A FALL DETECTION ALGORITHM BASED ON THREE-AXIS ACCELERATION

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In this article, a fall detection algorithm is designed, which mainly uses three parameters to judge the fall behavior, including impact, oscillation, and positive and negative.

Introduction

When a person falls, the center of gravity will be rapidly reduced, and at the same time, the acceleration in the Z-axis direction will quickly reach its peak, and when it collides with the ground, it will produce a larger acceleration, the direction of the acceleration is opposite to the direction of the collision, after the fall, the human body will be in a relatively stationary state, and the acceleration will be in a relatively flat and small state.It can be seen that during a human fall, the acceleration will have two peaks in opposite directions.

I. Judgment of impact

The sum of the three axial acceleration ranges can indicate the degree of change in the fall signal, so this parameter is used first. Let the maximum value of acceleration in the x-axis be $\max(a_x)$, the minimum value will be $\min(a_x)$, and the maximum value of acceleration in the y-axis will be $\max(a_y)$, the minimum value is $\min(a_y)$, and the maximum value of z-axis acceleration is $\max(a_z)$ and the minimum value is $\min(a_z)$. The three-axis acceleration extremes are $\Delta A_x = \max(a_x) - \min(a_x)$, $\Delta A_y = \max(a_y) - \min(a_y)$, and $\Delta A_z = \max(a_z) - \min(a_z)$, then the sum of the three-axis acceleration ranges in 4 seconds ΔA is defined as:

$$(\Delta A = \Delta A_x + \Delta A_y + \Delta A_z)$$

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II. Determine the oscillation

In the process of falling, the acceleration will be in a state of oscillating back and forth at the zero-crossing point, so in the process of falling, the zero-crossing points of the three-axis acceleration will increase dramatically, so the sum of the zero-crossing points is used to detect the oscillation of the fall signal. Let the number of zero-crossing points of the x-axis acceleration be $zero_x$, the number of zero-crossing points of the y-axis acceleration be $zero_y$, and the number of zero-crossing points of the z-axis acceleration be $zero_x$ in 4 seconds, then the sum of the zero-crossing points is defined as:

$$Zero = zero_x + zero_y + zero_z$$

III. Determine the polarity

The three-axis sign function is used to detect the polarity of the fall signal when a person falls and collides with the ground.

$$\text{sign} = \begin{cases} & \max(a_x) \times \min(a_x) < 0 \\ 1 \quad \text{if} & \wedge \max(a_y) \times \min(a_y) < 0 \\ & \wedge \max(a_z) \times \min(a_z) < 0 \\ 0 \quad \text{else} & \end{cases} \tag{1}$$

Sliding window processsing

The three-axis acceleration data is stored using three arrays with a size of 120: xAccArr, yAccArr, and zAccArr. By adjusting the upload frequency of the sensor to 30Hz, which means uploading 30 data packets per second, the reason for setting the array size to 120 is to facilitate sliding window processing. When the data size of the array reaches 120, a process similar to entering and exiting the queue begins. Each data is moved forward by 1 bit and processed and judged, thus achieving sliding window processing.

Summary

According to research [3], activities such as falling, jogging, jumping, and clapping can produce relatively large maximum human acceleration values, while activities such as going up and down stairs, walking, and bending over can produce smaller maximum human acceleration values. Therefore, the sum of acceleration range can effectively distinguish falls from other normal behaviors.

1. Chen Lin. Research on Fall Detection Method for the Elderly Based on Accelerometer from A Smart Watch, 2020. DOI:10.27135/d.cnki.ghudu.2020.003169.
2. Luo Wenzhi;Zhang Zihao;Guilin Weiling.Design of fall monitoring system for elder people based on LoRa,2022,30(18):114-118. DOI:10.14022/j.issn1674-6236.2022.18.024.