A Step towards Precision Farming of Rice Crop by Estimating Loss Caused by Leaf Blast Disease Using Digital Image Processing and Fuzzy Clustering

Toran Verma, Susanta Kumar Satpathy, Lokesh Kumar Sharma

CSE Department, Rungta College of Engineering &Technology,
Chhattisgarh Swami Vivekanand Technical University, Bhilai, 490024, INDIA

Abstract—**Precision Farming (PF) is generally defined as an information and technology based farm management system to identify, analyze and manage variability within fields for optimum profitability, sustainability and protection of the land resource. In this mode of farming, new information technologies can be used to make better decision about many aspects of crop production. Timely estimation and diagnosis of crop diseases in fields is very critical for the production of the crop. Blast is the most important fungal disease of rice and occurs in all rice-growing regions. In this paper, we describe the application of Fuzzy C-Mean Clustering algorithm to estimate the loss caused by blast disease in rice crop. A digital image has been taken by digital camera of rice crop, which is further analyzed by taking RGB feature of that image and then classified using Fuzzy C-Mean Clustering algorithm. That clustered information can be used for precision farming by farmer for decision support system.**

Keywords—**Precision Farming, Rice blast, fuzzy C-Mean clustering, image processing.**

I. Introduction

A. Precision Farming (PF)

According to Robert et al., [1] Precision farming is defined as information and technology based agricultural management system to identify, analyse and manage site-soil, spatial and temporal variability within fields for optimum profitability, sustainability and protection of the environment. The success of precision farming depends on numerous factors, including the extent to which conditions within a field are known, how best we can manage, the exact quantity of input recommendation and the degree of application control.

PF requires special tools and resources to recognize the inherent spatial variability associated with soil characteristics, crop growth and to prescribe the most appropriate management strategy on a site specific basis. It is a paradigm shift from conventional management practice of soil and crop in consequence with spatial variability. It is a refinement of good whole field management, where management decisions are adjusted to suit variations in resource conditions [2].

PF is a management philosophy or approach to the farm and is not a definable prescriptive system [3]. It identifies the critical factors where yield is limited by controllable factors, and determines intrinsic spatial variability. It is essentially more precise farm management made possible by modern technology. The variations occurring in crop or soil properties within a field are noted, mapped and then management actions are taken as a consequence of continued assessment of the spatial variability within that field.

Development of geomantic technology in the later part of the 20th century has aided in the adoption of site-specific management systems using remote sensing (RS), GPS, and geographical information system (GIS). This approach is called PF or site specific management [4] [5] [6].

PF acknowledges the conditions for agricultural production as determined by soil, weather and prior management across space and over time [7]. Conventional agriculture is practiced for uniform application of fertilizer, herbicide, insecticides, fungicides and irrigation, without considering spatial variability. To alleviate the ill-effects of over and under usage of inputs, the new concept of PF has emerged. Site specific management to spatial variability of farm is developed to maximize crop production and to minimize environmental pollution and degradation, leading to sustainable development.

1) Important issue related to precision farming

Economics: Change in costs, Change in revenues, Cash flow and Risk

Management: Data acquisition and analysis, Decision support systems, increased attention to management

Technologies etc. needed: Accurate GPS system, Variable rate technology, Site specific management service, Financing

Environmental: Reduce input losses, Increase water and nutrient use efficiencies

Precision farming involves looking at the increased efficiency that can be realized by understanding and dealing with the natural variability found within a field. Farmers who effectively use information earn higher return than those who don't. The potential of precision farming for economical and environmental benefits could be visualized through reduced use of water, fertilizers, herbicides and pesticides besides the farm equipments. Today, because of increasing input costs, the farmers are looking for new ways to increase efficiency and cut costs. Precision farming technology would be viable alternate to improve profitability and productivity.

B. *Rice Blast*

Agriculture is the mainstay of the Indian economy. Agriculture and allied sectors contribute nearly 17.8 and 17.1 per cent of Gross Domestic Product (GDP of India) during 2007-08 and 2008-09 respectively. The agricultural output, however, mainly depends on monsoon as nearly 55.7 per cent of area sown is dependent on rainfall. An all time record in production of food grains of 233.88 million tonnes is estimated in 2008-09 as per 4th Advance Estimates. The production of rice is estimated at 99.15 million tonnes [8].

Rice blast diseases caused production losses of US$55 million each year in South and Southeast Asia [9]. It is distributed in 85 countries. Damage is mainly influenced by environmental factors [10].

The rice blast disease is caused by the fungus Pyricularia grisea, which, in its sexual state, is known as Magnaporthe grisea. The disease can strike all aerial parts of the plant. Most infections occur on the leaves, causing diamond-shaped lesions with a gray or white center to appear, or on the panicles, which turn white and die before being filled with grain. P. grisea is highly specific to rice, although certain strains that don't attack rice can harm weeds in the rice field. Once on a rice plant, the fungus rapidly produces thousands of spores, which are carried readily through the air, by wind or rain, onto neighboring plants.

Some of the main type of rice blast diseases are Leaf blast, Collar Rot, Neck Rot and Panicle Blast, Node infection etc. The symptoms of the blast infection can be seen on the leaves as characteristics spindle-shaped spots, with ashy center, and on the leaf-sheaths and at the juncture as irregularly oval discolorations [11].

Figure 1.1(a), and 1.1(b), shows leaf blast disease. On the leaves, the spots are elliptical or diamond shaped. Blast diseases can be controlled by increasing resistance power of crop by breeding, chemicals or by agronomic practices but neither chemicals nor breeding provide a totally effective approach.

(a) (b)

Fig. 1 (a): Leaf Blast Symptoms (b) Leaf Blast Symptoms

The rice crop leaves that determine the blast disease is the lesion and colour of rice crop leaves. These are the symptoms that cause the blast diseases. According to colour and type of lesion, Abdullah et. al [12] present a fuzzy logic approach to handle the uncertainty and vagueness of paddy diseases.

C. *Image Processing*

Image processing methods are mainly used in two application areas: improve pictorial information for interpretation; and processing of image data for machine perception, storage, and transmission. A digital image is composed of finite number pixels, each with particular location and RGB intensity value.

Colour Image Processing is divided into two major areas: full colour where the images are acquired with a full-colour sensor, and pseudo colour, where a particular monochrome intensity is assigned for processing. In the RGB colour model, each colour appears in its primary spectral components of red, green, and blue [13].

Computer vision is a rapid, economic, consistent and objective inspection technique, which is non-destructive method of inspection, has found applications in the agricultural and food industry, including the inspection and grading of fruit and vegetable. This paper reviews the progress of computer vision in the agricultural and food industry [14]. Image processing and image analysis are the core of computer vision with numerous algorithms and methods available to achieve the required classification and measurements [15].

D. *Fuzzy Logic*

1) *Fuzzy Sets:*

Fuzzy sets are the sets with imprecise (vague) boundaries. It may be either discrete or continuous in nature. There are two important applications of fuzzy set theory, clustering and fuzzy inference system.

2) *Fuzzy Clustering*

In Data Mining, useful information is extracted from a set of data. Clustering is a powerful method of data mining. Clustering techniques create groups based on similarity of the pattern. Several methods of fuzzy clustering, such as Fuzzy C-Means(FCM), Fuzzy K-nearest neighbourhood Algorithm, Entropy Based Clustering, and others have been proposed by various researchers.

3) *Fuzzy C-means Clustering*

Fuzzy C-Means (FCM) is one of the most popular clustering techniques. The particular data of the set may be the member of several clusters with different membership values.

II. METHODOLOGY

Many techniques has been used to estimate loss caused by diseases in farming like regression analysis, spectral analysis etc. In this approach, RGB feature of diseased crop is analyzed to estimate the loss. During blast disease affectedness colors of leaves of rice crop continuously varies.

Before infection, crop's leaves color will be green, but after infection, leaves color changes with grey or white center. This variations in intensities of RGB contents is analyzed in this presented approach.

A. Acquire Knowledge about Blast Disease and Variation in Colour According to Affectedness

Knowledge acquisition process is done in structured and non structured way by reading books, discussion with the farmers and govt. expert.

B. Field Visit and Coloured Image Acquisition

In month September, 2010 Rice crop field is visited. Coloured picture has been taken by digital camera. Figure 2 is used in this experiment.

Fig. 2 Infected rice crop picture taken by digital camera

C. RGB Colour Information Acquisition

The RGB pixel information of infected and non-infected leaves is collected for clustering purpose using MATLAB. For this experiment, total 150 pixel information is taken from random locations. Sample information of 5 pixels is given in Table I and all 150 pixels is shown in Figure 3 scaled by 1/100.

TABLE I
SAMPLE INFORMATION OF PIXELS

R	G	B
[139	192	62]
[119	173	51]
[51	92	22]
[77	126	44]
[83	122	57]

D. Create Cluster by using Fuzzy C-mean Clustering

So, for proposed method, total sample data sets are collected from digital image taken from field by digital camera. Data will be stored in 3-dimensional space in $[R, G, B]$ format for each sample pixels of dimensional spaces 3. Thus total 150 data points with 3-dimensional space taken. Assume that points are represented by $x_i = [R_i, G_i, B_i]$, where $i = (1,2,...,150)$ .The sample of 150×3 data is shown in Table I and entire data is represented in the form of grid in Figure 3. This data will be clustered into three categories here and cluster fuzziness weighing factor is taken 2. Let us assume membership matrix with dimensions of 150×3.

In this experiment total number of 150 data points taken for experiments, number of cluster to be divided is 3 and cluster fuzziness 2. Data points are shown in Figure. 3. Size of random membership matrix is assumed and finally changes in membership values come out to be less than $1e-5$.

The values of membership matrix are updated until the changes in membership matrix come out to be less than values 1e-5. According to similar membership values in data sets with, cluster has been created.

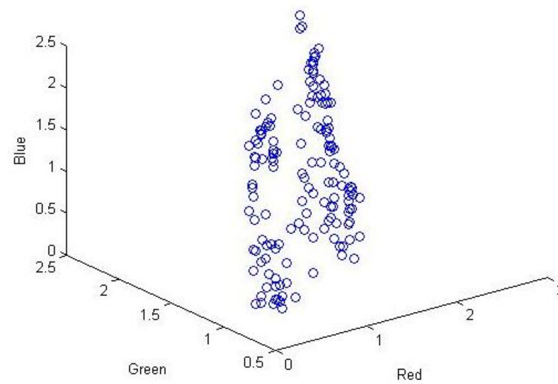

Fig. 3 RGB information of 150 pixels

III. RESULTS

After applying fuzzy c-mean clustering algorithm in 150 input pixels, it creates three clusters. After analysing the data, we get location and RGB intensity of clustered pixels given in Table II, III and IV.

TABLE II
NOT AFFECTED PIXELS (0 %)

S.No.	Location	[R G B]
1.	(2411, 1097)	[67 114 36]
2.	(2455, 1490)	[59 91 41]
3.	(2437, 1369)	[51 92 22]
4.	(2404, 946)	[77 126 44]
5.	(2411, 1109)	[83 122 57]
6.	(2453, 1476)	[48 87 24]
7.	(2435, 1294)	[58 96 35]
8.	(2379, 1004)	[86 129 57]
9.	(2455, 1519)	[48 85 31]
10.	(2444, 1392)	[48 92 39]
11.	(2430, 1324)	[60 102 39]
12.	(2155, 1353)	[83 131 55]
13.	(2450, 1397)	[44 88 27]
14.	(2708, 802)	[83 143 19]
15.	(3143, 809)	[113 169 20]
16.	(1674, 1841)	[93 150 35]

17.	(2831, 1865)	[42 106 12]
18.	(2867, 1825)	[51 96 15]
19.	(3163, 1879)	[53 90 13]
20.	(2965, 1440)	[53 110 16]
21.	(2844, 1522)	[56 112 5]
22.	(2967, 1335)	[71 120 15]
23.	(2708, 733)	[88 140 29]
24.	(1703, 1152)	[117 141 19]
25.	(2586, 1736)	[111 143 42]
26.	(2563, 1034)	[96 114 0]
27.	(2236, 815)	[104 104 32]

TABLE III
MEDIUM AFFECTED (1 % TO 30 %)

S.No.	Location	[R G B]
1.	(2917, 1552)	[140 194 72]
2.	(2761, 1753)	[139 192 62]
3.	(3182, 1325)	[166 214 79]
4.	(2627, 1131)	[119 173 51]
5.	(2800, 1007)	[147 200 70]
6.	(3009, 1148)	[124 183 55]
7.	(2768, 1495)	[150 190 39]
8.	(2245, 1660)	[178 222 98]
9.	(2630, 1857)	[172 220 84]
10.	(2626, 1870)	[175 227 93]
11.	(1645, 1203)	[168 215 87]
12.	(2646, 793)	[194 221 66]
13.	(2697, 1105)	[131 176 23]
14.	(2639, 764)	[195 221 72]
15.	(2639, 740)	[202 228 79]
16.	(3192, 922)	[183 222 77]
17.	(2648, 728)	[203 228 75]
18.	(1707, 1070)	[218 159 57]
19.	(1701, 1136)	[174 173 23]
20.	(2579, 1832)	[189 143 45]
21.	(2574, 1785)	[163 127 33]
22.	(2577, 1816)	[184 129 38]
23.	(1694, 1134)	[227 175 53]
24.	(2153, 1252)	[238 184 49]
25.	(2137, 1745)	[166 130 20]
26.	(2577, 1792)	[176 132 35]
27.	(2126, 1734)	[174 126 16]
28.	(2793, 1319)	[215 209 53]
29.	(1803, 1214)	[214 162 60]
30.	(2153, 1787)	[178 148 26]
31.	(2494, 1324)	[232 186 66]
32.	(1808, 1206)	[200 168 47]
33.	(1732, 1099)	[163 169 37]
34.	(2160, 1255)	[198 171 28]
35.	(2187, 936)	[195 149 37]
36.	(1709, 1085)	[213 162 44]
37.	(2490, 1324)	[221 170 63]
38.	(2175, 1921)	[203 201 66]
39.	(2158, 1792)	[175 140 22]
40.	(2195, 1685)	[188 143 58]
41.	(2552, 1034)	[209 195 44]
42.	(2554, 1041)	[218 181 14]
43.	(2793, 1317)	[230 215 64]
44.	(2786, 1364)	[198 221 81]
45.	(2550, 1043)	[196 173 18]
46.	(2554, 1041)	[218 181 14]
47.	(2644, 728)	[202 228 79]
48.	(2644, 720)	[194 222 75]
49.	(1698, 1103)	[224 175 56]
50.	(2164, 1297)	[210 176 50]
51.	(2162, 1290)	[195 173 51]
52.	(2577, 1707)	[141 158 43]
53.	(2492, 1317)	[229 187 75]
54.	(2494, 1297)	[199 191 56]
55.	(1808, 1212)	[195 166 49]
56.	(1805, 1206)	[209 161 61]
57.	(1703, 1123)	[199 170 32]
58.	(1812, 1199)	[163 155 28]
59.	(1694, 1121)	[221 172 44]
60.	(1723, 1116)	[187 183 34]
61.	(2026, 1531)	[190 151 84]
62.	(2320, 1009)	[180 155 89]
63.	(2019, 1529)	[186 156 86]
64.	(1988, 878)	[187 156 109]
65.	(2512, 1435)	[181 136 68]
66.	(2463, 1119)	[204 184 89]
67.	(2470, 1241)	[155 159 72]
68.	(2046, 1794)	[249 214 133]

TABLE IV
HIGHLY AFFECTED (MORE THAN 30%)

S.No.	Location	[R G B]
1.	(2802, 847)	[178 224 100]
2.	(2256, 1150)	[201 234 104]
3.	(2269, 1223)	[194 232 97]
4.	(1977, 1582)	[205 238 133]
5.	(1986, 1792)	[185 225 110]
6.	(1964, 1511)	[199 228 109]
7.	(1647, 1056)	[190 234 123]
8.	(2258, 958)	[207 237 105]
9.	(2240, 1132)	[200 237 98]
10.	(2797, 1317)	[231 226 80]
11.	(3248, 798)	[230 248 138]
12.	(2260, 909)	[211 237 110]
13.	(2639, 726)	[205 230 87]
14.	(2015, 1511)	[214 187 120]
15.	(2233, 822)	[215 193 120]
16.	(2209, 762)	[233 221 171]
17.	(2213, 798)	[203 186 130]
18.	(2233, 880)	[226 212 185]
19.	(2182, 902)	[215 186 126]
20.	(2334, 994)	[199 174 134]
21.	(2352, 985)	[201 168 115]
22.	(2492, 967)	[204 174 114]
23.	(2488, 949)	[203 172 115]
24.	(2447, 811)	[225 198 145]
25.	(2017, 1471)	[228 212 176]
26.	(2140, 1870)	[227 204 152]
27.	(1939, 1571)	[227 203 143]
28.	(2022, 1781)	[242 223 181]
29.	(1935, 1587)	[212 183 107]
30.	(2358, 1894)	[192 195 150]
31.	(2149, 1386)	[236 208 158]
32.	(1997, 1513)	[227 212 145]
33.	(1805, 1317)	[219 212 124]
34.	(1718, 1284)	[228 206 169]
35.	(1709, 1277)	[252 227 186]
36.	(1727, 885)	[245 230 147]
37.	(1997, 1194)	[215 185 115]
38.	(1823, 1330)	[244 225 185]
39.	(1816, 1326)	[247 226 179]

40.	(1799, 1319) [242 224 176]
41.	(1794, 1319) [210 200 149]
42.	(1919, 1738) [229 209 146]
43.	(1923, 1738) [237 208 148]
44.	(2465, 1348) [231 198 145]
45.	(2461, 1342) [235 204 140]
46.	(2456, 1335) [226 196 126]
47.	(2271, 1919) [238 221 165]
48.	(2296, 1910) [238 221 175]
49.	(2294, 1910) [225 209 160]
50.	(1685, 829) [255 248 213]
51.	(1676, 813) [255 248 198]
52.	(2182, 902) [215 186 126]
53.	(2229, 824) [222 202 152]
54.	(1694, 842) [255 246 201]
55.	(2046, 1794) [249 214 133]

Figure 4 shows the 2-D plotting of above data. Data is scaled by 1/100 before plotting. O, ×, and + represent centre point of three cluster. The clustered pixel is divided into three categories, pixels that are not affected by blast disease, medium level affected and highly affected pixel.

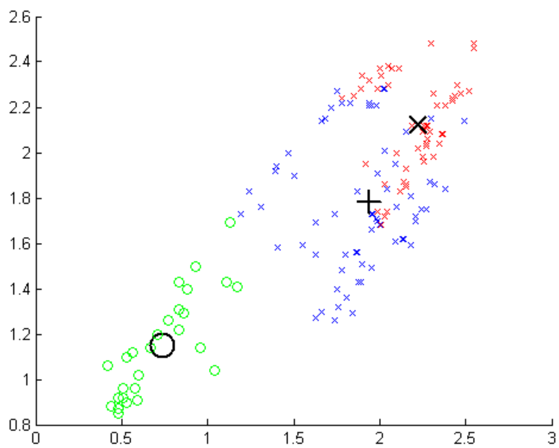

Fig. 4 2-D plotting of FCM clustered output

In this work, we have analysed the coloured digital image of the rice crop and then divide it into three different categories according to affectedness of blast disease. In this three categories, range of RGB element vary according to affectedness. That range is given in table V.

TABLE V
[R G B] RANGE OF THREE CLUSTERS

Affectedness	Range	R	G	B
Not Affected	Min	42	85	0
	Medium	73.84	114.9	29.9
	Max	117	169	57
Medium Affected	Min	119	126	14
	Medium	194.01	177.97	56.47
	Max	249	228	133
Highly Affected	Min	178	168	87
	Medium	222.3	212.2	147.73
	Max	255	248	213

IV. CONCLUSIONS

Precision agriculture gives farmers the ability to use crop inputs more effectively including fertilizers, pesticides, and tillage and irrigation water. More effective use of inputs means greater crop yield and/or quality without polluting the environment. At present many of the technology used are in their infancy. Blast diseases is influenced by many factors such as temperature, pH of the medium, Nutrition (Nitrogen), heavy metals on soil, Pathogenicity, age of rice plant, low night temperature, humidity etc. These all factors are environment dependent which is not possible to predict exactly. Thus, we cannot design a perfect expert system to predict and approximate loss. But, by this presented approach crop can be analysed during any time during the life of crop. This approach will not predict disease but will approximate the loss caused by that disease. This approximation will help the farmer to take precautionary measure to minimize the loss. Our experiment show 85 % accuracy to cluster affected, not affected and medium level affected pixels from 150 input pixels.

REFERENCES

[1] Robert, P.C., Rust, R.H. and Larson, W.E., preface. In proceedings of site specific management for Agriculture system, Minneaports, MN, ASA-CSSASSA,Madison, WI, pp. 13-14, 1994.

[2] Debashis Mandal and S. K. Ghosh, CURRENT SCIENCE, VOL. 79, NO. 12,1644-1647 , 2000

[3] Dawson, C. J., in Precision Agriculture (ed. Stafford, J. V.), BIOS Scientific Publishers Ltd, vol. 1, pp. 45–58, 1997.

[4] Brisco, B., Brown, R. J., Hirose, T.,McNairn, H. and Staenz, K., Can. J.,Remote Sensing, 1998, 24, 315–327.

[5] Palmer, R. J., in Proc. Site-Specific Management for Agric. Syst., Minneapolis, MN, ASA-CSSA-SSSA, Madison, WI, pp. 613–618, 1996.

[6] Carr, P. M., Carlson, G. R., Jacobsen, J. S., Nielsen, G. A. and Skogley, E. O., J. Prod. Agric.,4,57–61,1991.

[7] Heimlich, Ralph, Agric. Outlook, 19–23 April 1998.

[8] INDIA 2010, A REFERENCE ANNUAL, Ministry of Information and Broadcasting, Government of India, India, 54, 2010, 4, pp. 61.

[9] Devlin Kuyek, “Blast, biotech and big business,” Jointly published by Biothai (Thailand),GRAIN, KMP (Philippines), MASIPAG (Philippines), PAN Indonesia, Philippine Greens and UBINIG (Bangladesh) Research Inc., 2000.

[10] Hajime Kato, “Rice Blast Control,” in Proc. of Journal The Royal Society of Chemistry, Japan,2001.

[11] S.Y.Padmanabhan and N.K.Chakrabarti, “Diseases of Rice,” A Report on Rice Research in India, Indian Council of Agricultural Research, New Delhi India, 1985.pp 459-482.

[12] Abdullah1, A. A. Bakar, N. Mustafa, M. Yusuf, S. Abdullah and A.R. Hamdan, “Fuzzy knowledge modelling for image-based paddy disease diagnosis expert system,” Electrical Engineering and Informatics Institut Teknologi Bandung, Indonesia,642-644,2007

[13] Rafael C.Gonjale,Richard, and E.Woods, “Digital Image Processing,” Pearson Education, 2009, New Delhi, India, pp 416-446.

[14] Tadhg Brosnan, Da-Wen Sun,"Inspection and grading of agricultural and food products by computer vision systems-a review", Computers and Electronics in Agriculture,36,2002, 193-213

[15] Krutz, G.W., Gibson, H.G., Cassens, D.L., Zhang, M., Colour vision in forest and wood engineering. Landwards 55, 2-9, 2000

[16] D.K.Pratihar, “Soft Computing,” Narosa Publication, 2007, India, pp 118-123.

[17] Hong-Sik Shim, Sung-Jun Hong, Wan-Hae Yeh, Seong-Sook Han and Jae-Mo Sung, “Damage Analysis of Rice Panicle Blast on Disease Occurrence Time and Severity,” Plant Pathology Journal. Korea, Vol. 21(2), pp. 87-92, 2005.

[18] Mitsunori Yoshimura, Yoichi Torigoe, and Eiji Kanda, "Spectral Feature of Rice Leaves Infected by Blast," International Archives of Photogrammetry and remote Sensing. Vol. XXXI, Part B7 Vienna 1996.

[19] George D. Gouramanis, "Biological and chemical control of rice blast disease *(Pyriculariaoryzae)* in Northern Greece," National Agricultural Research Foundation, Plant Protection Institute of Thessaloniki, Greece, 1994.