Research On Prevention Of Falling Of Coconut Branches On Humans Using Iot Based Monitoring System

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Abstract: WSN (Wireless Sensor Networks) has been widely used in the civil field with the popularization of Internet of things technology. Coconut branches fall monitoring is a new field of WSN application; the use of unmanned aerial vehicle to replace traditional manual patrol can improve the inspection precision and reduce the labor cost. However, the field environment is complex, which poses a great challenge to the WSN path planning. In this paper, according to the terrain characteristics of coconut garden, the three-dimensional space model is established, and the ant colony algorithm is used to design the optimal path of WSN. The simulation results show that the algorithm proposed in this paper can find the optimal patrol route with the coincidence condition, which provides a basis for the research on the practical application of WSN in coconut fall inspection.

Key words: WSN, coconut fall prevention monitoring, three-dimensional space model.

1 INTRODUCTION

1.1 WSN Coconut field Monitoring

Path Planning

Relative to the WSN plains garden monitoring, the field monitoring path planning issues are more complicated. Because the surface of the field is peculiar and varied. Some are parallel to each other, stretching hundredths of kilometres and some overlap with each other, intertwined and incessantly continuous. This will be a three-dimensional WSN path planning problem, and the model is further complicated due to the need to consider the height of the tree [1]. In coconut field, sensors are fixed and when the coconut or branches gets dried up it will be intimated to the farmer immediately using the application. In order that WSN can conduct safe and efficient monitoring, we conduct abstract three-dimensional modeling to the environment area that needs to be inspected and then carry out optimization treatment with the ACA.

1.2 Three-dimensional Space Modeling

The modeling of the monitoring environmental area refers to represent the real environment information in the abstract way [2]. The modeling method is closely related to the optimization algorithm adopted and has a great impact on the results of WSN path planning [3].

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In this paper, the median interpolation algorithm is adopted. By interpolating the height data of a coconut field region, the three-dimensional terrain structure map of the corresponding field is constructed in the form of equal height data of adjacent nodes.

Figure 1: Monitoring area

The three-dimensional environmental space abstract modeling adopts three-dimensional grid method, with direct manipulation of the three-dimensional field data [4]. Assume a monitoring region as shown in Figure 1, with the minimum longitude and latitude of the field area as the origin of coordinates O, the right direction as the X axis, the forward direction as the Y axis, and the vertical level upward direction as the Z axis to establish the three-dimensional space coordinate system [5]. Figure 2 is a top view of monitoring area. The coordinate length in the X-axis direction is AE, the coordinate length in the Y-axis direction is AD and the length in the longitudinal direction is AB. a cube area ABCD-EFGH of monitoring area is constructed based on the three side lengths, as shown in Figure 3.
First, the AE edge is n-divided along the X axis to obtain n+1 plane Ni (i = 0, 1, ..., n). Then, as shown in Figure 4, all the planes Ni are equally divided along the Y axis by m, and divided by k along the Z axis to obtain a three-dimensional grid. The intersection of the grid graph is set as the node of the ant search path.

Till now, the monitoring area is discretized into a series of grid intersections and devoted by the set S. For any point p the coordinate is \(P(x_i, y_j, z_v)\) (i = 0, 1, ..., n; j = 0, 1, ..., m; v = 0, 1, ..., k) where i, j, v are the ordinal numbers of the points P on the three sides of X, Y, Z, respectively. Assume that the AE length is a, the length of the A1D1 side is b, and the length of the A1B1 side is h and the coordinates of point p are:

\[
\begin{align*}
x_i & = i \cdot a / n \\
y_j & = j \cdot b / m \\
z_v & = v \cdot h / k
\end{align*}
\]

2 ACA (ANT COLONY ALGORITHM) PATH DESIGN

2.1 Path point search rules
According to the position of the starting point and ending point, we set the direction of ant crawling, with the starting point coordinate of \(P_S\) and the ending point coordinate of \(P_M\). Suppose that the X-axis is the direction of ant crawling, and the starting point \(P_S\) and the ending point \(P_M\) are on planes \(N_0\) and \(N_n\), respectively. In the process of ACA optimization path, ants start from the starting point \(P_S\), and then crawl to a path node \(P_{i1} \cdot \checkmark \), \(j_1, v_1 \) on the plane \(N_1\). Then, the ant starts again from the point \(P_{i1} \cdot \checkmark \) to the path node \(P_{i2} \cdot \checkmark , j_2, v_2 \) on the next plane \(N_2\). According to this rule, the corresponding path points are selected on each plane in turn, and finally the end point \(P_M\) is reached to search for a monitoring path [7]. According to the fall status, the WSN based branches movement will be simplified as five movement status including forward, upward, downward, left moving and right moving [8]. Set the unit length of WSN moving forward during monitoring to be 1, with the allowing single-step maximum lateral movement \(L_y\) and the maximum longitudinal movement \(L_z\).
According to this movement rule, the ant selects the path point

\[ P_{1}^{i_{1}, j_{1}, v_{1}} \] on the \( N_{i_{1}} \) plane from the point \( P_{1}^{i_{1}, j_{1}, v_{1}} \) on the plane \( N_{i} \) as follows:

1. According to the range of single-step movement of the ant, all possible path nodes on the \( N_{i_{1}} \) plane are determined, namely the area is:

\[ \psi_{i_{1}, j_{1}, v_{1}} - L_{y_{i_{1}, j_{1}, v_{1}}}, L_{y_{i_{1}, j_{1}, v_{1}}} \]

2. Calculate the heuristic information \( H_{i_{1}, j_{1}, v_{1}} \) of all feasible points \( i_{1}, j_{1}, v_{1} \) in the feasible region \( \psi \) on the \( N_{i_{1}} \) plane;

3. Calculate the selection probability \( P_{i_{1}, j_{1}, v_{1}} \) of all possible points \( i_{1}, j_{1}, v_{1} \) in the feasible area \( \psi \) in the \( N_{i_{1}} \) plane according to the following equation;

\[ P_{i_{1}, j_{1}, v_{1}} \sum_{j_{1}, v_{1}} H_{i_{1}, j_{1}, v_{1}} = \frac{\tau_{i_{1}, j_{1}, v_{1}}}{\sum_{j_{1}, v_{1}} H_{i_{1}, j_{1}, v_{1}}} \]

(2)

0

(point \( i_{1}, j_{1}, v_{1} \) is a feasible point)-2

(point \( i_{1}, j_{1}, v_{1} \) is an unfeasible point)

4. The feasible points on the plane are selected with the roulette method according to the selection probability of feasible points.
\( H_i, j, v \square D_i, j, v \square M_i, j, v \square W^3 \) \( (3) \)

### 2.2 Heuristic function design

The heuristic function plays an important role in the fast convergence optimized solution of constraint algorithms [9]. In this paper, the navigation factors including safety and shortest distance of UAV monitoring are mainly considered and the heuristic function \( H_i, j, v \) is designed as follows:

Where, \( S_i, j, v \) is a safety factor. The equation is as follows:

\[
1 \quad \min_1 \quad z_y \quad h_v
\]

\[
S_i, j, v \quad z_y \quad h_v
\]

\[
1 \quad \min_1 \quad z_y \quad h_v
\] \( (4) \)

Where \( z_y \) is the field altitude when the WSN is at a feasible path node \( d_i, j, v \) and \( h_v \) is the height of the coconut tree at the path point \( d_i, j, v \). \( \Delta, \beta, \xi \) is a fast factor, which can reduce the monitoring distance. Its function value represents the expected path length between any point \( d_i, j, v \) in the selected area \( \psi \) on the rectangular plane \( N_i \) where the next path point is located to the target point \( P_M \).

The larger the value is, the shorter the total length of the final route selected for this point may be. The calculation method is shown in the equation:

\[
D_i, j, v \quad S_i, j, v \quad z_y \quad h_v \quad \min_1 \quad d_i, j, v \quad \psi \quad \Delta, \beta, \xi
\]

\[
d_i, j, v \quad \Delta, \beta, \xi \quad x_i - x_M - y_i - y_M - z_M - z_y
\]

Where \( x_i, y_i, z_i \) are the coordinates of feasible points \( d_i, j, v \) on the plane \( N_i \), and \( x_M, y_M, z_M \) are the coordinates of the ending point \( P_M \).

\( M_i, j, v \square \) is the same altitude factor. In the monitoring process, the WSN cannot frequently rise or fall, with the same altitude. In the face of obstacles, the WSN needs to change the altitude and continues to work at a certain point. In response, we designed the heuristic function \( M_i, j, v \) to minimize the variation of altitude. The greater the value of the heuristic function is, the bigger the possibility of the route can be made in the same height is. The calculation equation is as follows:

\[
M_i, j, v \quad \Delta_i, j, v \quad \min_1 \quad \Delta_i, j, v
\]

Where \( z_y \) is the height of the ant at time \( v \), and \( z_y \) is the height of the ant at time \( v + 1 \). \( w_1, w_2 \) and \( w_3 \) are coefficients, representing the importance of various factors.

### 2.3 Pheromone update principle

The pheromone update method is the key to successful ACA [10]. The algorithm in this section adopts (Equation as follow) local pheromone update rule. When the ants crawl over the path point, the pheromone of the path point is reduced, so as to increase the probability of the ants exploring the unknown path point, to achieve the purpose of global search.

\[
\tau_{i,v} \quad 1 - \varepsilon
\]

\[
\tau_{i,v} \quad \varepsilon \cdot \tau_0
\] \( (7) \)

Where \( \varepsilon \) is the number of 0 \( \varepsilon \) 1 and \( \tau_0 \) is the initial value of pheromone.

When ants finish a path search, the length of the path is used as the evaluation. Select the shortest path from all paths and increase the pheromone value of each node on the shortest path according to the global pheromone update rule. The update equation is as follows:

\[
\tau_{i,v}^f \quad (m) \quad 1
\]

\[
\tau_{i,v} \quad \sum_{i=1}^{n} \frac{1}{L_{i,m}}
\]

Where \( f (m) \) is the evaluation function value of the shortest path taken by the ant, as shown in the following equation.

\[
f_{m} \quad \sum_{i=1}^{n} \frac{1}{L_{i,m}}
\]

Where \( L_{m} \) is the length of the \( m \)th path of the \( m \)th ants passing through the path, and \( p \) is the volatility coefficient of the pheromone, 0 \( p \) 1.

### 3 ACA THREE-DIMENSIONAL PATH PLANNING SIMULATION AND RESULTS

Realize algorithm programming and verification with NS3 and use the environment model built in the previous section, with length of X-axis \( a=21km \), length of Y-axis \( b=21km \), length of Z-axis=2000m, the average amount of partitions \( n=21 \), \( m=21 \), \( k=10 \), the starting point coordinate \( P_S (1,10,800) \), ending coordinate \( P_U (21,8,1000) \), the maximum left and right movement \( L_y \) \( 2 \) and the maximum upward and downward movement \( L_z \) \( 2 \). Assuming that the weights of the factors in the heuristic function are equal,
the coefficient $\xi = 0.5$ for local pheromone updating and $\rho = 0.2$ for global pheromone update. The simulation results are shown in Figure 5 and Figure 6. The black line is the optimal path of the ACA. Figure 7 shows the fitness change of the best individual in the optimization process of ACA. It can be seen from the simulation results that the path optimized by the algorithm can meet the needs of UAV monitoring and verify the feasibility and correctness of the algorithm. However, the path is tortuous and not the optimal one. How to plan a better monitoring path is pending further study.

In this chapter, according to the different of the geographical environment of the coconut field, the WSN monitoring path planning is carried out for the coconut field. For the field monitoring, the three-dimensional space modeling is conducted and the heuristic function and the pheromone update rule are designed by ACA to optimize the monitoring path. Finally, the simulation results show that the path optimized by the algorithm in this paper meets the requirements of WSN monitoring and provides a reference for the practical application of WSN monitoring.

5 REFERENCES


4 CONCLUSION