Application of Machine Learning and Digital Image Processing In Wheat Crop Production: A Review

[1]Bhawana Sharma, [2]Jay Kant Pratap Singh Yadav
[12]Department of computer Science & Engineering, Ajay Kumar Garg Engineering College, Ghaziabad.

Abstract: To increase crop production is major concern in the fields of agriculture. Recent computation technologies can play important role to find gray area and provide optimal solutions. Machine learning and digital image processing can be used to enhance the crop selection, crop yield prediction, crop disease prediction, etc. In this paper, we study the applications of machine learning and Digital image processing used on wheat crop production. Objective of this study to identify the gap to increase the wheat crop production using digital image processing and machine learning provide a solution to finding the growth stages of wheat crop, once the growth stage of crop is found farmer can take precious and calculated step to enhance their production of wheat or other agricultural product. Proposed possible solutions to increase its productivity.

Keywords: **Machine Crop Management, Disease Detection. Learning Techniques, Digital Image Processing, Wheat Crop Production, Yield Prediction.**

I. INTRODUCTION

Modern scientific practices in farming will increase the monetary margins and enhance the agriculture sector. Depending on nature for better yield, there is still high risk probability in farming. Machine learning has emerged as the most fascinating stream of computer science. Machine learning and artificial Intelligence are synonymic terms used frequently, now and then. Finally, a computer system or machine made to learn like human beings i.e. it can think on its own provided if past data, data trends and possible combination of results are simulated or feed into its system [1]. The advancement of computer science viz. algorithm machine learning, etc. ultra-modern technologies can provide a satisfactory solution to some problems concerning with the weather forecast, weeds management, crop harvesting and storage, seed sowing and plant growth, pests protection, product selection and quality maintenance, etc. few survey are present in these fields such as different field applications, weed detection, yield prediction, crop management, plant stress prediction , disease detection in fruits, disease detection in plants, fruit grading, soil analysis, management zone clustering, water productivity in agriculture[4]. Farmers are dubious about what particular combination of plants to grow in a particular weather regime and on a particular soil giving the highly unrealistic nature of the monsoon. Current agriculture is heavily technology dependent and concentrated on heavy profits from selected hybrid crop plants which in a long run destroys the physical and biochemical nature of soil [5]. Several coordinated measures can be used for getting optimum yield from the farm land without compromising the fertility of the soil paving way to sustainable agriculture. In section 2, we discuss the study on application of machine learning in wheat crop production to identify the gap to increase the productivity. Wheat is grown on 13% cropped area of India. The most important food grain of India. South Western Asia is centre origin of wheat. 21 - 26 o C temperature and rainfall best suitable condition for wheat growth. Fig 1 shows different stages of wheat plant in accordance of its growth. It consists following stages:-

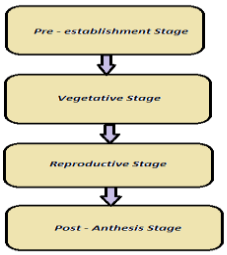

Fig.1. Different stages of wheat crop [3] [4]

1. Pre - establishment Stage

Sprouting of seeds by giving rise to seminal roots and second one is Emergency stage shows in Fig-2.

Fig. 2. Sprouting of seeds

2. Vegetative Stage

It consists of four stages as shown in Fig – 3, Fig – 4 and Fig – 5.

- Seedling Stage consists large root of young plant. It further differs entailed into one, two, three, four and five leaf stage.

- Crown Root Stage carried two to four leaves appearance of crown root.

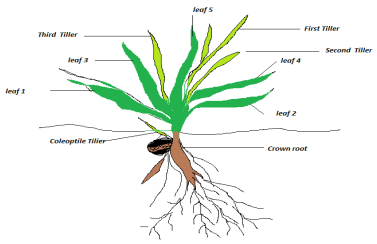

Fig. 3. Vegetative stage of wheat plant

- Tillering stage is a first stage and start form the germination of seed into the soil to the appearance first leaves as shows in Fig.4.

Fig. 4. Tillering Stage

- Jointing Stage: Jointing stage starts when the stalk forms its second node, a hard joint from which the plant rises upwards. The wheat plant appears maximum green during this stage as shown in Fig 5.

Fig. 5. Jointing Stage

3. Reproductive Stage

This stage of wheat plant consist three type of phases

- Booting Stage: In this stage the head of the wheat develops and becomes visible. This stage ends with the tips of the head called Awns, begin to grow as show in Fig-6.

Fig. 6. Booting Stage

- Heading Stage: This stage begins with the emergence of awns from the sheath and Spikes stars emerging out from the leaf sheath as show in Fig-7.

Fig. 7. Heading Stage

- Flowering Stage: This stage consists Fertilization of ovaries occurs and start to meeting of the seeds. After this stage green color start decreasing as shown in Fig-8.

Fig. 8. Flowering Stage

4. Post – an thesis Stage

Post –In this stage consist two type of wheat maturity. Fig-9 shows filling stage while Fig-10, Fig-11, Fig-12 and Fig-13 shows different maturity levels.

- Filling Stage: The ovaries after fertilization is completed start elongation and transform into seed or ovules passing through milk soft dough and hard dough stages as shows in Fig-9.

Fig. 9. Filling Stage

- Maturity Stage: In this stage color of the glumes changed and become fairly hard. And moisture gradually reduced the plant. During the ripening stage the kernel loses the rest of its moisture and it turns yellow and is ready to be harvested [5].

Fig. 10. Maturity Stage

Fig. 11. Maturity Stage

Fig. 12. Wheat Seeds

Fig. 13. Wheat Seeds

Wheat growth can be broadly divided into following stages as shown in Fig 14.

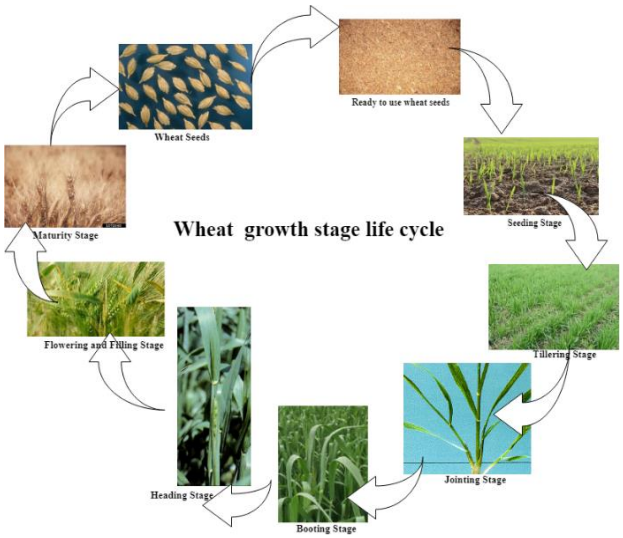

Fig. 14. Different stages of Wheat growth

II. RELATED WORK

Wheat growth can be broadly divided into different stages. Several machine learning applications have been developed to identify wheat leaf diseases, weed detection in wheat, soil management, water stress management for wheat and may more areas. Best of my knowledge there is no effective and efficient work done to identify the growth stages of wheat using machine learning applications. In this related work I have been cover last three decades work for wheat crop. In very first, Zhang, N. et al. 1995 [2] used shape and geometrical features for weed detection in wheat crop. Several image features like compactness, eight the invariant moments and eccentricity for batter result. In another paper Moshou, D. et al. 2004 [3] developed a system with image spectral reflectance features to detection of yellow rust infected and healthy winter wheat canopies and artificial neural network was used to detection application. Result accuracy of healthy wheat were 98.9% and accuracy of infected yellow rust was 99.4%. Moshou, D. et al. 2005 [4] developed a system to identify yellow rust infected and healthy winter wheat under field circumstances. And artificial neural network is used for detecting yellow. Result accuracy achieved for yellow rust infected wheat 99.4% and accuracy for healthy wheat were 98.7%.

In another paper Moshou, D. et al. 2006 [5] developed a system to identify field condition for healthy winter wheat and discrimination of nitrogen, yellow rust infected and also stressed. Artificial neural network and SOM were used in detection system. Result accuracy for nitrogen stressed were 100% while accuracy for yellow rust infected wheat were 99.92% and accuracy for healthy wheat were 99.39%.In paper Guevara-Hernandez, F. et al. 2011[9] on the basis of external characteristics authors reorganized two grain types using different image features like colour, shape and textural features. The overall result accuracy using selected features property like shape, colour and texture were 99%. Tian, Y. et al. 2012 [10] reorganized leaf rust Pucciniatriticina, pucciniastriformis and leaf blight, powdery mildew leaf diseases in wheat crop. Identification of these leaf diseases authors use wheat image colour, texture and shape features. SVM based multiple classifier system were used for detection, accuracy rate of result 95.16%. Moshou, D. et al. 2014 [11] developed an application to identify water stress detection in wheat crop based on optical multisensory fusion with a least square support vector machine classifier. Accuracy in result, achieved in four categories. First category was control treatment healthy and well supplied with water and its accuracy was 100%. Second category was healthy treatment and deficient water supply and its accuracy was also 100%.Third category was Inoculated treatment with sectorial trifici and well supplied with water and its accuracy was 98.75%. Last category was inoculated treatment and deficient water supply and its accuracy was 98.7%.

In another paper Majumdar, D. et al. 2015 [12] developed a detection system for 4 different types of leaves disease using fuzzy clustering algorithms and result accuracy for classification of different diseases were 56%. Olgun, M. et al. 2016 [13] developed an application using K-Means clustering algorithm for grain grading of wheat overall result accuracy was 88.33%. Jiang, G. et al. 2016 [14] developed an application to reorganised weed row detection in wheat crop. This application used k-means clustering algorithm. Weed detection accuracy rate was up to 90%. Mondal, D. et al. 2016 [15] developed an identification application for disease detection on wheat leaves. Author used wheat image features for disease detection on wheat leaves and its accuracy rate was 94% for non-diseased wheat images and 95% for diseased wheat images. Pantazi, X.-E.et al. 2016 [16] developed a system for wheat yield prediction within field variation using artificial neural networks. It is very effective for wheat yield prediction. Yield prediction accuracy rate was 81.65%. Zhang, J. et al. 2017a [17] done work for disease and pest detection. There were several image features used like image colour, image shape and texture. These image features of wheat image were used to prepare a system to reorganize diseases and pest detection in wheat crop production. Its result accuracy rate was 77%. At last Shi, Y. et al. 2017 [18] used spectral features of image for reorganization of diseases and pest detection using spectral image features like MSR, NRI, SIPI, NPCI and many more. Result classification accuracy was 82.9%, 87.9%, 89.2% for three occurrence levels such that slight, severe and moderate. Table.1 and Table.2 contain summery on application of machine learning in wheat crop production.

Table.1. Summery on application of machine learning in wheat crop production

Citations	Year	Work	Outcome
[2]	(1995)	Effective criteria for weed identification	Proposed method helps to weed identification in wheat.
[3]	(2004)	Detection of yellow rust in wheat	Helps to maintain the wheat crop quality.
[4]	(2005)	Plant diseases detection	Helps to increase wheat crop yield productivity.
[5]	(2006)	Identify field conditions for healthy winter wheat and discrimination of nitrogen, stressed and yellow rust	Helps to enhance the crop production as well as crop quality.
[9]	(2011)	Extracting the mean spectral reflectance to differentiate on ends in wheat grains	Helps to increase wheat crop yield to the farmers to increase their wheat crop yield.
[10]	(2012)	Recognitions of wheat leaf diseases	Helps to identify diseases in wheat leaf so that minimize the yield loss.

[11]	(2014)	Water stress detection based on optical multisensory fusion	Helps to water management for wheat crop
[12]	(2015)	Classify wheat leaf images to identify rust disease on wheat leaf.	Helps to enhance crop quality of wheat.
[13]	(2016)	Wheat grain classification.	Helps to increase wheat crop yield.
[14]	(2016)	Rows detection of wheat to identify early growth stages.	Helps to enhance crop yield production.
[15]	(2016)	Rust disease detection in wheat.	Disease detection helps to remove the disease so that the farmers enhance crop quality.
[16]	(2016)	Developed a system for wheat yield prediction using ML and advance sensing technique.	Helps to increase wheat crop yield to the farmers to increase their wheat crop yield.
[17]	(2017a)	Pests and diseases detection in winter wheat.	Helps to enhance crop quality and productivity of wheat.
[18]	(2017)	Reorganization of Pests and diseases detection using spectral image features like MSR, NRI, SIPI, NPCI etc.	Disease detection helps to remove the disease so that the farmers enhance crop quality.

Table.2. Summery on application of machine learning in wheat crop production

Citations	Year	Technique Used	Result Accuracy Rate
[2]	(1995)	machine vision	
[3]	(2004)	reflectance measurements and neural networks	accuracy rate of healthy wheat 98.9% and Accuracy rate of infected yellow rust 99.4%.
[4]	(2005)	hyper-spectral and multi-spectral fluorescence imaging using Kohen maps	Accuracy achieved for yellow rust infected wheat 99.4% and accuracy for healthy wheat 98.7%.
[5]	(2006)	ANN/XY-Fusion	accuracy for nitrogen stressed 100% & accuracy for yellow rust infected wheat 99.92% and accuracy for healthy wheat 99.39%.
[9]	(2011)	machine vision system	Result accuracy rate 99%.
[10]	(2012)	SVM-based multiple classifier system	accuracy rate of result 95.16%
[11]	(2014)	least squares support vector machine classifier	achieved in four categories: a) Control treatment healthy and well supplied with water and its accuracy was 100%. b) healthy treatment and deficient water supply accuracy rate 100% c) Inoculated treatment with sectorial traffic and well supplied with water accuracy rate 98.75%.

			d) inoculated treatment and deficient water supply accuracy rate 98.7%
[12]	(2015)	fuzzy C-means clustering	Result accuracy rate 56%
[13]	(2016)	SVM classifier	Overall result accuracy was 88.33%.
[14]	(2016)	Hough transform and vanishing point	Aaccuracy rate was up to 90%
[15]	(2016)	Pearson correlation coefficient and rough fuzzy C-means	Accuracy rate was 94% for non-diseased wheat images and 95% for diseased wheat images.
[16]	(2016)	machine learning and advanced sensing techniques	Accuracy rate was 81.65%.
[17]	(2017a)	foliar spectral measurements	Result accuracy rate was 77%.
[18]	(2017)	spectral indices and kernel discriminant Analysis	Classification accuracy was 82.9%, 87.9%, 89.2% for three occurrence levels such that slight, severe and moderate.

III. CONCLUSION AND DISCUSSION

In this paper, we discussed application of digital image processing and machine learning in wheat crop management such as wheat disease detection, weed detection, wheat yield prediction etc. It has been observed that there is no works have been proposed to identify the growing stages of wheat. In future, we proposed and developed a system using digital image processing and machine learning to identify the growing stages.

REFERENCES

[1] Taiwo, O. A. Types of Machine Learning Algorithms, New Advances in Machine Learning, Yagang Zhang (Ed.), ISBN: 978-953-307-034-6, Intech, University of Portsmouth United Kingdom. Pp 3 - 31 (2010). Available at Intech open website: http://www.intecho.

[2] Zhang, N., Chaisattapagon, C. Effective criteria for weed identification in wheat fields using machine vision. Trans. ASAE 38 (3), 965–974 (1995).

[3] Moshou,D.; Bravo,C.; West, J.; Wahlen,S.; McCartney, A.; Ramon, H. Automatic detection of "yellow rust"in wheat using reflectance measurements and neural networks. Comput. Electron. Agric., 44, 173–188 (2004). [CrossRef]

[4] Moshou, D.; Bravo, C.; Roberti, R.; West, J.; Bodria, L.; McCartney, A.; Ramon, H. Plant disease detectionbased on data fusion of hyper-spectral and multi-spectral fluorescence imaging using Kohonenmaps. Real-Time Imaging, 11, 75–83 (2005). [CrossRef]

[5] Moshou, D.; Bravo, C.; Wahlen, S.; West, J.; McCartney, A.; De Baerdemaeker, J.;Ramon, H. Simultaneous identification of plant stresses and diseases in arable crops using proximal optical sensing and self-organizing maps. Precis. Agric., 7,149–164 (2006). [CrossRef]

[6] D. Brian Fowler, Crop Development Centre, University of Saskatchewan, Saskatoon, Canada.

[7] Nelson, J.E., K.D. Kephart, A. Bauer, and J.E. Connor. Growth staging of wheat, barley, and wild oat.Montana State Univ. Coop. Exten. Service, Bozeman, and Univ. Idaho Coop Exton. Service, Moscow (1988).

[8] The Agricultural and Processed Food Products Export Development Authority (APEDA), New Delhi, www.apeda.gov.in

[9] Guevara-Hernandez, F., Gomez-Gil, J. A machine vision system for classification of wheat and barley grain kernels. Spanish J. Agric. Res. 9 (3), 672–680 (2011).

[10] Tian, Y., Zhao, C., Lu, S., Guo, X. SVM-based multiple classifier system for recognition of wheat leaf diseases. In: World Automation Congress (WAC), 2012. IEEE, pp. 189–193 (2012).

[11] Moshou, D.; Pantazi, X.-E.; Kateris, D.; Gravalos, I. Water stress detection based on optical multi sensor fusion with a least squares support vector machine classifier. Biosyst. Eng, 117, 15–22 (2014). [CrossRef]

[12] Majumdar, D., Ghosh, A., Kole, D.K., Chakraborty, A., Majumder, D.D. Application of fuzzy C-means clustering method to classify wheat leaf images based on the presence of rust disease. In: Paper presented at the Proceedings of the 3rd International Conference on Frontiers of Intelligent Computing: Theory and Applications (FICTA) (2014), pp. 277–284 (2015).

[13] Olgun, M., Onarcan, A.O., Ozkan, K., Işik, Ş., Sezer, O., Ozgişi, K., Koyuncu, O., Wheat grain classification by using dense SIFT features with SVM classifier. Comput. Electron. Agric. 122, 185–190 (2016).

[14] Jiang, G., Wang, X., Wang, Z., Liu, H. Wheat rows detection at the early growth stage based on Hough transform and vanishing point. Comput. Electron. Agric. 123,211–223 (2016).

[15] Mondal, D., Kole, D.K. A time efficient leaf rust disease detection technique of wheat leaf images using Pearson correlation coefficient and rough fuzzy C-means. In: Information Systems Design and Intelligent Applications. Springer, pp. 609–618 (2016).

[16] Pantazi, X.-E.; Moshou, D.; Alexandridis, T.K.; Whetton, R.L.; Mouazen, A.M. Wheat yield prediction using machine learning and advanced sensing techniques. Comput. Electron. Agric., 121, 57–65 (2016). [CrossRef]

[17] Zhang, J., Wang, N., Yuan, L., Chen, F., Wu, K. Discrimination of winter wheat disease and insect stresses using continuous wavelet features extracted from foliar spectral measurements. Biosyst. Eng. 162, 20–29 (2017a).

[18] Shi, Y., Huang, W., Luo, J., Huang, L., Zhou, X. Detection and discrimination of pests and diseases in winter wheat based on spectral indices and kernel discriminant Analysis. Comput. Electron. Agric. 141, 171–180 (2017).

AUTHORS PROFILE

Bhawana Sharma was born in Ghaziabad District of Uttar Pradesh, India, in 1991. She complete her Bachelor of Computer Application from R. C. C. V Girls College, Ghaziabad affiliated to Choudhury Charan Singh University, Meerut in 2011. And Master of Computer Application from Punjab Technical University, Jalandhar in 2015. She is pursuing M.Tech in Computer Science & Engineering from Ajay Kumar Garg Engineering College, Ghaziabad affiliated to Dr. APJAK Technical University, Lucknow. Her Present research interests include Image Processing, Machine Learning and Deep Learning.

Mr. Jay Kant Pratap Singh Yadav was born in Firozabad District of Uttar Pradesh, India, in 1983. He got his graduation from United College of Engineering and Research, Allahabad, UP Technical University Lucknow, M.Tech in Computer Engineering from NIT, Surat, Gujrat and pursuing PhD. from Jamia Millia Islamia (Central University) New Delhi. He has published twelve research paper in various international journals and four research articles in International Conferences. He is an Assistant Professor in the Department of Computer Science and Engineering of AKGEC Ghaziabad affiliated to Dr. APJAK Technical University, Lucknow. His present research interests include Image Processing, Machine Learning and Soft Computing.