The collision-free path planning procedure based on the fusion universal gravitation search algorithm is as follows:

Step1. Establish a three-dimensional environment model for the spatial cellular robot working environment, generate a three-dimensional spatial discrete node set \( p(x, y, z) \). Initialization parameter, initial velocity of particle \( v^i_T \), initial acceleration \( a^i_T \), number of ants \( Nc_{\text{max}} \), heuristic factors \( \alpha \) and \( \beta \), initial value of pheromone attenuation coefficient \( \rho_0 \), initial value of angle coefficient \( \xi^0 \).

Step2. Select the starting point and the target point to facilitate the planning of the distance between nodes and the global map information in the path planning problem in the discrete grid space model.

Step3. Calculate the particle fitness function \( fit_i(t) \) and update the interparticle attraction \( F^d_{ij} \).

Step4. Perform a rough search and update the particle-related locations \( x^d_{ij} \).

Step5. If \( t > t_{\text{max}} \), proceed to the next step, otherwise, let \( t = t + 1 \) and go to step 3.

Step6. Convert the optimal or suboptimal solution of the path plan obtained by the gravity search algorithm into the initial value of the pheromone \( \tau^d_{i,j,k} \) and update the pheromone \( \tau^d_{i,j,k} \) distribution.

Step7. Use the stratification strategy to divide the 3D space model into planes and limit the searchable area \( M_w(v = 0,1,..,n) \) of each aliquot plane \( M_w, v = 0,1,..,m/h_{\text{max}} \). And define the maximum lateral distance \( x_{\text{max}} \) and the maximum longitudinal distance \( z_{\text{max}} \) of ants. According to the prior information of spatial model, the maximum number of layers \( w_{\text{max}} \) and the maximum number of explorables \( v_{\text{max}} \) are defined.

Step8. Let \( w \) be assigned a value of 1.

Step9. \( v \) is assigned a value of 1, \( Nc \) is assigned a value of 1.

Step10. Place the ant k definition on the searchable area \( M_w, v \) in the plane \( M_w \) of \( P_w \).

Step11. Calculate the current point \( P_w \) corresponding to the multivariate heuristic function \( H(i, j, k) \) according...