Chapter 4

Image Processing Method for Seed Selection

4.1 Introduction

Though the yield of the sugarcane depends upon the variety of sugarcane used for plantation, the quality of seed is equally an important criterion to increase the yield. Generally, sugarcane is propagated by cutting sections of the stalks called sets. The selected seed for planting should be fresh and juicy with an age of 9 to 10 months. It must be free from pest and disease with fully developed eye buds. The seed should be from fresh planted sugarcane and not Ratoon [39].

In sugarcane agriculture, planting methods are based on slope and soil condition of land, wind direction, availability of water, etc. Normally sugarcane is planted by ridge and furrows method by using three eyed (buded) sets. For this method 3.5 to 4 MT seed is required per hectare. This method requires more seed and human force for planting hence it is costly.

Instead of conventional method of planting, row method of sugarcane planting is used for maintaining optimum plant population. It is easy for management and gives high yield. It uses two eyed sets and planting is done by keeping 4 to 6 cm distance between two sets. This type of planting needs 2 to 2.5 MT seed per hectare [40].

In Spaced Transplanting (STP) method single eyed sets are used for planting. In this method sets are directly grown in field or grown in polythene bags in nurseries that are transplanted into the field after 50 to 55 days from the date of plantation. The STP method needs 750 kg to 1MT seed per hectare is required, which saves seed
cost by 60 to 70%. The distance between two sets is kept at 30 cm during the plantation. This method is more economical and therefore is widely acknowledged, now a day.

In pair row method of planting, cane sets are placed in subsequent two furrows and third furrow should be kept free of sets. This method not only saves the seed cost but also enable use of the third furrow’s space to grow inter crop which increases the sustainability of the farming. Further, Paired row method is also very easy to manage and allows sufficient sunlight for faster growth of the sugarcane [40].

Wide row method is another new method of planting the sugarcane and is carried out in alternate furrows. The distance between two rows is about 150 cm and gives an additional advantage of efficient irrigation.

Sugarcane planting with traditional method is costly, time-consuming, requires great human force and high volume of sugarcane stalk per hectares. Now a days sugarcane planting machines are used to reduce the human force and time. However, these machines do not have control on cutting location. In uncontrolled cutting process 3 to 6 buds set may get planted instead of single bud. This ultimately results into more population of sugarcane stalk which affects the yield. Sometimes, cut may appear on the bud as well, which results into no germination of the bud and we lose the seed. Also, it has no facility to identify diseased node, so planting of diseased nodes affects the yield and quality of the sugarcane.

In addition to proper controlled cutting of stalk, it is necessary to identify any disease in the node as it affects the yield and quality of the sugarcane. Unfortunately the traditional sugarcane planting machines do not have any such facility.

This chapter deals with solutions to overcome these problems and talks about use of image processing method for seed selection.

4.2 Analysis and Design

Sugarcane stalk consists of segments called joints as shown in Figure 2.3. Joint is made up of a node. Node is a place where the bud, growth ring, leaf scape and root primordial are located. Growth ring and leaf scape forms continuous edges and root primordial appear as alternative dot [36].

Inter node distance (distance between two successive nodes) plays important role
In the usual practice, it is noted that during the period of water stress, distance between newly formed sugarcane nodes reduces as compared to inter nodes distance that are already grown in proper irrigation rate [11]. A disease called Pokka-bong (a viral disease) is the one, in which the distance between the nodes reduces. If sugarcane suffers due to Red-rot disease, the stalk of sugarcane cracks in-between nodes [48]. Such stressed and diseased nodes are not at all suitable for germination.

Considering the advantages of STP method of plantation and experience of agricultural researchers the proposed work starts with assumption that the sugarcane node is said to be normal if:

1. The difference between two consecutive nodes is less than 30 % and
2. There is no crack on stalk.

The proposed methodology of identification of normal nodes is elaborated in Figure 4.1. The system consists of following important components [49]:

1. Personal Computer (PC),
2. Charged Coupled Device (CCD) camera and Lighting system,
3. Control system and Cutter,

In this report, the scope is restricted to the design of image processing algorithm to select the normal single node from the sugarcane stalk. The proposed systems task is to capture the image of the sugarcane stalk and locate the cut point in between consecutive sugarcane nodes that are found acceptable for plantation [50].

4.3 Implementation

In this research, algorithm is designed for automation of the sugarcane planting machine to identify the sugarcane node and to select the cut point at center of two consecutive nodes if stalk is normal.

Algorithm: The processing steps of the proposed algorithm are as follows:

1. Acquire the image of sugarcane stalk
2. Preprocessing of image to convert in proper format:
   - Resize the image
   - RGB to HSI conversion
3. Obtain the sharp horizontal edges of sugarcane stalk by convolution
4. Obtain binary image by thresholding
5. Identify the node of the sugarcane stalk
6. Feature extraction:
   - Computation of area between the nodes
   - Detection of crack on the inter-node
7. Locate the cut point on the stalk.

A brief description of the process and steps involved are:

1. **Image acquisition**: To acquire the images a Nikon make 12 Mega pixels with 4X zoom digital camera was used. To distinguish objects the images need to have an easily separated background [50]. White background was used in this experimentation. The advantage is that it does not deceive the camera into
over-exposing. White is not a hue, but comprises all hues with zero saturation and maximum intensity. Sugarcane stalk was placed on the white background. Distance between camera and sugarcane stalk was adjusted such that it covered 3-4 nodes of the sugarcane stalk. The sample input image is shown in Figure 4.2.

2. **Preprocessing of image** : These steps convert input sample image in a more suitable format for the segmentation and fast processing.

- **Image resizing** : Original input colour image is of size 4000 x 3000, which is resized to 256 x 256, to improve the speed of further process. The resizing of an image is performed by the process of the interpolation [51].

- **Convert RGB image to HSI** : In second stage, RGB colour image is converted into HSI space as below

\[
H = \begin{cases} 
\theta & \text{if } B \leq G \\
360 - \theta & \text{if } B > G 
\end{cases}
\]  

(4.1)

With,

\[
\theta = \cos^{-1}\left\{ \frac{\frac{1}{2}(R - G) + (R - B)}{[(R - G)^2 + (R - B)(G - B)]^{1/2}} \right\}
\]

The saturation component is given by

\[
S = 1 - \frac{3}{(R + G + B)^{[\min(R, G, B)]}}
\]  

(4.2)
Finally, the intensity component is given by

\[ I = \frac{1}{3}(R + G + B) \]  

(4.3)

For convenience \( h, s \) and \( i \) values are converted in the ranges of \([0,360]\), \([0,100]\) and \([0,255]\) respectively by:

\[ H = h \times \frac{180}{\pi}, \quad S = s \times 100, \quad I = i \times 255 \]  

(4.4)

HSI colour model decouples the intensity \( I \) component from the colour carrying information (hue and saturation) in colour image. Hue is colour attribute that describes a pure colour, whereas saturation gives a measure of the degree to which a pure colour is diluted by white light while intensity is the most useful descriptor of monochromatic images.

3. **Horizontal edge detection** : To identify a node and locating the cut point on the sugarcane stalk it is necessary to identify the sharp horizontal edges of the stalk where node is placed. These edges are formed by the root primordial, leaf scare and root bands.

Edge detection refers to the process of identifying and locating sharp discontinuities in an image. The discontinuities are abrupt changes in the pixel intensity which characterize boundaries of object in an image. Classical method of edge detection involves convolving the image with an operator, which is constructed to be sensitive to large gradients in the image while returning values of zero in uniform region.

The gradient of the image function \( I \) is given by the vector

\[ \nabla I = \begin{bmatrix} \frac{\partial I}{\partial x} \\ \frac{\partial I}{\partial y} \end{bmatrix} \]  

(4.5)

The magnitude of this gradient is given by

\[ \nabla I = \sqrt{\left(\frac{\partial I}{\partial x}\right)^2 + \left(\frac{\partial I}{\partial y}\right)^2} \]

And its direction by

\[ \theta = \tan^{-1}\left(\frac{\partial I}{\partial y}/\frac{\partial I}{\partial x}\right) \]  

(4.6)
One can use any pair of orthogonal directions to compute this gradient, although it is common to use the $x$ and $y$ directions.

Convolution operation used for identification of sharp edges, it combines the amount of pixels in order to obtain desirable results. Convolution operation is carried by equation

$$C(X, Y) = \sum_{i=1}^{M} \sum_{j=1}^{N} P_{i,j}(X, Y) \times M_{i,j}(X, Y)$$

(4.7)

Where, $C(X, Y)$ is pixel value after convolution, $P(X, Y)$ is original pixel value and $M(X, Y)$ is convolution mask matrix. Different characteristics of images can be obtained with changing of $M(X, Y)$ matrix.

- **Appropriate mask matrix for convolution operation**: Standard matrices are used for selecting suitable matrix mask on 100 sugarcane node samples. Roberts, Sobel and Perwitt masks are evaluated on these images.

  Roberts mask in edge detecting is one of the earliest techniques. The mask used by Robert edge detector are $[1 0; 0 -1]$ and $[0 1; -1 0]$.

  Instead of finding approximate gradient component along the $x$ and $y$ directions it approximates gradient components along directions at $45^0$ and $135^0$ to the axes respectively. Thus the Roberts cross operator uses the diagonal directions to calculate the gradient vector. The computational speed for this detection is fast and produces resultant image as shown in Figure 4.3 in case of sample image.

  However, the performance of this detector is quite poor with the noise in image. In this case other details such as pixels in the image related to crack, bud, insect byte, dust and low light intensity is treated as a noise.

In the next step, $3 \times 3$ approximation that defines $\frac{\partial I}{\partial y}$ for Prewitt and Sobel masks are used to detect the horizontal edge components of the sample image. Figure 4.4 and Figure 4.5 shows the horizontal edge detected image of sample image using Perwitt and Sobel masks respectively.
Figure 4.3: Stalk image after edge detection by Roberts mask

Figure 4.4: Stalk image after edge detection by Perwitt mask

Figure 4.5: Stalk image after edge detection by Sobel mask
Table 4.1 shows statistical analysis of percent error of node location by standard masks. Right Sobel, Left Sobel, east Perwitt, west Perwitt and western south Perwitt mask are evaluated. Only the right Sobel is able to identify the node locations with the average and standard error of 2.08% and 0.30% respectively.

<table>
<thead>
<tr>
<th>Statistics</th>
<th>Right Sobel</th>
<th>Left Sobel</th>
<th>West South Perwitt</th>
<th>West Perwitt</th>
<th>East Perwitt</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of nodes</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Average error (%)</td>
<td>2.08</td>
<td>11.9</td>
<td>27.94</td>
<td>17.63</td>
<td>21.31</td>
</tr>
<tr>
<td>Maximum error (%)</td>
<td>15</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Error limit (%)</td>
<td>15</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Variance</td>
<td>8.82</td>
<td>619.5</td>
<td>1696.72</td>
<td>1016.24</td>
<td>1388.83</td>
</tr>
<tr>
<td>Standard deviation</td>
<td>2.97</td>
<td>24.89</td>
<td>41.19</td>
<td>32.62</td>
<td>37.27</td>
</tr>
<tr>
<td>Standard error (%)</td>
<td>0.3</td>
<td>2.49</td>
<td>4.12</td>
<td>3.36</td>
<td>3.73</td>
</tr>
</tbody>
</table>

It is clear that the error percentage of right Sobel mask matrix is the lowest and has minimum variance and standard deviation in comparison with the other masks. The right Sobel mask is assigned as the best matrix with the variance and standard deviation of 8.82 and 2.97 respectively.

The right Sobel mask is also used to find node location of other sample images of sugarcane stalk with high light intensity and low light intensity. The results of the same is as shown in Figure 4.6. These results show that light intensity has no significant effect on the identification of node location.

Figure 4.6: (A-B) Before and after processing image of sugarcane stalk with high light intensity, (C-D) Low light intensity
4. **Image thresholding**: The image is converted to a binary image by thresholding which eliminates the noise and reveals the nodes. In this report, Otsu thresholding method is used. Otsu method is an overall automatic threshold selection method, which chooses the threshold to minimize the intraclass variance of the black and white pixels [52, 53]. In the sample image of the sugarcane, threshold value obtained is 0.4863. The thresholded image of sugarcane stalk is as shown in Figure 4.7.

![Figure 4.7: Binary image of sugarcane stalk](image)

5. **Node identification**: Negated image of sugarcane stalk as shown in Figure 4.8, is used for node identification. For the image of sugarcane stalk, due to presence of growth ring, leaf scare and root primordial, continues edges have appeared [54]. Only the edges that correspond to the node are of importance. All other edges are eliminated from the image by applying threshold. To identify the node, the image is scanned in top down format. In this process total number of black pixel in each row are counted and are divided by total number of pixels in a row. The resultant value is compared with threshold. If resultant value is greater than threshold it is considered as a node.

Then, an algorithm is implemented to identify the nodes by using the following steps:

\[
\text{Number of node pixels in a line} \div \text{Total number of pixels} \geq \text{Threshold} \\
\text{Node} = \text{True} \\
\text{Else} \\
\text{Node} = \text{False}
\]
In the sample image of sugarcane, the numbers of horizontal lines so obtained were 34. All these lines were arranged in descending order of the number of black pixels in line. In this experimentation, threshold was computed iteratively and selected in such a way that the number of black pixel content in ninth line (7) is divided by total number of pixels in that row (256). The threshold value of sample image is thus 0.0273. The node identified image is as shown in Figure 4.9. For every image, the threshold value is different and is selected automatically by the algorithm.

6. **Feature extraction**: For the better quality and higher yield of sugarcane it is...
necessary to select normal node for plantation. From the discussion with expert sugarcane producers and agricultural scientist, it is concluded that:

- In case of all the varieties of sugarcane there is no any standard for internodes length and width of sugarcane stalk. For individual varieties it varies according to type of soil, water, fertilizer, and environment [11, 48].
- In next case if sugarcane stalk suffers by disease like Red-rot or in excessive fertilizer doses of Potash (K), crack of indefinite length, appears parallel to vertical edges and in between nodes of sugarcane stalk.

So the sugarcane node is said to be normal node if the area difference between two consecutive nodes is less than thirty percent (30%) and there is no any crack on internodes otherwise it is stressed or and diseased.

To test the normal node condition of the sugarcane stalk, it is important to extract certain features such as area between two consecutive nodes and vertical line corresponding to crack on the sugarcane stalk. For identification of normal node following two steps are carried out:

- **Calculation of area between nodes**: To calculate the area between two consecutive nodes of the sugarcane, the binary image of the sugarcane stalk is used [55]. First the image is filtered for smoothing and for noise reduction (such as removal of small details from an image prior to object extraction and bridging of small gaps in lines). Remaining noise is cleared by morphological process called ‘Closing’ operation that tends to smooth sections of contours (it generally fuses narrow breaks and long thin gulf, eliminates and fills gaps in the contour). Then the area is measured in terms of pixels in an image in between consecutive nodes. In sample image area between first and second node is 926, and in between node second and third is 846. Here the area difference is 9 %. This shows that the nodes are not stressed or diseased.

- **Detection of crack on the node**: For identification of crack on the node, ‘I’ component of the ‘HST’ image is filtered using vertical mask is as shown in Figure 4.10.

This result into noise reduction, such as removal of small details from an image and revealing only vertical edges corresponds to crack. Particularly ‘I’ component is used in this operation, because it does not change much
with shading and lighting [56, 57]. Resultant image is thresholded (iterative threshold was evaluated and selected as 0.15) and negated. In selected sample image, vertical line corresponding to crack is observed in between first and second node. No such line is in between the second and third node. Thus, the first node is identified as a diseased and second node is normal node. Crack detected image is as shown in Figure 4.11.

7. **Locating cut point on the sugarcane stalk**: If the node is normal, cut point is located on sugarcane node by using following algorithm

\[
DS = \frac{H(i + 1) - H(i)}{3} \quad (4.8)
\]
\[
FC = H(i) + DS \quad (4.9)
\]
\[
SC = FC + DS \quad (4.10)
\]

Where, \( DS \) - is one third of the distance between two consecutive nodes, 
\( H(i) \) - is the location of node \( i \),

Figure 4.10: Vertical edge detection mask

Figure 4.11: Stalk crack detected image
Figure 4.12: Cut-point located image

$H(i + 1)$ - is the location of node $i + 1$,
$FC$ - is the location of the first cut point and
$SC$ - is the location of the second cut point.

In the sample input image of sugarcane stalk, the area difference between first and second nodes is only 9\% but crack is observed in between first node and second node. So the first stalk is not normal node and hence no cut point is located in between first and second node. Whereas in second and third node there is no crack on stalk, so node is the normal node and the algorithm locates the cut point at the center of the stalk. The location of nodes, background and cut-point are displayed by blue and red colour lines as shown in Figure 4.12.

4.4 Results and Discussions

In traditional planting process by using human force, one can easily find the stressed or diseased node with necked eye and knowledge. In presented research work normal node is automatically identified by the designed algorithm.

For justification and validation of result of proposed algorithm, Graphical User Interface (GUI) is designed as shown in Figure 4.13 using Matlab (Version 7.4). Designed GUI has a manual processing unit; in which desirable image is selected by pressing Input Image button. Selected colour image appears at right hand corner window of GUI. Using this window one can easily assess the normal node conditions visually. Further image processing operation is started by pressing Node Detection button. That locates the cut points in the position of cutting, only in normal node conditions. Also, at
Figure 4.13: GUI for normal node identification and locating cut point

left hand corner window it shows the number of normal nodes and stressed or cracked nodes. Thus input colour image of sugarcane stalk at right hand corner window of GUI, cut point located image at left hand corner window and displayed number related to node status is sufficient for validation of results of designed algorithm.

During the experimentation, the algorithm was tested on two more popular used varieties of sugarcane (CO-86032 and CO-C671). Well focused sharp 100 images of normal nodes, 50 diseased node images and 50 images of stressed nodes are tested using this algorithm.

Tabular representation of test images and result is given in Appendix-B. Table 4.2 shows the success rate of identification of normal nodes, diseased nodes and stressed nodes. The observations with respect to Table 4.2 are as follows:

<table>
<thead>
<tr>
<th>Nodes</th>
<th>Manual observation (N)</th>
<th>Using algorithm (P)</th>
<th>Success Rate (%) ( P/N \times 100 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal Node</td>
<td>100</td>
<td>95</td>
<td>95.00</td>
</tr>
<tr>
<td>Cracked Node</td>
<td>50</td>
<td>43</td>
<td>86.00</td>
</tr>
<tr>
<td>Stressed Node</td>
<td>50</td>
<td>50</td>
<td>100</td>
</tr>
</tbody>
</table>

1. The success rate of identification of normal node is 95% which shows that the light intensity and the shape of nodes have no significant effect on the identification of node location in this method. The success rate of normal node identification is strongly validated by observing actual numbers of normal nodes of input image at right window of GUI and Normal node counted by algorithm on the left hand
window. In addition to this cut points appears only in normal node condition. It is observed that there are two a reason in which algorithm fails to identify node:

- Nodes with undeveloped growth ring, leaf scare and root band and
- If leaf is not removed properly from the stalk, sheath part of the leaf cover growth ring, leaf scare and root band.

2. The success rate of identification of the defective node (cracked) is 86%. There are two factors affecting the crack identification process:

- Airy root on the node which forms black pixel line in between two successive nodes and detects it as a crack.
- If the crack is not in the camera vision, that crack does not come in image of the stalk.

3. The success rate of identification of stressed node is 100% which shows that algorithm effectively identifies the stressed nodes.

The success rate of identification of cracked and stressed node is justified by comparing visually observed image at right hand window of GUI, normal and stressed or cracked node count shown by algorithm at left hand window. Also algorithm does not locate the cut point if sugarcane stalk is stressed or cracked

Careful observation shows that cut point fixed by the algorithm is at center of the sugarcane stalk.

4.5 Concluding Remarks

An algorithm is developed for identification of node location on sugarcane stalk. Further, algorithm checks the condition of the node whether the node is stressed or affected by disease. Algorithm is successful in identifying the normal node and locating the cut point upon satisfying the conditions of normal node. Designed GUI useful for justification of success rate of normal node identification, stressed and cracked node identification. As the system rejects non suitable nodes for plantation, it is a useful tool for efficient and cost effective Precision Agricultural.

Next subsequent chapters of this report will elaborate more on the implementation aspects for crop status management that includes Growth, Chlorophyll and Disease severity measurement.