Simulation Distributed of Cucumber Leaf Area in Greenhouse

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Simulación de la distribución del área foliar de pepino en invernaderos

Resumen

En este trabajo se ha utilizado el software Photoshop y Matlab para estimar el área foliar de cultivo de pepino con precisión y rapidez basado en el desarrollo de tecnologías de procesamiento de imágenes. Para ello, la distribución del área foliar fue simulada con *Ordinary Kriging* (OK). En este trabajo, se utilizaron plantas en diferentes etapas de crecimiento y diferentes ubicaciones. En cuanto a los resultado, a partir del día 37 se muestran diferencias en la estimación respecto al valor real. El área foliar máximo en el periodo de ensayo fue de 5617.03 cm2 y su ubicación fue en el norte del invernadero. El índice de área foliar es un parámetro importante como indicador del crecimiento de la planta.

Palabras clave: Área Foliar; Tecnología de procesamiento de imágenes; Kriging Ordinario; Distribución

Abstract

Using Photoshop and Matlab software, cucumber leaves areas were measured accuracy and rapidly based on image processing technology. Meanwhile, Distribution of cucumber leaves areas were simulated using ordinary kriging (OK). Plant leaves areas were different on diverse growing stages and locations. On the 37d, there are huge difference of leaves areas. The maximal leaves areas appeared on north of greenhouse, and they are 5617.03 cm^2. It was used to knowing situation of plant growing and supply data for production manage and yield estimated.

Keywords：Leaf Area; Image Processing Technology; Ordinary Kriging; Distribution

Introduction

Cucumber(*Cucumis sativus L.*) was one of main plants in greenhouse. Cucumber leaf shape was wide-oval section and membranous, its length and width both were 7-20 cm. Large leaf area could satisfied demand of cucumber transpiration , but could not satisfied demand of light on different canopy height. Leaves areas distribution was analysed on different canopy height, then light demand of leaves

could be satisfied through additional lighting timely to save energy and improve yield and quality of plant.The methods of calculated leaf area had coordinate paper, relative coefficient, leaf area meter and image processing technology. Primitively parameters of coordinate paper were leaf size and blade shape. A regression formula was established based on relative coefficient method, using leaf length and width(Max, Vincent and Raju; 2008). Leaf area meter was expensive and carry inconvenient(Flávio and Marcos; 2002). During development of computer vision technology continually, a method was formed gradually that image software calculated leaf area. But most of authors were just simulated individual plant leaf area. Greenhouse was a half closed environment, and climate was inconformity inside greenhouse leaded to growing situation of plant was different. Spatial interpolation method was used to ore resources evaluate, drilling and sampling and so on. Recently years, it was used to spatial difference analysis of greenhouse, and result was good.

In this study, image background was disposed using photoshop, then calculated leaf pixel using Matlab software. Leaf pixel divided reference substance pixel, and multiply really size of reference substance, Leaf size was reached. Depend on known leaves areas on different locations and stages, distribution of leaf area was simulated based on Ordinary Kriging method, using origin software. The result was good. 3D image putted out growing situation of plant in different locations , and supplying data bases for production manage of greenhouse.

Materials and Methods

This study was conducted from September to November 2015 and a solar greenhouse at Beijing Xiao Tangshan base, in Changping district, Beijing, PR China (40°10’48’’N, 116°28’12’’E) . The greenhouse (with a north-south orientation) was 420 m^2 (60m length × 7m width) and was constructed of metal arches covered with polyethylene films. The cucumber seedlings were planted on September 1 and were transplanted on September 9, and the harvest season ended on November 20. The experiment material was ‘Jingyan Mini 2’. From transplanted data to harvest season ended , photos of all of leaves of 5 plants were collected every 10 days, collected location was ‘M’ type, which is show in picture 1 . And camera type was NikonD90, white paper plate was as photoground plate, and there was a rectangle on plate as reference substance, its area was 2cm×4cm, as follow picture 2.

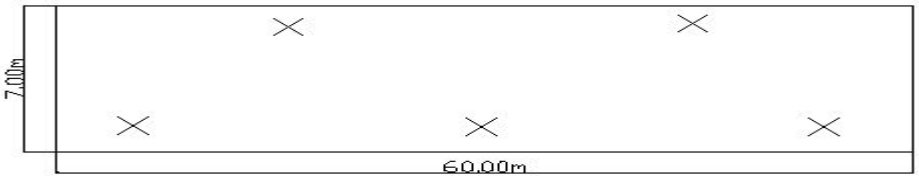

Figure 1. Locations of cucumber collected

Cucumber leaves images were picked up using Photoshop(Adobe, San Jose, California, USA), background purify. Calculated leaf and reference substance pixels using Matlab2010a(MathWorks, Natick, Massachusetts, USA) software, and area of reference substance was 8cm^2. As follow flow chart and formula 1 of calculated leaf

area. Ordinary Kriging, also known as space partial interpolation method, it was a method that variable regionalization was estimated optimal and unbiased in limited region based on variogram theory and structure analysis, and it was used to research distribution of continuation variable in the region and estimated value of measured points. Leaf area distribution inside greenhouse could be simulated based on Ordinary Kriging, using known leaf area at five different locations.

$$S_y = \frac{p_c}{p_y} \times S_c \qquad (1)$$

Where S_y is size of leaf area(cm^2), P_c is pixel of reference substance, P_y is pixel of leaf, S_c is size of reference substance(cm^2).

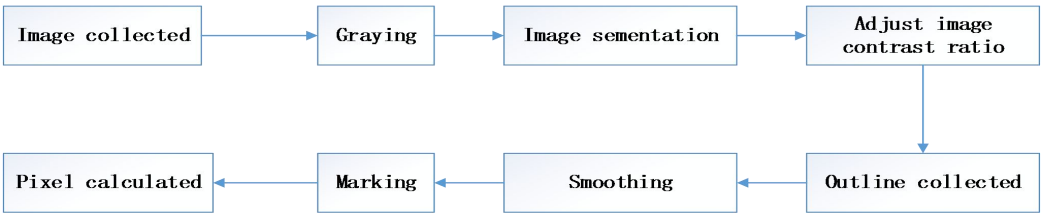

Fig.2 Flow chart of calculated leaf area

Fig.3 leaf photo collected

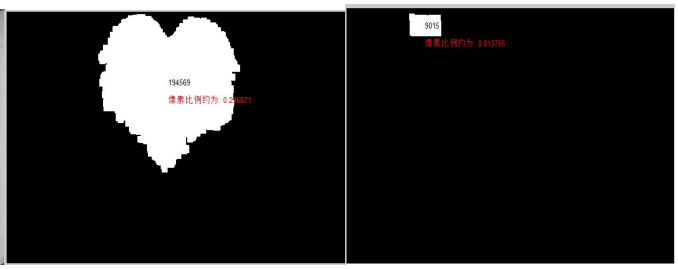

Fig.4 Calculation pixels of draw leaf and reference object

Results

During cucumber growing, leaves areas were increased gradually. The result show in Table 1. When 37th, maximum of leaves areas were 4471.32cm^2, average leaves were 19 every plants. Cucumber leaves decreased gradually when 47th, expected normal production manage (pruning and threshing). Cucumber leaf appeared shrinking and browning, because cucumber downy mildew happened . When 62th , cucumber leaves were maintain 10, leaves areas were 1202.35cm^2.

When 37th, Distribution of leaf area was increased from middle to east and west direction. The maximum of leaves areas was 5617.03cm^2, leaves areas of the west location was 3468.92cm^2, difference of distribution was huge. Fig5(1) and Fig5(2) were both represented distribution of leaf area when 37th, one was three dimensionality simulation and other picture was plane figure. Leaf area was increased from middle to east and west direction. The maximum of leaf area was 5617.03cm^2, leaf area of the west location was 3468.92cm^2, difference of distribution was huge.

Dissuction

Many researches have been carried out to estimate leaf area through measuring leaf dimensions. In general, leaf length, leaf width, or combinations of these variables

have been used as parameters of leaf area models (Williams and Martinson; 2003). Young build a non-liner formula was used to estimated of individual leaf area using leaf length, leaf width and SPAD value. (Young, Oh and Myoung; 2007),but parameters achieved need mass labour and material resources. Image processing technology could be got target, this method could not limited by leaf shape and used to calculate leaf area of various plants. Spacial interpolation method could be used to simulate distribution of leaf area inside greenhouse to know growing condition and supply data bases for production manage and yield evaluated.

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Table 1 calculated leaf area on different locations using Image processing technology

Days(d) / leaf area(cm^2)	9	19	30	37	47	54	62
1	49.75	257.31	2370.13	4209.29	4072.58	2003.11	821.32
2	52.34	307.46	2711.33	4661.95	4876.48	2175.92	948.72
3	82.94	544.07	2542.63	4399.40	4252.36	2552.31	592.87
4	44.96	601.54	2691.17	5617.03	3129.07	1974.75	1946.13
5	43.81	498.93	2347.10	3468.92	3693.09	1986.14	1702.72
Average Leaf Area	54.76	441.86	2532.47	4471.32	4004.72	2138.45	1202.35
SD	16.13	151.10	343.51	779.04	649.95	490.92	588.33

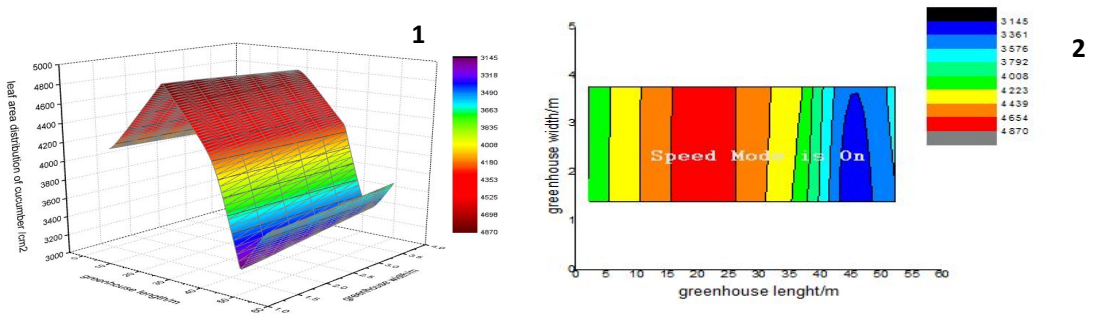

Fig.5 cucumber area distribution on 37th d