Inspection and Classification of Defects in Pharmaceutical Capsules Using Neural Network

Abha Sharma[1], Sugandha Arora [2]

[1]*Student of Dept.of Computer Science Engineering, SVIET-Banur, India.*
[2] *Assistant Professor of Dept.of Computer Science, SVIET-Banur, India.*

Abstract—*The Indian pharmaceutical industry has flourished tremendously in recent years. But, due to diverse environmental conditions the quality of capsules are prone to defects. We need to identify and classify these defects for high throughput, decreased development time and reliable inspection. Various elements that can come under quality considerations are; shape, size, appearance, color, surface, texture, taste, odor. In this research we have implemented Harris Algorithm which used to identify defects and mark the interest point by adjusting thresholding, window size, and sigma values. Neural network is used for classification of these defects. The proposed method is easy to integrate and it will also eliminate the need of sophisticated mechanical fixtures for testing these capsules.*

Keywords— *Harris Algorithm, Neural Network, Scaled Conjugate Gradient (SCG), Threshold values and Confusion Matrix.*

I.   INTRODUCTION

Pharmaceutical industry is one of the largest developing industries in terms of production area as well as consumption. There is a relatively large population of buyer who consume capsules as they are easy to swallow and due to their attractive appearance. Over so many years in this industry focus on producing pharmaceutical capsules with zero defects. The capsule should be prefect with respect to its shape, size, appearance, color, texture, taste, and odor. The two part (body and cap) gelatin capsules (figure-1) are susceptible to several common flaws which are caused by inconsistent manufacturing process.
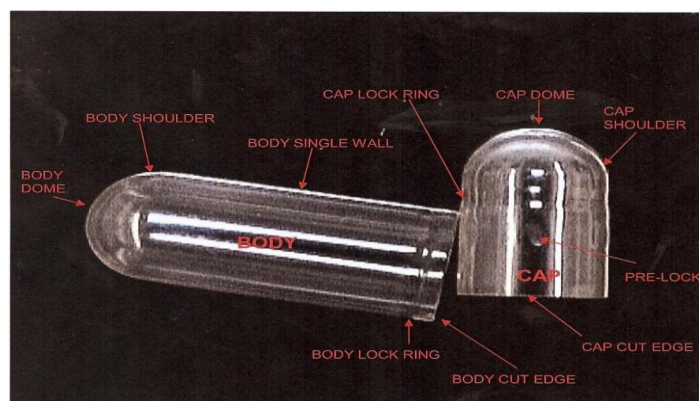

Figure-1 Proper Closing Station Set-Up

These defects can sometimes cause very serious problem. For example if the defect is in the form of hole or crack, it is possible that the capsule filling will spill out and will have unsafe effects if it reaches the end-user. Detection of defects is necessary to protect the consumer from many hazardous impacts. To do the same we need to regulate our inspection system. As still there are many manufacturing companies which do not use automated inspection system as shown in figure-2. Detection of defects will not only benefit the consumer but also help the pharmaceutical industry to raise the standard of production. Automated visual inspection system is solution to this problem.

II.   RELATED WORK

There are number of automatic capsule inspection methods that have been proposed in recent years. In [2], a custom approach is followed for capsule inspection system. The major focus is on design of hardware system for capsule inspection. It considers the proper orientation position of the capsule for detection of defects. M.J Islam [7] proposed border tracing algorithm [6]. This technique divides the capsule image in three parts to some computational terms.

Zhu Zhengtao [4] follows morphology filtering and segmentation, for online capsule inspection system. Zuo Qi [5] based on edge extraction the capsule image is extracted and then identify whether the capsule is defective or not using Bayesian decision system. In [1], to enhance scratches, cracks or holes, thresholding and histogram analysis is proposed to identify the defects in pharmaceutical capsules. Also in [3], Harris algorithm is used to detect the defective corners in capsules. Match is performed between descriptions in two views by autocorrelation. This algorithm identifies all possible defects in pharmaceutical capsules.

Figure-2 Current visual inspection system

III. APPROACH FOLLOWED

The goal of this research is to automate the visual inspection system to detect and classify the defects present in the pharmaceutical capsules. We will identify the defective capsules and classify those defects. For doing our research work four types of defects are considered, namely cracked, dent, split and telescopic.

A. Pseudo Code for finding defects in capsules

```
for each capsule in capsule data base
        for each test capsule image
                extract features of capsule
                        match each co-linear points and auto co-relation data points
                        If true
                            Ignore each window
                        Else
                            Mark window as defective
                        End
                End
End
```

B. Harris Algorithm

This algorithm is used for detecting the popular interest points due to strong invariance to [8]: rotation, scale illumination variation and image noise. It is a simple and stable which retain majority of true corners, thereby increases the accuracy of detection and reduces the chances of errors caused in matching. The detection of defects in pharmaceutical capsules is done on the basis of intensity.

Harris algorithm identifies the defective capsule by matching the test (input) capsule image with original image. If test capsule image does not match the template image (original image) then it is defective. Through Harris algorithm we determine the minimum and maximum threshold values for the defect that can be classified further.

C. Neural Network

There are number of applications where neural network are used. As we know neural networks have ability to derive meaning from complicated or imprecise data therefore it can be used to extract patterns and detect trends that are too complex to be noticed by either humans or other computer techniques. Therefore a trained neural network can be thought of as an "expert" and can be used in real time identification of defects in capsules in visual quality inspection system. To design neural network: First we Collect Data, then Create Network, Configure Network, Initialize Weights, Train Network, Validate Network and last Use the Network.

D. Training Function Used: Scaled Conjugate Gradient (SCG)

In the proposed work we introduce SCG backpropagation algorithm is used for classification of defects. It is preferred because it has highest accuracy with minimum mean square error (MSE). This algorithm can work over the large system with sparse data set and can obtain good approximation to solution. The most important configuration issue is to select an optimal number of hidden layers. To solve this, repeated experiments were performed to determine the size of the hidden layer. The final ANN was made with 12 hidden layers.

In hidden layer and output, the sigmoid activation function is used. The features computed after neural network processing is used for classification. In the present study, we have divided the features into 70% for training, 15% validation and 15% testing. We have used the data sheets separately for training, validation and testing as well as combined features obtained after appending.

IV. EXPERIMENT AND ANALYSIS

A. Detection of Defects

Harris Algorithm is used to find out deformities cracks, dents or split that might be present in the capsule, whenever there is difference between the gradient magnitudes of the pixels of the image which are connected. A colour marker is drawn by changing the intensity of the object. See figure-3 (a)-(f).
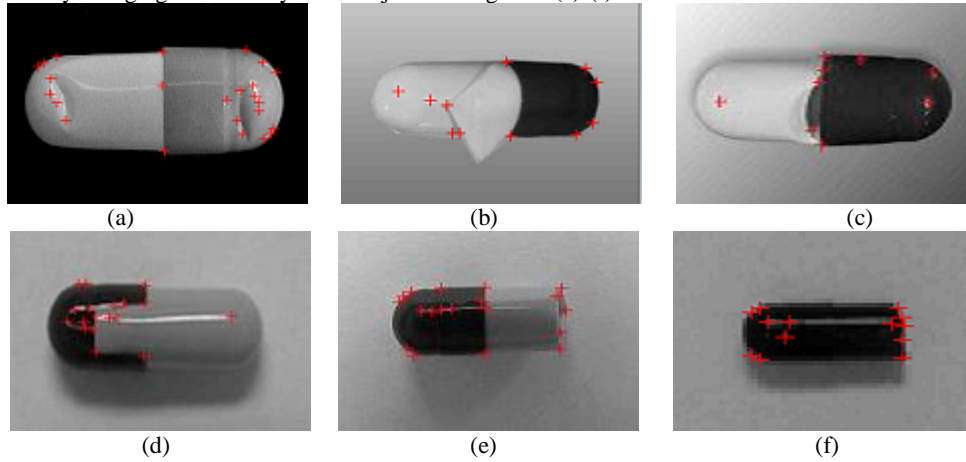

(a)	(b)	(c)
(d)	(e)	(f)

Figure-3 (a)-(f) Show how Harris Algorithm marks the defective capsules (a) Dented capsule (b) Locking defect (c) Split defect (d) Telescopic defect (e) Punched end (f) Capsule with a crack.

B. Creation of Data sheet to train Neural Network

Data set is created on which NN training will be executed. This dataset consist of following parameters:

1. Minimum thresholding value
2. Maximum thresholding value
3. Non maximal radius value
4. Sigma
5. Window size

These parameters are taken as input. Once the defect is identified the values of minimum and maximum threshold are taken as shown in table-1. These thresholding values are taken for each of the defects that will be classified and these thresholding values will vary for each category of defects. Whereas non maximal radius, sigma and window size values remain constant for each category.

Table 1 Range of threshold values for different defects

Type of Defect	Range of Threshold Values	
	Min Threshold Values	Max Threshold Values
Cracked	22	18
Cracked	17	33
Cracked	20	33
Cracked	18	32
Cracked	19	31
Punched	17	35
Punched	16	34
Punched	19	32
Punched	18	33
Punched	20	31
Split	21	28
Split	33	36
Split	30	39
Split	32	37
Split	27	22
Telescopic	13	14
Telescopic	37	45
Telescopic	22	36
Telescopic	40	42
Telescopic	18	34

C. Confusion Matrix (Classification Matrix)

43

The performance of classifier is analyzed using confusion matrix which is also known as table of confusion. It displays the number of correct and incorrect predictions made by the model compared with the actual classifications in the test data. The confusion matrix lists the correct classification against the predicted classification for each class. The number of correct predictions for each class falls along the diagonal of the matrix. All other numbers are the number of errors for a particular type of misclassification error.
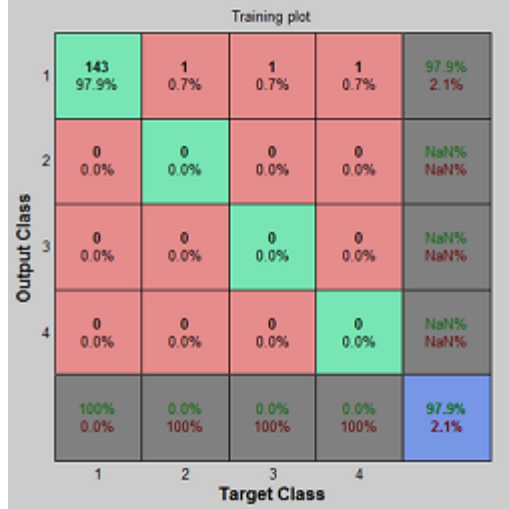
V.   INTERPRETATION OF RESULTS

Figure-4 **Training Phase Confusion matrix**

In Figure-4 we can see that there are few misclassifications due to which there is minimum drop in accuracy. We can also see that in lower triangular matrix there is no misclassification. Similarly in upper triangular matrix class 1 was misclassified one time as class 2 by 0%, one time as class 4 by 0.7% and again one times as class 4 by 0.7%.

In figure-4 we can see that the green boxes represent the final accuracy for each class as each class was correctly trained. Out of 208 columns of dataset 143 have been used for training purpose. Finally overall accuracy is shown in blue box which shows that each class classification was correctly learned by SCG classifier with zero mean square error and within stipulated parameters and gives 97.9 % results.

In figure-5 we can see that there is increase in accuracy as we move through training phase and it shows 100% accurate results and the misclassification in upper and lower matrix is zero.
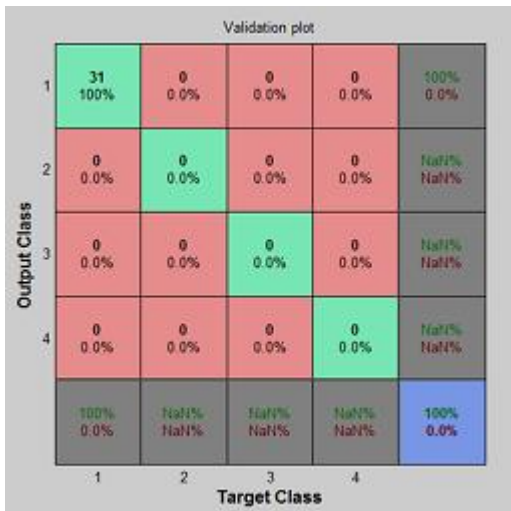

Figure-5 Validation Phase Confusion matrix

Figure-6 Testing Phase Confusion matrix

In figure-6 we can see that it is exactly similar with accuracy from validation phase and it is also 100%. As the resultant accuracy is 100% and the misclassification in upper and lower matrix is zero.

In figure-7 we can see that when we consider real time data set than the accuracy was decreased and reaches to 94.2% which is still a good amount. The rate of misclassification is similar when compared to other phases
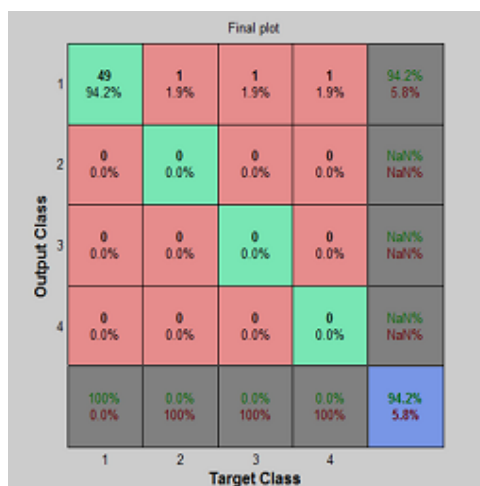
Figure-7 **Real Time Confusion matrix**

Real Time Confusion matrix show the result of 94.2% due to the fact that classes 2, 3, and 4 have intersection of their feature values which leads to such kind of results. However, also the results are not having a clear cut hyper plane between the classes.

It is apparent from the confusion matrix graphs that class 2, 3 and 4 don't have many values in terms of true positive neither do they have misclassification except class 2 which is as low as 1% misclassification. This phenomenon is seen in all the phases including the real time network after neural network is trained as shown in figure-7.

VI.   CONCLUSIONS AND FUTURE SCOPE

A. Conclusion

The undesirable effects present in pharmaceutical capsules can be unsafe from consumer as well as producer point of view. So it is necessary to detect and classify them. We used image processing tools and neural network to detect and classify these pharmaceutical defects. This will not only help us in keeping high production, but also facilitate in reliable and accurate testing in manufacturing pharmaceutical capsules. The result is a highly cost effective solution that provides quality guarantee much desired by the customers in this competitive market. The proposed method is easy to integrate and it will also eliminate the need of sophisticated mechanical fixtures for testing these capsules.

B. Future Scope

- There is other corner detection methods which can be explored in future study which can help us to detect cracks and dents more accurately and efficiently even on highly non uniform textured pharmaceutical capsules.
- Other than Neural Network there are many more optimization techniques that may offer more options in results and accuracy e.g. Support vector machines.

VII.   ACKNOWLEDGEMENT

REFERENCES

[1]. Huang, T.; Yang, G.; Tang, G.,"**A fast two-dimensional median filtering algorithm,**" Acoustics, Speech, and Signal Processing, IEEE Transactions on , vol.27, no.1, pp. 13-18, Feb 1979.

[2]. Anthony C. Karloff, Neil E. Scott, Roberto Muscedere, "**A Flexible Design for a Cost Effective, High Throughput Inspection System for Pharmaceutical Capsules**", 2008 IEEE.

[3]. Hardeep Kaur and Er. Nidhi Garg, "**Inspection of Defective Pharmaceutical Capsules using Harris Algorithm**", International Journal of Advances in Electronics Engineering 2011.

[4]. Zhu Zhengtao, Huang Liuqian, Yu Xiongyi, "**Pre-processing Techniques for On-Line Capsule Inspection Based on Machine Vision***", 2011 Fourth International Conference on Intelligent Computation Technology and Automation, 2011 IEEE.

[5]. Zuo Qi, Shi Zhongke, General design for capsule integrality detection system based on machine vision[J], Journal of Xi'an Jiaotong, University, Vol. 36, no 12, Dec. 2002. (in Chinese)

[6]. A. Chottera and M. Shridhar, "**Feature extraction of manufactured parts in the presence of spurious surface reflections**", *Canadian Journal of Electrical and Computer Engineering*, Vol. 7, no. 4, pp. 29-33, 1982.

[7]. M.J. Islam, Q.M.J. Wu, M. Ahmadi and M.A. Sid-Ahmed "**Image processing techniques for quality inspection of gelatin capsules in pharmaceutical applications**", in *10th International Conference on Control, Automation, Robotics and Vision (ICARCV 2008)*, Hanoi, Vietnam, December 17-20, 2008.

[8]. C. Schmid, R. Mohr, and C. Bauckhage. **"Evaluation of interest point detectors",** International Journal of Computer Vision, 37(2):151–172, June 2000.