An Intelligent Pruning Device for Tomato Lateral Branches

Wei Sun¹, Shanshan Cao¹, Qin Qiu¹,², Jianzhai Wu¹, Liwei Xing¹ and Jifang Liu¹,*

¹Agricultural Information Institute, Chinese Academy of Agricultural Sciences, Beijing, China
²College of Computer and Information Engineering, Xinjiang Agricultural University, Urumqi, China

*Corresponding author: liujifang@caas.cn

Abstract. In order to realize automatic pruning technology of tomato, an intelligent pruning device of tomato lateral branch was designed. A pulley is arranged in the track at the top of the greenhouse tomato planting shed, and a bracket is arranged through a mechanical connection, and a positioning module and a lidar module, a positioning module, a lidar module, a secondary close-range camera and a binocular camera are arranged in the middle section of the crossbar. Through binocular camera to identify and locate the axil part of the leaf, the mechanical arm II fixed the main stem of tomato plant, and judged whether the lateral branch grew in the axil of the leaf through the terminal visual unit, so as to prune or smear the inhibitor to complete the pruning of the tomato lateral branch. This paper effectively solves the efficiency of tomato daily management low and low precision technical problems, which provide a solution for the artificial picking of substitute tomatoes.

Keywords: Tomato lateral pruning, Binocular vision, Robotic arm, Deeplab, Harris algorithm

1. Introduction
Tomato fruit is rich in nutrition and unique in flavor. In addition to being affected by climate, tomato yield is related to cultivation measures. The effect of cultivation density and pruning mode on growth-type tomato has been reported many times [1, 2]. In the process of tomato planting management, due to the strong growth of tomato and strong branching ability, it is necessary to carry out lateral branch dressing regularly to ensure the effective utilization of nutrients, reduce energy waste, and improve the economic benefits of tomato planting [3, 4]. However, many growers have problems such as late pruning, hand pinching and improper treatment of side branches and diseased branches, which not only affect the growth of tomato plants also reduces tomato quality. With the shortage of labor resources, the labor cost rises, so that the development of facility tomato in China has encountered a bottleneck. For large-scale growers, artificial pruning of large areas of tomato needs to invest a lot of manpower and material resources, and the cost is too high. Therefore, to solve the problem of labor substitution in tomato lateral pruning and to study and popularize tomato automatic pruning technology has become an urgent problem to be solved at the present stage. In view of the above situation, the invention designs an intelligent tomato lateral pruning device in order to be beneficial to solve the above problems.
2. Architecture
The system architecture design must start from the whole, the overall structure design, and then each sub-module function detailed design. The intelligent pruning device of tomato lateral branch is composed of central processing unit, image acquisition system, recognition and positioning system, pruning manipulator and actuator, power management system. The architecture is shown in Fig.1.

Among them, the identification and positioning system can obtain the information around the device in real time, which is used to collect the information of crop planting and obstacles under the device, and transmit the information to the central processing unit to realize navigation, path planning and autonomous lifting. By improving the Deeplab model, the central processing unit can identify the position of tomato leaf axil and determine the position of main cutting point of tomato lateral branch. Branch growth point cut.

![Figure 1. Architecture diagram.](attachment:image.png)

3. Key Technologies

3.1. Tomato Lateral Branch Identification Technology
Tomato lateral branch recognition includes the following steps: (1) first obtaining 30000 pictures of tomato plants in greenhouse and field, marking the pretreated pictures of tomato plant trunk and leaves and tomato lateral branches, dividing the labeled samples into training set and test set according to 5:1 ratio; (2) then improving the DeepLab model and training it, in which the DeepLab model is proposed by the Google team, is a widely used semantic segmentation network structure part of the network Inception module optimization Deep Lab model network. Structure to reduce the complexity of the network, different sizes of convolution layer and pool layer stacked together, increase the width of the network, the original Inception module of 5*5 convolution replaced by a connected 3*3 convolution, further enhance the ability to extract features, reduce complexity; (3) use the improved Inception module to modify the conv5 convolution layer in the DeepLab network, the Pooling4 output feature map into the improved Inception module, after the improved module processed output, access to the ASPP. module, where the ASPP includes two parts: multi-scale cavity convolution and image-level features; multi-scale cavity convolution includes, 1×1 ordinary convolution, 3×3 cavity convolution with 6 hole rate, 3×3 cavity convolution with 12 hole rate and 3 cavity convolution with 18 hole rate; the image-level feature, to find the mean value of the input on [1, 2] dimension, after 1×1 ordinary convolution, then use the linear difference resize to the size of the input image, finally connect four convolution and image level feature, and finally get the output of the network through a 1×1
convolution. After improvement, the number of parameters of this part will be reduced from about 7.08 million to about 1.04 million, less than 15% of the original network part. On the basis of having excellent feature extraction ability, the number of parameters will be greatly reduced, so that the performance of the network in training can be effectively improved. Finally, the improved DeepLab model is trained with the training set and tested with the test set. When the accuracy is higher than 95%, it is used for tomato side branch identification of the tomato side branch pruning device of the tomato.

3.2. Tomato Lateral Branch Location Technology
By using the trained deep learning tomato plant recognition method, the target lateral branch image is extracted, the region of interest of the lateral branch growth point is determined according to the contour boundary of the lateral branch and tomato plant trunk and leaf, and the lateral branch is extracted by fast parallel refinement algorithm. The bifurcation point between the lateral branch and the plant trunk is detected by Harris algorithm, and the pruning point position information is obtained by calculation.

The positioning module is specifically GNSS, to transmit the information to the central processing unit by collecting crop planting and obstacle information under the device through the positioning module and the lidar module. With the assistance of the first auxiliary light source, the binocular camera uses the elevation angle to collect the image information of tomato plant, and transmits the collected image information of tomato plant to the central processing unit. The central processing unit uses the training set model to identify the position of tomato leaf axil and control the position of the first manipulator at 1~2 cm above the leaf axil growth point to immobilize the tomato trunk through rubber clip 24 for fine operation of the other shell main arm.

3.3. Tomato Lateral Branch Pruning Technology
Central processing unit controls the secondary close-shot camera. On the one hand, the secondary close-shot camera is to determine the relative position of the trunk, blade and lateral branch near the fixed position of the first manipulator, to distinguish the blade from the lateral branch, and to accurately locate the lateral branch as the pruning position 1 cm above the leaf axil, so as to avoid mispruning the blade; At the other hand, the position of leaf axils without lateral branches is precisely located, so that the second manipulator can accurately smear the growth inhibitor to the place where the lateral buds may be initiated, and accurately control the position of the inhibitor smear to cut off one cm above the growth point of the lateral branches of the axils of the leaves, and apply the growth inhibitor to the axils of the leaves without lateral branches to prolong the pruning cycle. Period.

The connection between the main shell arm and the middle arm of the secondary close-range camera is also provided with a hook and a siphon, which is used to extract the medicine bottle containing the growth inhibitor, the siphon is used to extend into the bottom end of the medicine bottle to provide the medicine for the coated cotton, when the medicine bottle hanging from the hook needs to be replaced, the device moves to the preset position, and the first manipulator is replaced by a rubber clamp medicine bottle.

The secondary close-shot camera, with the cooperation of the second auxiliary light source, cut off one cm above the growth point of the lateral branch in the axillary part of the leaf, apply the growth inhibitor to the axillary part of the leaf without the lateral branch, prolong the pruning period, and have a rotating shaft at the base, which can realize 360° rotation, realize the precision of automatic pruning of tomato plants, and realize the accurate and efficient application effect to the maximum extent, and provide support for the automatic pruning of tomato. The tomato lateral pruning device is shown in Fig.2.
4. System Implementation

The utility model relates to an intelligent pruning device for tomato side branches, which comprises a track mounted at the top of the greenhouse tomato planting shed, arranged along the ridge direction of the tomato planting shed, and the interval width of the track is equal to the spacing of the tomato planting ridge. The overall design of the tomato lateral prune is shown in Fig.3.

The pulley is also connected with a driving motor through a chain ring and a sprocket, the driving motor is specifically a servo motor, and the signal connection between the servo motor and the central processing unit is used to accurately drive the pulley to move in the track and move to a position requiring pruning; the middle of the bearing is welded with an intermediate rod, the top of the mechanical connector is fixed in the middle section of the intermediate rod, the mechanical connector comprises a first mechanical connecting rod, a second mechanical connecting rod and a lifting rope
5. Conclusion

The intelligent pruning device of tomato lateral branch is a complex system. This paper introduces the human composition of the intelligent pruning device of tomato lateral branch. It mainly uses binocular vision system to obtain tomato image. The improved DeepLab model is screened according to tomato size and color. The bifurcation point between lateral branch and plant trunk is detected by Harris algorithm. It provides a solution to the technical problem of low efficiency and low precision in automatic pruning of tomato, and provides a solution for pruning tomato Unmanned is of great significance.

Acknowledgments

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