockwise rotation, along the X axis is moving in the direction of the said forward movement, the arrow in rotor moving in a plane above said the motor speed increase, below that the rotational speed of the motor decline.

(1) vertical movement: also increases the output power of the four motor, increased rotor speed leads to the increase of the total tension, when the total pulling force sufficient to overcome the whole weight, four rotor aircraft and ground vertical upward; conversely, and reduce the output power of the four motor, four rotary wing aircraft is vertical drop, landing until the balance, the realization of the along the Z axis of vertical motion. When the external disturbance is zero, the lifting force generated by the rotor is equal to the weight of the aircraft, the aircraft will keep hovering.

(2) pitch motion: in figure (b), the motor 1 of the speed of the motor speed up, 3 of the motor speed drop (change the amount of the same amount), motor 4, motor speed of 2 to maintain the same. Due to rising 1 lift rotor, rotor 3 lift decline, unbalanced torque generated by the fuselage around the Y axis rotation. Similarly, when the speed of a motor 1 drop, 3 motor speed is increased, the body will be around another direction of y-axis rotation, pitching motion of the vehicle.

(3) rolling motion: and figure B the principle is the same, in Figure C, change the motor and the motor 4 speed and keep the motor and motor constant speeds of 3, can make the body around the X axis rotation (forward and reverse), realizing the rolling of the aircraft. (4) yaw motion: rotor process can form and rotation direction opposite torque due to air resistance, in order to overcome the influence of anti torque, the four rotor of two forward, two inversion and each diagonal rotor

rotating in the same direction. Anti torque and the size of the rotor speed, when the four motor speed and in the same, the four rotor anti torque balance each other. Four rotor aircraft does not rotate; when the four motor speed is not exactly the same, the imbalance of the anti torque will cause rotation of the four rotor aircraft. In Figure D, when the rise in the motor A and the motor speed, motor and motor speed decreases, rotor and rotor 3 on the fuselage anti torque is larger than the rotor and rotor of the fuselage anti torque, the body will be in surplus anti torque under the action of around Z axis, vehicle yaw motion, steering and motor, a motor 3 turn in the opposite direction.

(5) before and after the movement: in order to achieve the aircraft in the horizontal plane around, around the movement, must be in the horizontal plane of the aircraft to exert a certain force. In Figure e, increase the speed of the motor 3, so that the tension increases, the corresponding reduction in the motor 1 speed, so that the tension decreases, while maintaining the other two motor speed unchanged, the reverse torque is still to maintain balance. According to the theory of figure B, the aircraft first has a certain degree of tilt, so that the rotor pull the horizontal component, so the aircraft can be achieved before the flight movement. The backward flight is exactly the opposite of the forward flight. (in Figure C figure B, the aircraft in the production of pitch, roll motion also produces along the X, Y axis of the horizontal movement.

(6) the tendency to move: in Figure F, due to the symmetry of the structure, the tendency of the flight of the working principle is exactly the same as before and after movement.

Simulation and verification

To test the control performance of MFAC-ABC, the compressor outlet pressure model $G_s = \frac{12}{345s^2+16s+1}$ is selected as the controlled object. MFAC is developed in the MATLAB / Simulink and the preparation of ABC optimization algorithm is made. Using ABC optimization algorithm, it comprises MFAC-ABC control with MFAC, and simulation is made without disturbance and under constant disturbance. As can be seen from the verification results, compared with the traditional MFAC and MFAC-PSO control, MFAC-ABC control has obvious advantages in aspects of overshoot, response time and robustness for the air compressor outlet pressure, which has validated the effectiveness MFAC-ABC. Optimized parameters of η_k and μ are shown in Figure 1

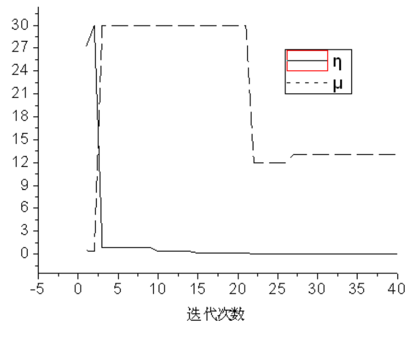

Figure 1Optimal-tuning results of η_k and μ

Figure 2 shows that after 23 iterations, η_k gets the optimal solution 0.04726, and after 26 iterations, μ gets the optimal solution 13.04238. Meanwhile, it is set that $\rho_k = 1$ = 1, λ = 0.1 .. According to this set of parameters, the resulting fit is 718.848. At the same time, simulation results of the compressor outlet pressure model are obtained without disturbance and under constant disturbance under the control of MFAC-ABC, shown in Figure 1and Figure 2

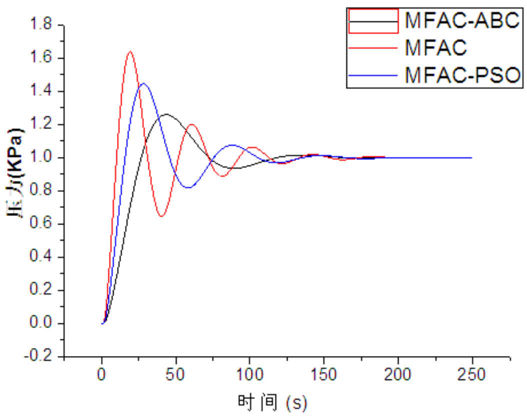

Figure 2Simulation results of compressor outlet pressure control without disturbance

Conclusion

In allusion to issue of parameter tuning in MFAC, MFAC-ABC is proposed, and MFAC-ABC simulation module is developed using MATLAB/Simulink, and this module is used to build a system model of outlet pressure controlling of air compressor and simulation is made. The simulation results show that MFAC-ABC has advantages of small overshoot, short adjusting time, strong robustness and others, with good stability and steady precision, having perfect control effect.

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