

## Stereo Based Guidance for Field Harvesting Machinery

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### Abstract

The need for increase in food production leads to development in agricultural equipments. Moving towards precision agriculture machine vision is introduced to increase the productivity in minimal time period. The most difficult and time consuming part of agriculture is ploughing the field and harvesting since many of the off-road vehicles is enforced for the purpose and the vehicles are used in the natural terrain surface having irregularities, flying dust particles around and rough surface. This leads to vibrations, continuous changing conditions and presence of weeds in between the rows of crops due to difficulties in the existing conditions the vehicle operator is in need of a proper guidance in operating the off road harvesting vehicles for finding the location of the cut and un-cut edges and also for identifying rows between the crops for the chemical spraying process. This work figures out a system based on the disparity map to overcome the difficulty of the off-road vehicle operators by giving 3D structure of the crop field. A digital camera is mounted on the vehicle and the personal computer is fixed in the harvesting vehicle to show the disparity values of the intended scene the operator gets navigation from the disparity displayed on the monitor present inside

the cabin. The test is conducted in the pearl millet field for row detection and a corn field for detection of un-cut edges.

**Key Words :** Agricultural, Disparity, Field, uncut, Row, Pearl millet field, corn field, 3D, off-road vehicle.

## 1 Introduction

The most important and delicate operation in the field of agriculture is harvesting since it should be carried out in the short span of time based on the favourable climatic conditions. It is also important to get the full yield without any losses in the amount of grain which is harvested. In case of corn harvesting crop gleaned is take place based on the certain conditions. Like fair to middling moisture in the corn cob, good climatic condition should met there should not be rain or snow fall, soil should be dry to allow the harvesting machine in the field and the availability of the machine operator should also meet [13, 14]. The operator is forced to work under specific time period such as work cannot be extended after the dusk, along with this the above conditions should also be considered [13]. Due to the force and stress that is applied to the operator it may lead to sit back in the performance even it may lead to life threading accidents. To avoid such situations semi automated vehicle navigation system is figured out in this paper.

The machine vision detects path in between the rows of the crops in the agricultural field, computer vision based navigation system can direct off road harvesting vehicle for performing cultivation, chemical spraying, and harvesting in the agricultural field [18]. In computer vision based navigation system, features of crop rows are extracted from images captured from the field to give guidance to the vehicle operator. Thresholding methods apply to the intended region to extract the features [18]. The challenging issue in the thresholding methods is determining the threshold since the images are taken in the natural lighting condition and crop growth varies with time. It is also a challenge to distinguish the weed and the crop while estimating the rows between the crops.

Machine vision based image processing is the one of the solution to guide the off-road harvesting vehicles [12]. To get the full field information such as the distance of the objects in the field, structure

and depth of the plants a stereograph provides a 3D visualization of the intended image captured from the field by aggregating stereo pair images captured by binocular camera or a stereo camera at a same time. These kinds of three dimensional images are less sensitive to changes in lighting conditions. Due to this features applications for stereovision have been applied in agriculture field for figuring out the arguments of a jade tray graft. The challenge faced by this method is fixing the camera at a position it may not be affected by dust particles and the fixed angle of the camera should point the row and the edges of the crop.

We have divvied stereo based harvesting vehicle navigation in conditions of true corresponds that is boasting in the two images that are yielded by the same physical entity in the space. The proposed method takes images from the single high resolution digital camera and generates the stereo pair from the single image captured through the single digital camera to provide the real world i.e. three dimensional coordinates of the agricultural field. The algorithm for stereo based disparity estimation is given in the section 3.

## 2 Literature Review

The colour image is commuted into a gray level image. It is accomplished by splitting the colour channel of the image into its red colour, green colour and blue colour and the method divvied by Woebbeck, et.al, [1] is applied to educe living plant tissue. Subsequently, the gray level image is cleaved into orientation divest where the upper limit of gray levels bespeak the bearing of an interested row, every high value ascertains a row section and the center of gravity of the section is noted at this divest location. Rows between the crops are distinguished by merging noted details of the same process as used by the Hough transform or by the process of linear regression. The scheme proposed by Sainz Costa [2, 5] gives the video sequences based analyzing for differentiating rows between the crops. Crop rows dominate on the directions found out by the place of exclusion regarding to the 3D [11, 15], view of the field. Exploiting this concept, this method applies a gray scale shift based method as proposed by Ribeiro [3] and the picture is

changed into the binary image by thresholding. Both of the images are split into 4 horizontal bars. Rectangular dapples are depicted in the binary image to differentiate between the crops and rows. The gravity centre of these bars are used as the points specifying the rows of crops and adjustment is made based on these points. The commencing frame is a reference that guides the system for finding the position of the upcoming dapples in upcoming frames, [20] and in Wheeler [4] the source RGB image is converted into gray scale. The converted gray level image is split into 8 horizontal stripes. The chroma of the pels throughout these stripes demonstrates a time to time differentiation, imputable to the parallel corn rows. Since there is prior knowledge of the camera parameters, position of the camera and the spacing between the crops are known, the spacing between the rows in image pel can be estimated for every horizontal band by a pinhole model camera. By Hague T [19] Band pass filter is applied to this model to enhance the pattern [16], and this gives a high response in the frequency domain [17]. Sometimes it is tough to use horizontal patterns to differentiate crops and weeds form an unparallel patch.

The approach proposed by Pla, et.al [13] applies color image segmentation to identify crops and soil. Based on the color it collects the sketch of the regions with the same color. The ensuring sketch and their properties are connected into contour points, these results to identify the crops and the rows through the vanishing points. The flaw with this method is drawing the sketch, if the weed is present in between the rows this method may include that as a crop and it may not differentiate the rows between the crops. In Romeo et al. [6] identifies the row between the crops by vanishing point. The process is based on the supervised fuzzy logic and finding out the highest accumulation of green pixels in the region in the direction of vanishing point. This method is fully hooked on the training data set.

To overcome the difficulties faced by the existing methods 3D based stereography is introduced in the field of agriculture. In general 3D information is generated based on the multi view images [7, 9] and depth maps [22]. For generation of the depth information two cameras are used to generate the multi view images each camera is kept apart as the distance between the two human eyes (approximately 2.5 cm) [23, 25]. The depth map of the scene is generated

based on the distance information of the intended scene. Based on the depth map intermediate view of images at an arbitrary virtual viewpoint is reconstructed [24]. The other method adopted for the generation of stereograph images is by using stereo depth cameras [21, 25] which will have two cameras fixed in it and automatically estimates the depth information based on the images captured. The difficulty faced by using two cameras based method in agricultural machineries is locating the two cameras at the appropriate angle and the cost of stereo camera is comparatively high.

To prevail gross Pearl millet field information, the proposed stereograph based method can deliver a 3D view of the field by merging two images of agricultural field acquired from a normal digital camera [7, 8]. The image with depth is obtained from the angular deviation among the stereo pair generated from the monocular image; this approach is minimum prone to changes in lighting conditions since the single camera is used to capture the monocular image which is source for the stereo pair the intensity of the light in the stereo pair will remain the same and the stereo pair will not suffer from ghosting or vibration effects. This work figures out the formulation of row detection and uncut edge detection in a corn field for navigation of the off-road vehicle operators.

### **3 System Architecture**

#### **3.1 Stereo vision based crop edge and row detection system**

The stereograph represents a scene with its depth information based on the two images in slightly different angle between them [10].

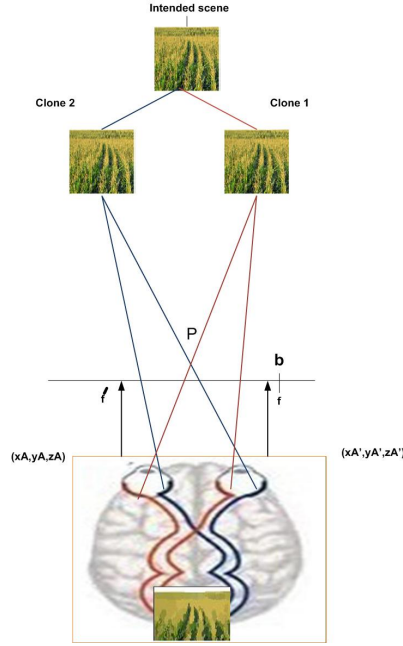


Figure 1: model of stereo vision formation

In the fig.1  $f$ - Focal length,  $P$ - projection,  $b$ - baseline,  $(x_w, y_w, z_w)$  represents the clone1 image and  $(x_{w'}, y_{w'}, z_{w'})$  clone 2 image. The proposed stereo vision based crop un-cut edge detection and row detection employs single digital camera with high resolution. Proposed method clones the captured scene and creates the stereo pair.

The coordinates of Clone1 and clone 2 is defines as eq 1 and 2,

$$A(x_w, y_w, z_w) = A(x_w - b/2, y_w, z_w) \quad (1)$$

$$A'(x_{w'}, y_{w'}, z_{w'}) = A'(x_{w'} - b/2, y_{w'}, z_{w'}) \quad (2)$$

Horizontal displacement is found between the stereo pair the deviation angle gives the depth map of the scene. It is defined by the formulas as follows, Mathematically it is difference between the equ (1) and (2) by solving this equations it ends up with actual deviation level ( $z$ ).

$$z = \frac{bf}{x_w - x_{w'}} \quad (3)$$

By the same process the solution for x, y also can be obtained,

$$x = \frac{b(x_w + x_{w'})}{2(x_w - x_{w'})} \quad (4)$$

$$y = \frac{by}{x_A - x_{A'}} \quad (5)$$

Once the disparity is obtained the depth map of the scene is obtained from the above formulation and the distance between the nearer object and far object can be calculated from the depth map from which the un-cut edges are highlighted and the rows between the crops can be differentiated.

### 3.2 Camera location

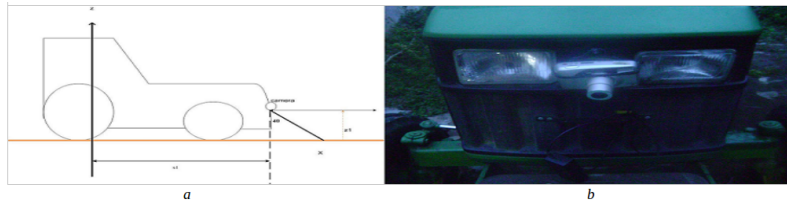


Figure 2: depiction of camera position and vehicle used in experiment

Here in Fig.2 x1 offset camera location, x, z vehicle location, z1 camera location offset in vertical.

The proposed stereo crop row and un-cut edge detection system is based on a single camera. This provides the guidance to the half road vehicle operator. The problem faced while experimenting is locating position of camera and tilted angle. The camera is located at different positions like top of the off-road vehicle, at mount and between the lamps. It is found that the position between the lamps gives the satisfactory result of the view angle of 40 degree shown in Fig. (2)(a,b). The camera used for experiment is normal digital camera which is capable of capturing seven type of frame resolutions (1024x768, 1280x1024, 160x120, 176x144, 320x240, 352x288, 640x480). The camera is installed at the height of 2m from the

ground level and the camera is adequate to capture scenes between 1m to 9m as shown in the Fig.(2).

The scene captured through the camera is sent to the processing unit and the disparity is estimated according to the formulas (1) to (5). It gives the rows between the crops and un-cut edges accordingly the operator of the half-road vehicle operator can steer the vehicle.

## 4 Results and Discussions

The Fig. 3 (a), image depicts the pearl miller crop rows with a height approximation of 0.6m and the distance between the rows are 0.55 m. The disparity map of stereo images Fig.4 (b) (c) are estimated by scene captured from the camera fixed on the off-road vehicle. The darker portioned objects are nearer and the lighter portions are far.

The high resolution digital camera is mounted on the off-road harvester vehicle in the way it cover version a square area of 4m width at the top, 1m width on the bottom and 5m in distance, located about 1.5m on the face of the tractor. The arrangement shows up to 4 crop rows as seen in the Fig. (3).



Figure 3: crop rows and disparity in two scales



Figure 4: source image and validation test results

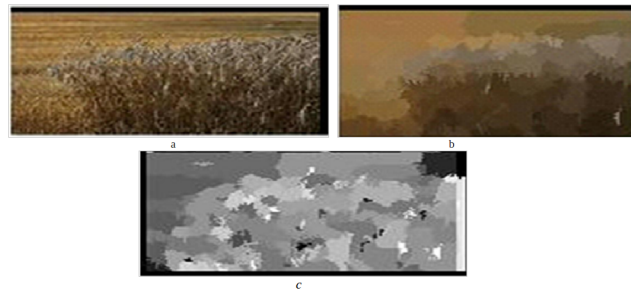


Figure 5: source image and disparity of un cut edges

## 5 Conclusion

The proposed work looks into the methodology for agricultural machinery guidance system based on single high resolution digital camera. Field inspection results show that the stereo vision guidance system could capture a scene through the single camera lens and based on the single image captured disparity is estimated. Since single digital camera is used its cost efficient method for farmers which reduces the overhead cost of getting high cost stereo cameras. Based on the disparity image created on the screen the machine operator can steer the vehicle through the rows and get through the uncut edges and find the rows between the crops and this method is not restricted to particular type of crop.

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