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Precise Measurement of Residue Cover by Means of Image Processing Techniques

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Abstract

Determination of crop residues on the ground is one of the basic requisites in many agricultural researches such as estimating the potential of different conservation tillage tools for covering the crop residue. There are several indices for estimation the residue covers while most of them are not only laborious and time consuming but also impressed by human errors. In this study a method has been developed which can be used to measure the percentage of the residue covers based on image processing techniques. In as much as crop residues have various colours, three species of crop residues were considered in this study including corn, wheat and canola residues. Colour spaces HSV, and RGB were used to investigate the highest contrast between the residue and soil. The optimum combination of colour components in RGB colour space which can discriminate the residues from the soil was also determined. Misclassification rate of the residues as the soil was measured less than 2.3%. Weight of the residues per unit area was collated versus area residue covers gained from the image based technique. Results showed a good correlation between the corn and canola residues determined from the images and their weights while for wheat it was depended on the density of the residues on the ground. It was concluded that this method is practical for fast and convenient determination of residues on the ground.

Key Words: Residue, machine vision, colour space.

INTRODUCTION

Remainders of crop product on the field after harvesting so called “crop residues” or mulch play an important role on soil conservation. Crop residue cover index is the ratio of the area covered by the residue to the total considered area. Maintaining the residual crop on the farm land has advantages such as easy water movement through the soil [4,7]. In the conventional tillage system a compacted layer is shaped under the top soil layer and prevent from seepage of water through it. In conservative soil systems due to mulch surface of the soil, water seepage is done easily through the soil. Also crop residue preserve top soil from direct sunlight at the spring and then soil surface evaporation is decreased. Therefore higher moisture is available for the plant in longer time duration [10, 11,17,20]. Crop residues also increase the organic matter and improve the soil structure [1]. In conservation soil system, proper management of crop residue causes increment of the organic matter. Higher organic matter leads to higher capacity for water absorption and then finally water moves through the soil better [5]. Application of mouldboard plough in conventional soil system causes soil erosion to occur sooner but in the conservative soil system crop residue prevent soil erosion. Totally, retention of crop residue after harvesting may affect on anti erosion of soil. Scientists found 15% of corn residue cover can reduce soil erosion by 75% [12].

Crop residue has some disadvantages for example in the fallow season, these residues don’t permit disintegration of soil aggregates. This effect may be increased at region with higher rainfall. Indeed, crop residue may affect on primary tillage and its quality decrease. On this way determination of crop residue is an essential component to manage a farm correctly.

Determination the extent of crop residue on the field is an exhausting job while there is not a distinct and accurate criterion for its measurement. There are several indices for estimation the residue covers while most of them are not only laborious and time consuming but also impressed by human errors.

It is possible for one to compare two treatments with different amount of crop residue. Human vision system is fast and accurate enough in this case but the problem is that the magnitude must be stated numerically to be reported and to be used for comparison between several treatments or treatments in different times. Interpretation of the extent perceived by vision system to numerals is possible by simulation of human vision system. Machine vision comprising image processing system adjoined to pattern recognition algorithms can afford these jobs. Machine vision has been developed recently at more fields as a new method. This new procedure has been employed in the farm science in several years ago. Grading, packaging and volume or mass determination of agricultural stuff as well as weed identify are some application of machine vision in farm science. Distinguishing between plants and soil in colour images is a frequent problem and in many studies transformation of different colour spaces were used for this purpose. Chapron et al. (1999) applied different colour spaces to separate vegetation and soil in maize fields [2]. Hemming and Rath (2001) used eight different morphological features and three colour features to detect cabbage or carrot plants in weedy fields: 59–95% of the cabbage plants and 51–90% of the carrot plants were correctly identified [9].

There are several ways to estimate residue in an agricultural farm land namely visual estimation [14], line transect [16], point intercept [5], meter stick [8], spiked wheel [16] and the photographic techniques [15]. In each procedure measurement is performed at several points and then it is computed their average to report as the amount of crop residue. All above methods are time consuming and don't suit for large agricultural lands [6].In this research a method is presented based on image processing techniques to measure the crop residue on the farm lands based on the colour images acquires in normal field condition.

MATERIALS AND METHODS

Image Acquisition

A digital camera (Canon IXUS 96015) was used to acquire digital images under various lighting conditions from the fields in the College of Agriculture of Shiraz University. Several image resolutions were selectable but the resolution of 1600*1200 pixels was used. More image resolution seems not to have a significant increase in volume estimation of residues. A frame with 1×1 meter was fabricated. It is thrown randomly in the farm land. Images were taken at a distance of about 2.5 meter height from the ground having 24-bit RGB data and JPEG format. Images were captured accurately from the inside of the frame which yielded cropped images to be 1200*1200 pixels. Image Processing Toolbox version 6.00 for MATLAB version7 was used for algorithm development [13-19].

In colour image processing several colour models is defined. Two colour spaces RGB and HSI were investigated in this study. Fig.1 shows the algorithm used for segmentation of the residues from the soil. This research has been devoted to determine crop residue for wheat, corn and brasica produce. For any product, 10 images were captured with different levels of crop residues. Crop residue were then collected and weighed by means of a weighing device having ±1 gram accuracy.

RGB Algorithm

RGB components were extracted from the colour images. Several combinations of the components were constituted and tested as below:

R/g, G-B, (G-B)/(R-G), R/(R+G+B), G/(R+G+B), B/(R+G+B), (G-R)/(G+R), 2G-R-B.

These combinations have presented a good potential for segmentation of crop and residues from the soil [21]. Green components of some of the crop residues are more than the two other components crop residue has some of green colour whereas soil doesn't have. Thus using it crop residue can be known from the soil. After application of these indexes, image transformed to binary system using Otsu algorithm [18].

Variation in illumination caused by sunlight changes is one of the most important problems in colour photography at normal condition of the field. To overcome this problem, the aforementioned indices were constructed so that they attenuate the effect of light change.

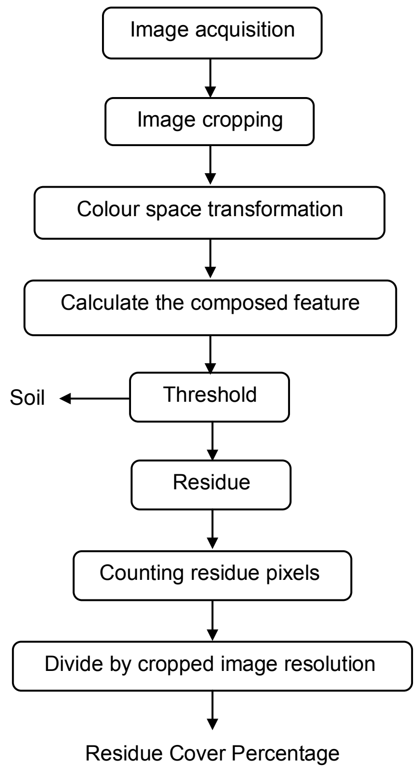

Fig.1. Algorithm of segmentation between soil and residues

HSI Algorithm

The HSI colour system has a good capability of representing the colours of human perception, because human vision system can distinguish different hues easily, where as the perception of different intensity or saturation does not imply the recognition of deferent colours. The HSI coordinates can be transformed from the RGB space. The formulas for hue, saturation, and intensity are:

$$H = \arctan\left(\frac{\sqrt{3}(G-B)}{(R-G)+(R-B)}\right) \quad (1)$$

$$Sat = 1 - \frac{\min(R,G,B)}{I} \quad (2)$$

$$Int = \frac{(R+G+B)}{3} \quad (3)$$

The hue is undefined if the saturation is zero, and the saturation is undefined when the intensity is zero [3].

RESULTS AND DISCUSSION

The result of segmentation using the proposed algorithm is a binary image with white pixels representing residues and black pixels representing the soil. Percentage of crop residue is determined by dividing the number of white pixels to all pixels of the image. One of the segmentation procedure based on the combination of RGB components is shown in Fig. 2.

To compare the accuracy of different methods in approximation of crop residues, 20 images were taken from fields of corn, wheat and canola. Twelve of these images were already used to develop the algorithms. To evaluate the

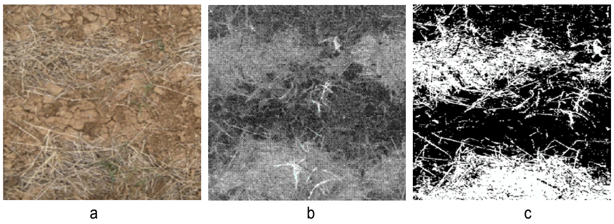

Fig.2. Residue segmentatiın a)Original Image, b)Combination of RGB components c)Segmentatiın result; soul is shown by black pixels and crop resdues are represented by white pixels

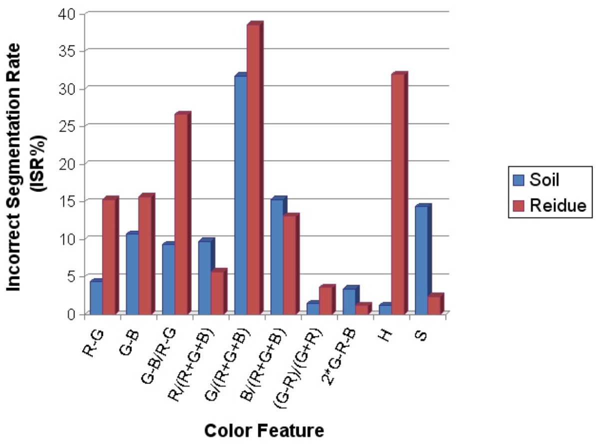

Fig.3. Incorrect segmentation rates of different combinations of HSV and RGB color components

algorithms, eight images were used and manually marked by Adobe Photoshop CS2 software (version 9). Misclassification rate (MCR) of each algorithm was considered as the ratio of residue pixels incorrectly distinguished as soil pixels. Figure 3 shows the incorrect segmentation rates of different colour indices for each of the composed colour feature. As it can be seen the best result was gained by the combination features (G-R)/(G+R)ratio and 2G-R-B equations with average ISR of 2.3%. The segmentation results for all three crop species i.e. wheat, corn and canola was almost the same. Therefore these equations were used in the residue coverage estimation algorithm. The proposed algorithm can be used for measuring the accurate coverage area of the residues.

Estimating The Weight Of Residue

It may be desired to determine the weight of the residue on the surface or the volumetric percentage of the residues. In such cases, image processing can also make an estimation of the weight of the residues. It is obvious that accurate measurement of the volume or weight of the objects needs complete 3D imaging. However the weight estimation is possible if there is a good correlation between the coverage area and the weight of the residue. Therefore such correlation was investigated for the three cases corn, canola and whet residues. Fig.4 shows the results. As it can be seen in Fig. 4 good correlation was observed between the coverage area and weight of the corn and canola residues. Less correlation coefficient was attained in the case of wheat residue. It means that the aforementioned hypothesis for weight estimation have not satisfied in the case of the wheat residue. It could be due to accumulation of plenty of wheat residues in some locations with small occupied area. Causes the volume and surface correlation to be changed in different locations and significant correlation can not be achieved.

CONCLUSIONS

A method of residue measurement on the ground was described in this paper based on the image processing techniques. Several colour features were investigated for segmentation of the residues from the soil in the images. The best performance was gained with two combination of RGB colour components which was (G-R)/(G-B) and 2G-R-B relations with an average correct segmentation rate of 97.7%. Therefore, the coverage area of the residues can be measured by this method.

The experiments also showed that there was a good correlation between the corn and canola residues determined from the images and their weights while for wheat it was depended on the density of the residues on the ground. In cases that the pile of residue does not present in the field, the weight of the residues can also be estimated. It was concluded that this method is practical for fast and convenient determination of residues on the ground.

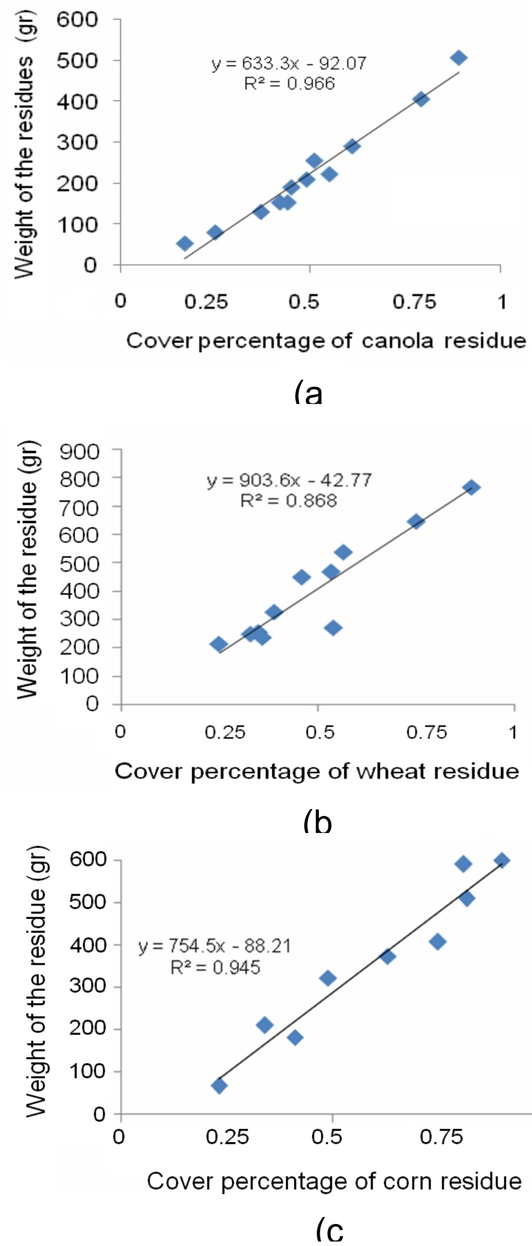

Fig.4. Percentage of residue cover versus the weight a) Canola residue B) Wheat residue C) Corn residue

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