Recognition of Orchard Path Based on Machine Vision

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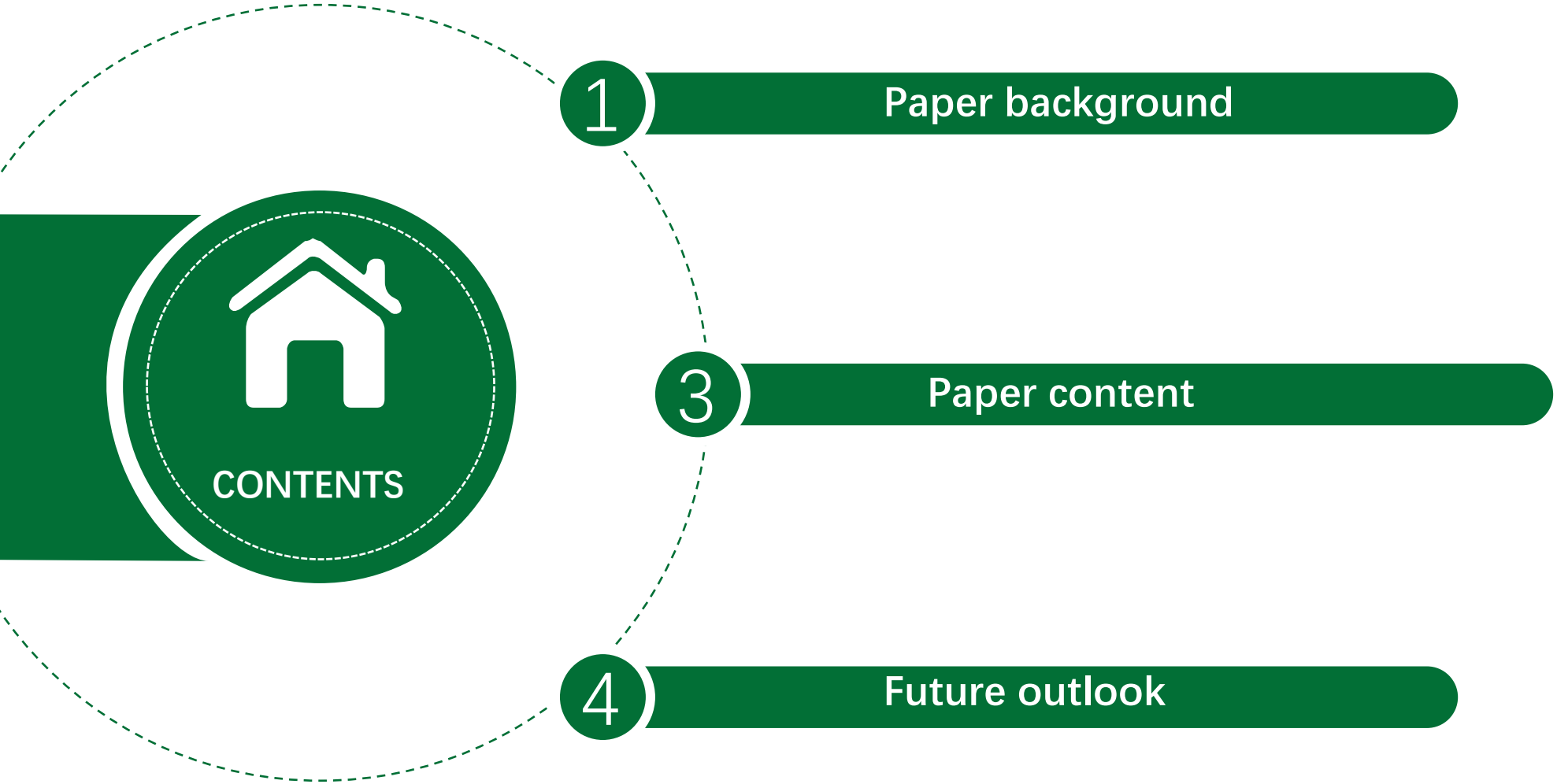
Paper Report



- Paper background

Unmanned orchard

Weeding robot

Spray robot

Picking robot

Unmanned orchard

Advantages of unmanned orchard

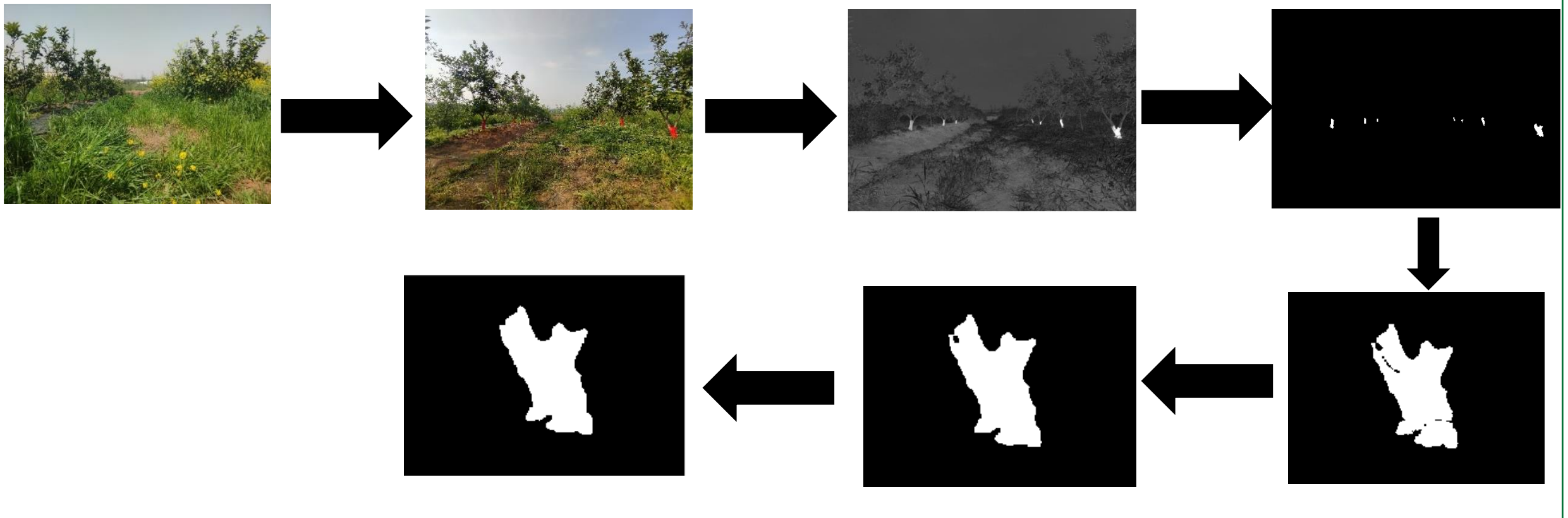
- Productivity is increased
- manufacturing cost is reduced
- precise management of orchard is realized

Experimental research environment

China is dominated by hilly orchards

The United States, Canada, etc. are dominated by plain ranch orchards

An Ridge line fitting



An Ridge line fitting

Color space is converted from RGB to Lab → Extract the a component and binarize it → Morphological closing operation to close the boundary → Fill holes and eliminate small noises

$$L = 116 * f(y) - 16$$

$$a^* = 500 * (f(x) - f(y))$$

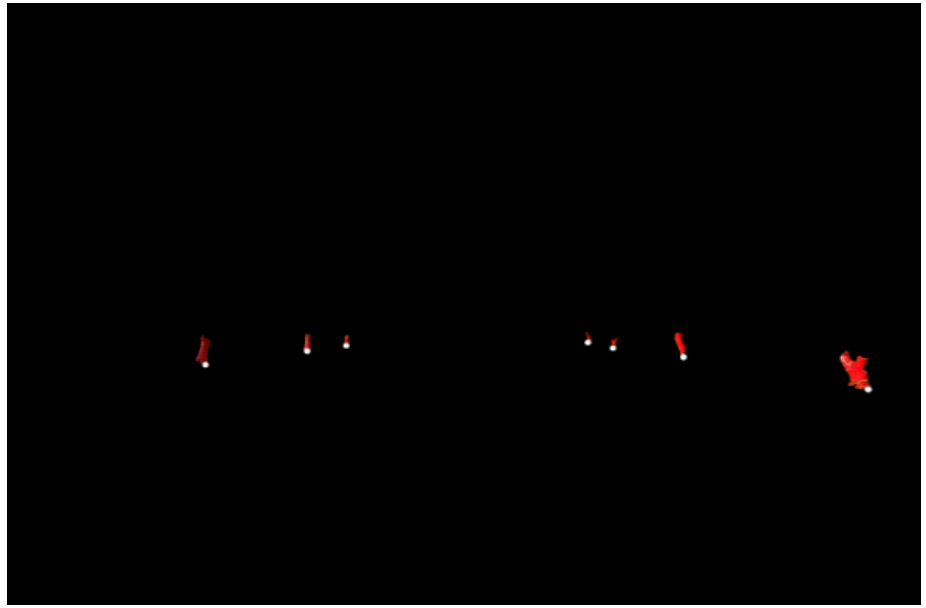
$$b^* = 200 * (f(y) - f(z))$$

$$f(t) = \begin{cases} t^{1/3} & t \le 0.008856 \\ 7.787 * t + 0.1379 & t < 0.008856 \end{cases}$$

$$(x\ y\ z) = \begin{pmatrix} 0.4125 & 0.3576 & 0.1805 \\ 0.2162 & 0.7152 & 0.0722 \\ 0.0183 & 0.1192 & 0.9505 \end{pmatrix} * \begin{pmatrix} \frac{r}{255} & \frac{g}{255} & \frac{b}{255} \end{pmatrix}$$

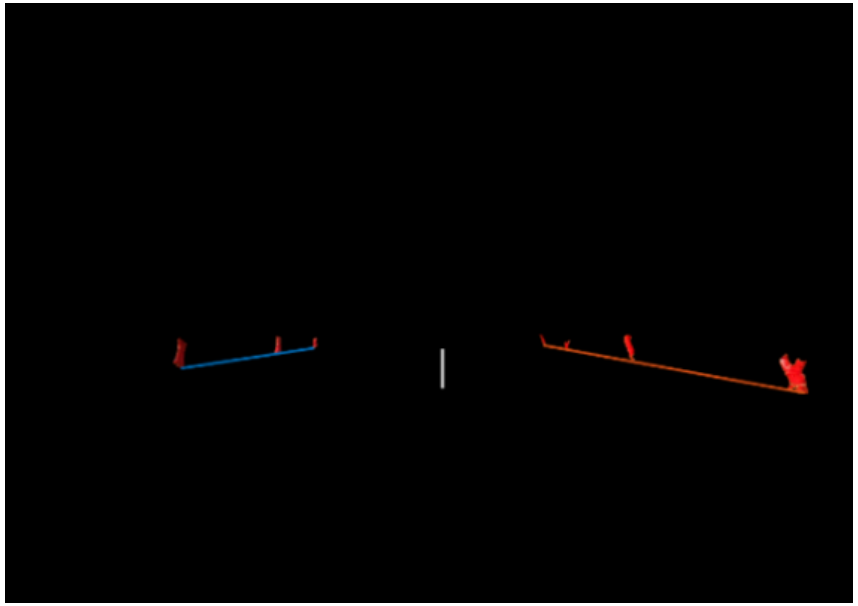
$$a^* = \begin{cases} a^* & a^* > T \\ T & a^* \le T \end{cases}$$

Feature Points Extraction.



line-by-line scan → Extract feature points

Feature Line Fitting

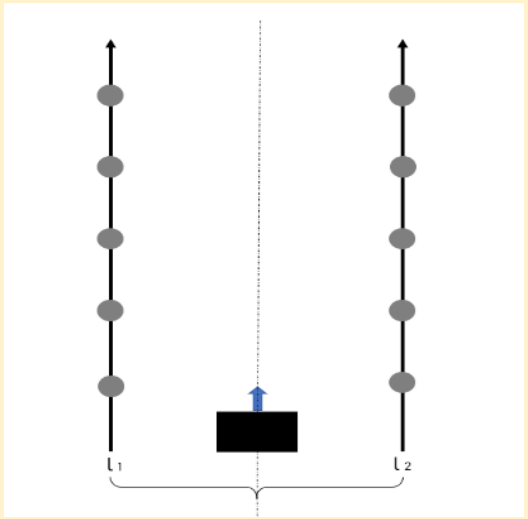


$$\min \sum_{i=1}^{n} (y - kx_i - b)^2$$

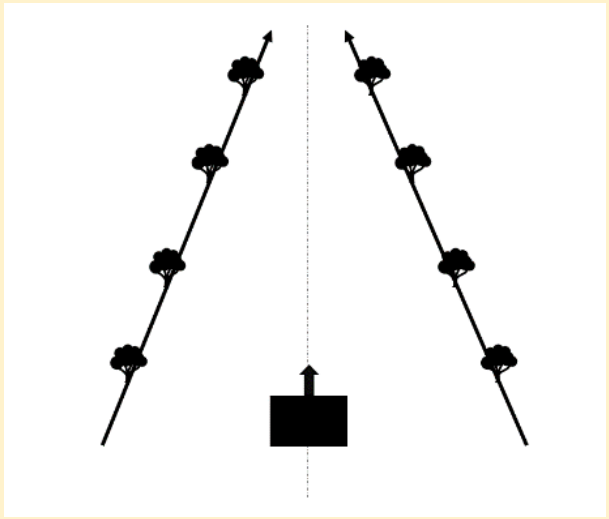
$$k = \frac{n\sum x_i y_i - \sum x_i \sum y_i}{n\sum x_i^2 - (\sum x_i)^2}$$

$$b = \frac{\sum y_i \sum x_i^2 - \sum x_i \sum x_i y_i}{n\sum x_i^2 - (\sum x_i)^2}$$

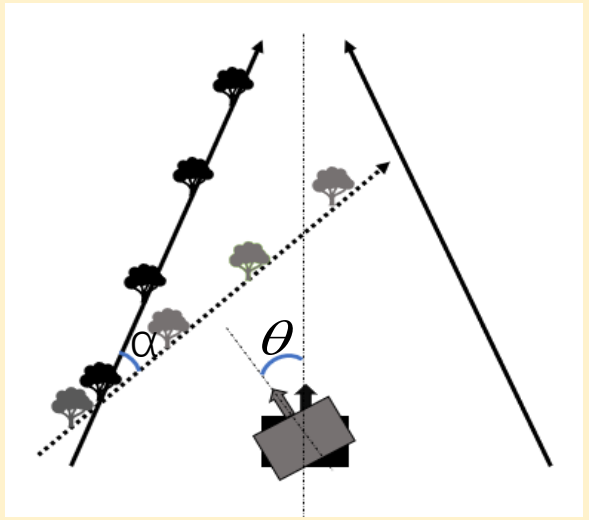
Pose Obtainment and Adjustment in Images



World coordinate system

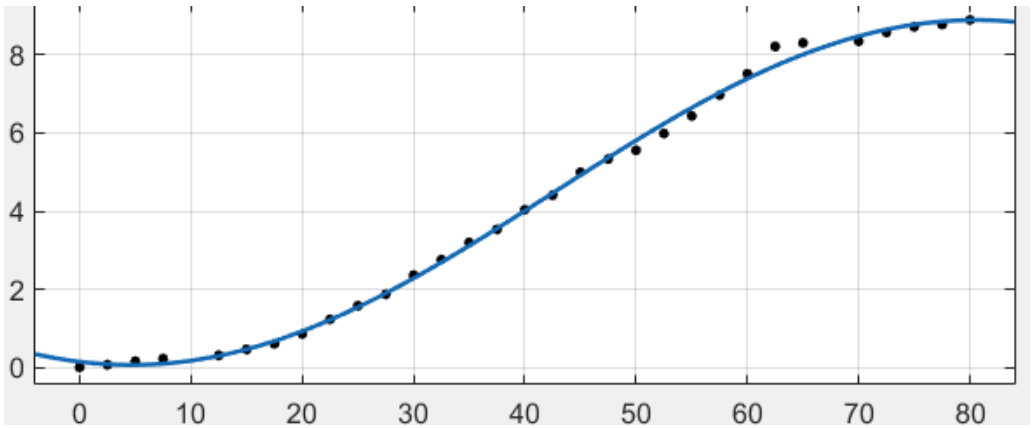


Camera coordinate system



The relationship between α and θ

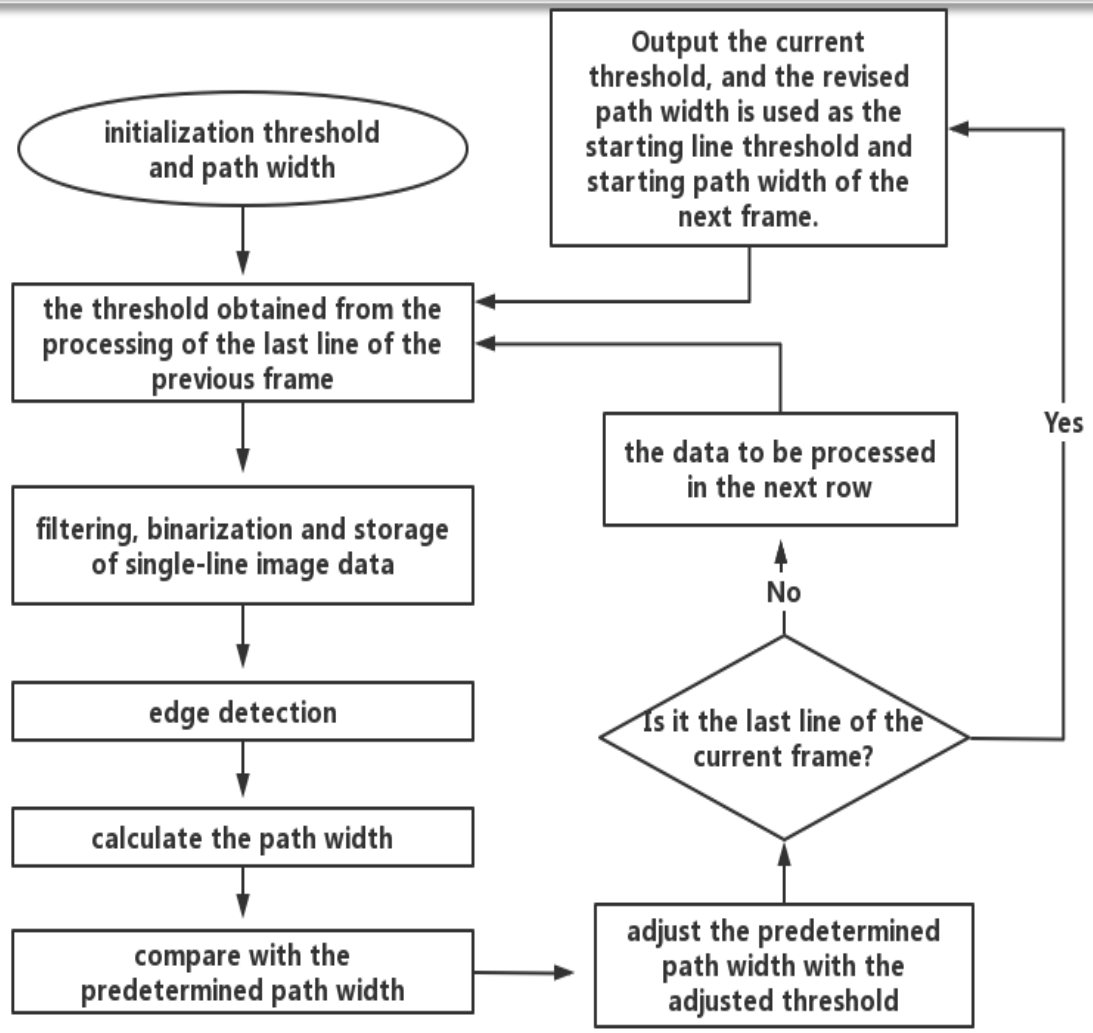
Camera angle calibration



$$a = f(\theta) = a_0 + a_1 * \cos(\theta * w) + b_1 * \sin(\theta * w)$$

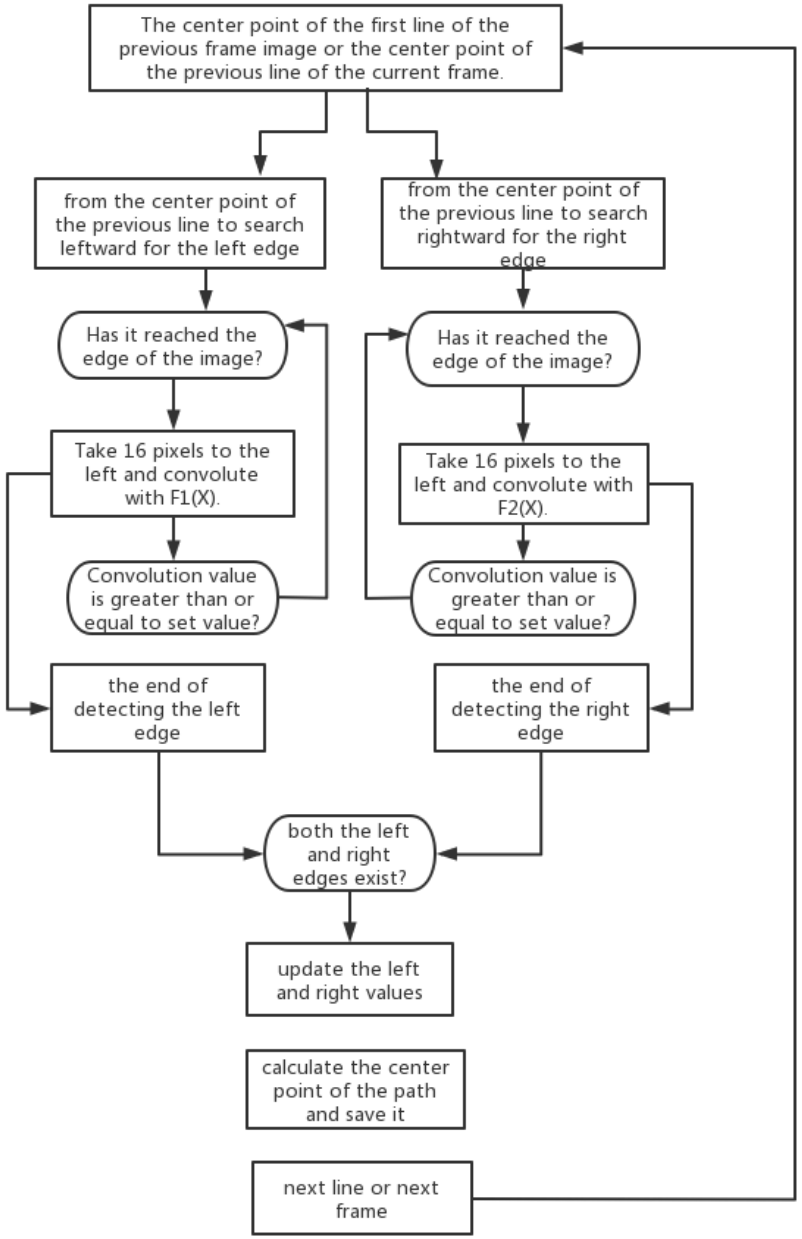
$$a_0 = 4.479,\quad b_1 = -0.8418,\quad w = 0.04138$$

Path Recognition



Flow chart of adaptive path recognition algorithm

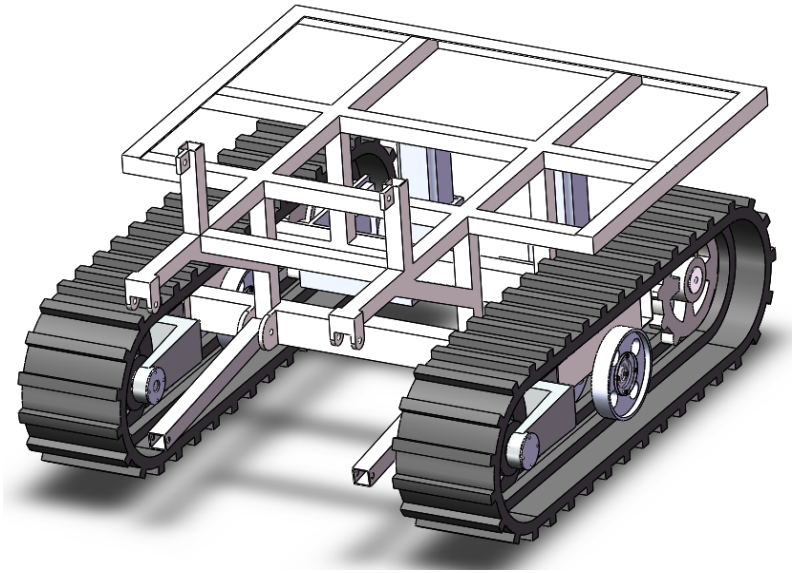
Path Recognition



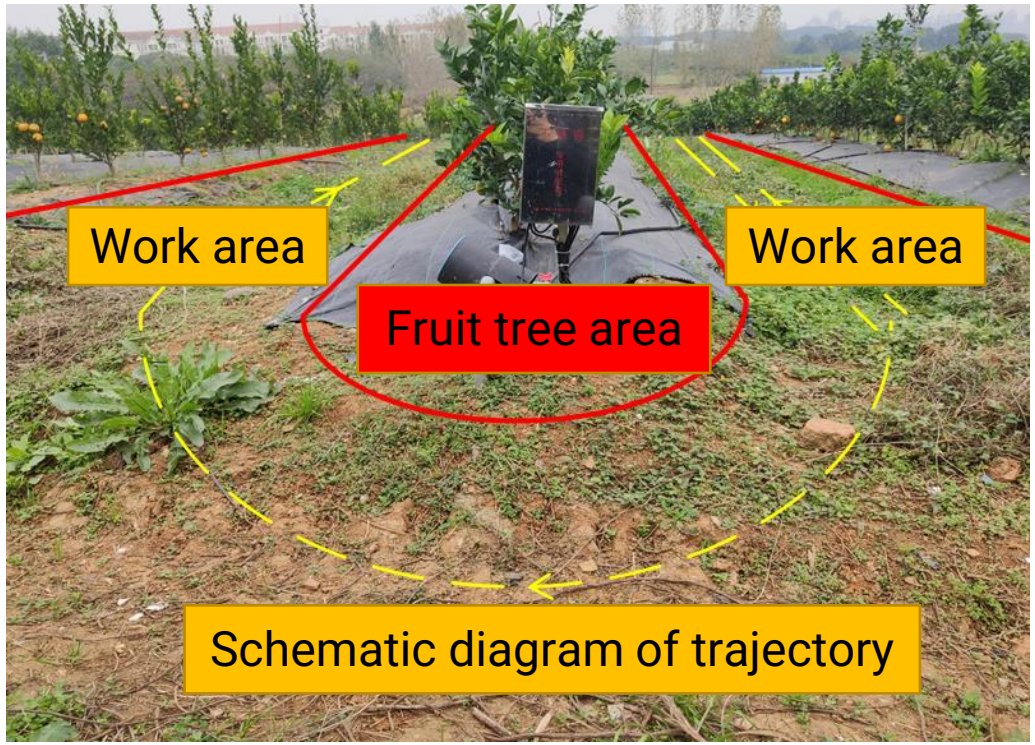
Flow chart of adaptive path recognition algorithm

Experimental Verification

Hardware and Software Platform



3D drawing of general platform



General platform physical map

Experimental Results


0°


15°


30°


45°


60°


75°


105°


120°


135°

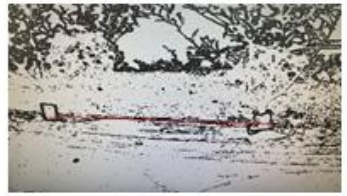

150°


165°


180°

Image of original trunk navigation line


0°

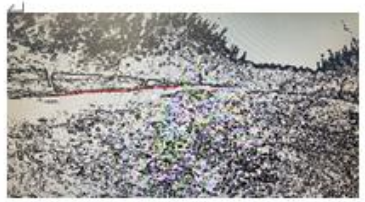

15°


30°


45°


60°


75°


105°


120°


135°


150°


165°


180°

Image of trunk navigation line extracted under sobel edge detection

•Future outlook

1. The construction of the vibration reduction system of the orchard general platform

2. The realization of orchard path recognition algorithm (write path recognition algorithm program with verilog hardware programming language)

3. Multi-sensor realizes data fusion through FPGA to control the global path planning of orchard general platform

Thanks for your listening

January 23, 2022