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Application of Improved BP Algorithm Based on Numerical Optimization to Image Segmentation of Cucumbers

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Abstract: For the cucumber harvesting robot, the recognition is the important steps. First of all, segmentation of cucumber image is required. Aiming at the problems that BP algorithm has slow convergence rate and is likely to fall into local minimum point, Chaotic mechanism is introduced to LMBP algorithm and the problem of local limit value for network is solved using global moving characteristic of chaotic mechanism is weight optimization, it can make convergence rate of network faster. The research result of applying the improved BP algorithm to the segmentation of cucumber image shows that the new method had good effect on separating the cucumber from its background.

Key words: LM algorithm, chaotic mechanism, BP algorithm, cucumber, image segmentation

INTRODUCTION

With the aging of the population and the reduction of the agricultural labor force, fruit and vegetable picking robot becomes the world's research hotspots. Fruit and vegetable picking robot complete identification of the fruit picking and transportation of the whole process without people. Fruit and vegetable picking robot identify ripe fruit from the leaves and branches in the background according the fruit color, size and shape of the target and determine its spatial location, thus complete the picking operation.

At present, the practical application of artificial neural networks, most of the neural network model is the use of BP neural network and its variations (Angeles, 1985; Kazeroumian, 1987; Miller *et al*., 1987), however, the original BP algorithm have many inadequacies, training time is too long, the convergence rate is very slow, Often converge to local minima, difficult to adjust the initial weights, learning rate and momentum coefficient and other parameters. In this paper, the LM algorithm neural network learning rate with the chaotic mechanism is used for image segmentation of cucumber fruit.

THE IMPROVED BP NEURAL NETWORK

The original BP algorithm is a gradient descent method (Wilamowski *et al*., 2001), based on gradient descent method is only linear convergence, very slow. The LM algorithm is a fast algorithm of the standard numerical optimization (Chen *et al*., 2003), it combine gradient descent method and the Gauss-Newton method, also is improvements in the form of the Gauss-Newton method, it has the local convergence of the Gauss-Newton method, also has the gradient descent method of the global characteristics. The LM algorithm uses approximate second derivative information; it is much faster than the gradient method. A brief description about the LM algorithm is as followed.

Assume x(k) is the k-th weights and thresholds of iterative vector, new weights and thresholds of vector x(k+1) can be obtained according to the following rules:

$$x(k+1) = x(k) + \Delta x \tag{1}$$

$$\Delta x = -[J^T(x)J(x) + \mu I]^{-1} J(x)e(x) \tag{2}$$

$$J(x) = \begin{vmatrix} \frac{\partial e_1(x)}{\partial x_1} & \frac{\partial e_1(x)}{\partial x_2} & \cdots & \frac{\partial e_1(x)}{\partial x_n} \\ \frac{\partial e_2(x)}{\partial x_1} & \frac{\partial e_2(x)}{\partial x_2} & \cdots & \frac{\partial e_2(x)}{\partial x_n} \\ \vdots & \vdots & \cdots & \vdots \\ \frac{\partial e_N(x)}{\partial x_1} & \frac{\partial e_N(x)}{\partial x_2} & \cdots & \frac{\partial e_N(x)}{\partial x_n} \end{vmatrix} \tag{3}$$

where, $\mu>0$ is constant, i is unit matrix?If introduce the function to (1), thus:

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$$h(y) = \sqrt{e}\frac{A}{R} y e^{-y^2/R^2} \quad (4)$$

Namely,

$$x(k+1) = x(k) + \Delta x + h(y) \quad (5)$$

where, A and R can be seen as the magnitude and radius of nonlinear self-feedback to drive. They can control the scope of activities of the weights. When R is fixed, A can determine the weights of dynamical systems which the size of power is transferred between the local minima of its energy, the larger A, the right value correction of range is greater. The formula is a chaotic mechanism.

$y = \Delta x(k) = x(k) - x(k-1)$, assume $|y| = |x(k) - x(k-1)|$ is the speed that dynamical systems close to the fixed point, If |y| is large, the system is away from the fixed point, h(y) should be rapidly reduced, the weight value is corrected rapidly to approach the fixed point of the system. When the state of |y| is intermediate values, the dynamic system of weights will enter a certain neighborhood of a fixed point, self-feedback of h(y) will be a new driving force out of fixed point, the final weights enter a neighborhood of the optimal fixed point under global significance.

CUCUMBER FRUIT IMAGE FEATURE EXTRACTION

Human eye can feel dynamic range of the light intensity up to 10 orders of magnitude, the dynamic range of existing cameras and film is just a small window. RGB values collected with these devices are susceptible to ambient light and light and dark objects. In order to reduce these effects, using the normalized formula, RGB values is normalized to the rgb color space.

$$r = \frac{R}{R+G+B}, g = \frac{G}{R+G+B}, b = \frac{B}{R+G+B} \quad (6)$$

Although the cucumber fruit color is similar to the stem leaves color, however, due to reflectance and moisture content of the different cucumber fruit and leaf, there are some differences in color depth of cucumber fruit and their stems leaves; the color of fruit is darker than the stems of cucumber generally. In this article, assume (I, j) is any point in the image, g(i, j) is g value of (i, j), eigenvectors of points (i, j) is:

$$I(i,j) = \begin{bmatrix} g(i-1,j-1), & g(i,j), & g(i+1,j-1) \\ g(i-1,j), & g(i,j), & g(i+1,j) \\ g(i-1,j+1), & g(i,j+1) & g(i+1,j+1) \end{bmatrix}^T \quad (7)$$

The three layers BP network is used in this study which the input layer and hidden layer consists of nine nodes, the output layer contains one node, assume training images is F1, F2 is the tutor signal for artificial segmentation of cucumber image, binary encoding for the image the F2, point within cucumber fruit is encoded 1, points within the background region is encoded 0(In the actual calculations, respectively 0.9 and 0.1). Train the network to get effective weights of the network. The network can be treated split cucumber image processing, if the final signal of output layer is less than 0.1, the image pixels as the background, if the final output signal is greater than 0.9, the image pixels as the cucumber, if the final output signal between 0.1 and 0.9, we cannot conclude whether this pixel as a cucumber and background.

CUCUMBER FRUIT IMAGE SEGMENTATION EXPERIMENTS

We selects three more representative of the image(Yuan and Zhang, 2006): Fig. 1a for a more intact image of a cucumber fruit; Fig. 1b for cucumber fruit stalk block; Fig. 1c is difficult which even the human eye cannot easily distinguish the cucumber fruit. Improve BP segmentation method are used to segment the cucumber fruit, segmentation results shown in Fig. 1, Fig. 1d is the segmentation result of Fig. 1a, Fig. 1e is the segmentation result of Fig. 1b, Fig. 1f is the segmentation result of Fig. 1c. From the image after segmentation processing, we can see cucumber fruit and

Fig. 1(a-f): Continue

Fig. 1(a-f): Image segmentation results based on improved BP algorithm (a-c) The original image of cucumbers and (d-f) Segmented image

background regions have a clear outline, fruit extract and other subsequent processing is conducive.

CONCLUSION

Chaotic mechanism is introduced to LMBP algorithm and the problem of local limit value for network is solved using global moving characteristic of chaotic mechanism is weight optimization, it can make convergence rate of network faster. The research result of applying the improved BP algorithm to the segmentation of cucumber image shows that the new method had good effect on separating the cucumber from its background. The advantage of this method is change the training set simply, can be used for soybean, tobacco, wheat and other image segmentation. The use of neural network image segmentation method does not exist the problem of how determine the threshold adaptively, but also has better fault tolerance and association functions. Therefore, the neural network for image segmentation is worth studying.

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