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Bangladeshi Fresh-Rotten Fruit & Vegetable Detection Using Deep Learning Deployment in Effective Application

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***Abstract*—Finding rotten fruits and vegetables has been important, especially in the agricultural industry. Computer vision has significant applications in the automation of damaged, freshness detection of fruits and vegetables. In recent decades, the farming sector has discovered computer machine vision and image processing technology to be more and more beneficial, particularly for implementations in quality control by identifying rotten and freshness. Farmers cannot contribute effectively between fresh and rotten fruits, vegetables because this is mainly done by people. People tire out after performing the same task for several days, whereas robots do not. By identifying weaknesses in agricultural product, the study suggested a technique for minimizing human effort and worktime. Vegetables and fruits with defects might affect healthy fruits if they are not identified in time. As an outcome, we put up a methodology to stop rottenness from spreading. The suggested model detects between fresh and decaying fruits and vegetables depending on the input fruit and vegetable photos. In this work, we used six different types of fruits and vegetables like carrot, potato, calabash, cucumber, eggplant, and cauliflower, as well as fruits likes mango, banana, star fruit, jackfruit, guava, and papaya. This study discusses multiple image processing methods for rottenness categorization of fruits and vegetables. A Convolutional Neural Network (CNN), KNN, and SVM are used to gather the features from the data fruit and vegetable photos. On Google and Kaggle datasets, the efficiency of the suggested model is evaluated, and CNN model shows the greatest accuracy which is 95 percent.**

Keywords—Rotten fruit, fresh fruit, rotten vegetable, fresh vegetable, rotten detection, fresh detection, agriculture, image processing, CNN, KNN, SVM

I. INTRODUCTION

For identifying man-made logic and intense deep learning research, image classification and recognition is the most effective evaluator. This is now the most commonly used method of monitoring our everyday activities and work. As a result, it will cover literally every part of daily life. Deep learning technique analyzes and deals with picture information using a layered structure, that can also increase image identification performance. It may grow further and spread more widely in the future. Picture classifiers and recognizers will resolve a wide range of problems. We can handle many challenges in our regular lifestyle by using image processing through deep learning methods. Bangladesh is a farming country, as we all know. Finding defective fruits and vegetables has been difficult, particularly in the farming sector. The look of fruits and vegetables is a major sensory attribute that influences their market value, preferences of consumers, and choice. Although human can classify and evaluating all the stored fruits and vegetables but it is unsatisfactory, time-consuming, unpleasant and costly. Sometimes we cannot tell if a fruit is fresh or rotting just by looking at it anymore. We can use CNN to solve so many products and real-world problems. As a result, we proposed a methodology for identifying defects in fruits and vegetables to reduce effort and time, minimize manufacturing costs, and decrease labor hours. Several organic foods and items are not classified based on looks alone. Supermarket lighting can confuse us by providing ill-fitting items. We can categorize every item according to its present status by using a deep learning imaging technique. We are researching on these kinds of fruits like mango, banana, star fruit, jackfruit, guava, papaya and vegetables like carrot, potato,

Calabash, cucumber, eggplant, cauliflower as part of our study. The above fruits and veggies are being used as a demonstration to identify their exact state to use an image processing method. Natural fruits and vegies are usually exceeding our ability to care for. As a result, a lot of people have a limited understanding of how to buy such items. Many people can't understand is it fresh or not. By applying our application in this method, we can ensure that consumers will have adequate knowledge about purchasing these items, as well as ensure that all foods have health benefits and nutrients. We can implement a variety of type algorithms, but for this project, we'll utilize one type version of (CNN). So, we'll finally be able to easily find a fresh mango or it rotten mango, fresh banana or rotten banana as like star fruit, jackfruit, guava, papaya and vegetables like carrot, potato, Calabash, cucumber, eggplant, cauliflower. It will simplify our lives than before because We can quickly determine whether our expected fruit or vegetable is fresh and get additional information. We can achieve anything with an image classification and recognition technology that is already man-made. This technique works on practically all organic and non-organic objects, such as fruits, vegetables, chemicals, and so on.

II. Literature Review

Fruit and vegetable assorting has an impact on the export industry as well as evaluation. Humans can sort and grade, but it is lengthy and subjective. To assure their freshness and market worth, an expert fruit sorting system is required. Fruits and vegetables are rated using a computer vision approach that is accurate, egalitarian, and non-destructive. Acquisition, segmentation, feature extraction, and classification are the four major processes of a computer vision-based examination.[1] Classifying different types of fruits is a difficult task. This paper describes a system for identifying between four different types of fruit and analyzing the fruit's quality rank. Fruit detection accuracy is 80.00 percent (k-NN) and 95.72 percent (k-NN) respectively (SVM).[2] In the agricultural industry, detecting rotten fruits has become crucial. The functionality from the input fruit images are extracted using a Convolutional Neural Network (CNN). The proposed model performs admirably both transfer learning models and state-of-the-art methods in terms of performance.[3] Human effort is subjective in traditional hand-picking methods. Advanced artificial methods, such as CNNs, have emerged as a promising way to achieve higher accuracy, despite the fact that they require a large number of samples. For apple disease classification, CNN methods rely on hand-crafted characteristics that are not strong and complicated. The results of this study support our proposed model's superiority.[4] Outer features such as color, volume, shape, texture, and the presence of damage are used to assess the quality of fruits and vegetables. We have presented different feature extraction techniques to train Probabilistic Neural Network (PNN) classifiers by studying damages inflicted on apple fruits.[5] The aims of this project is to use CNN to determine whether an apple is fresh or rotten. By trying to identify apples using Resnet 50 and classifying them using the proposed model, we were able to achieve 97.92 percent accuracy for the two classes of nearly 5031 images in our classification [6] The fruits can be sorted by the system. It can be used to inspect the status of fruits. It can be used to classify fruits in a retail store's self-service system. The system makes use of the high-quality 'ImageNet' dataset. There are 5 different kinds of fruit images in it. CNN are used in the model to recognize fruits from images. The accuracy was found to be 92.23 percent. Ml algorithms are outperformed by deep learning algorithm.[7] The traditional method is inconvenient, inconsistent, and quickly affected by the environment. The proposed Convolution Neural Network (CNN) model has a precision of 98.23%. The results demonstrate that the proposed CNN model is effective in classifying fruits. The image data are then separated into fruit categories using a SoftMax function.[8]

This paper proposed methods for analyzing the freshness of impudent fruits. It is ideal for raising public awareness about the dangers of eating rotted fruits. Image segmentation with machine learning support is the basis for the proposed method. The data set's basic requirements are derived from GoogleNet, ResNet and Alexnet. There are 54122 images available. CNN model has a 94.2 percent accuracy for class 3 (banana) and a 99.1 percent accuracy for class 8. (orange).[9] Traditional methods for detecting food spoilage are slow, time-consuming, subjective, and inefficient. For extracting features, a proposed vision-based framework employs histograms, gray level co-occurrence matrices, a bag of features, and convolutional neural networks. Support vector machines-based classification techniques are used to carry out the classification.[10]

III. Proposed Methodology

Bangladesh is a country whose economy is built on agriculture. In our research we mainly focus Bangladeshi fruits and vegetables. Because our main source of income is agriculture. Bangladesh's farming industry provides for 14.2% of the country's GDP and employs 42.7 percent of the workforce. Fresh fruit or vegetable sales are increasing every day.

The fruits and food production industries are playing a more active role in the twenty-first century [13]. The connection of exporters and importers is determined by worldwide exchange as well as the flow of fruit and vegetable needs. There is a lengthy and time-consuming transportation technique for exporting or importing rotten or nearly rotten fruit which also obstructs quality control of a large quantity of fruits and vegetables. As a result, compared to prior years' global agricultural production and export, fruits and vegetables output is predicted to drop even more. The collapse of trade is not just another challenge, unstable environmental trends, climate change, and Temperature rise is one of the major causes. Import or export response is generally required to monitor the condition of fruits and vegetables in a special way. Because it helps to understand the vitality of fruits and vegetables or how long it can be stored.The complete system diagram is showed below in the Fig 1.

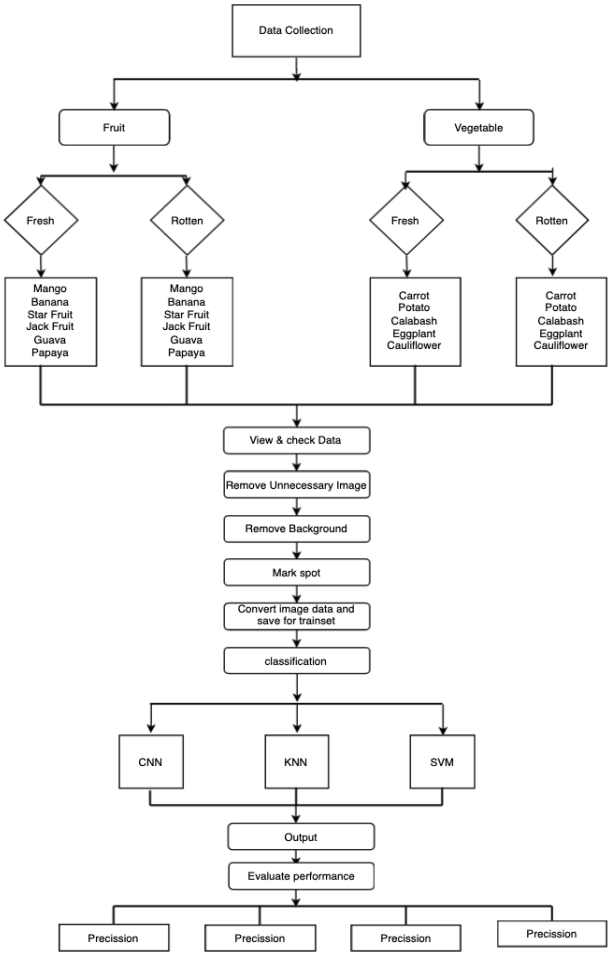

Fig. 1. System diagram

A. Data Collection

We used some commonly available Bangladeshi fruits and vegetables in our research. We have collected our required dataset from Google.com and kaggle.com.we collected two categories' data fruits and vegetables. For classification, the dataset includes fresh fruits, rotten fruits, and fresh vegetables, rotten vegetables which is shown in TABLE I. The fruits data set is divided into 6 types and vegetables is divided into 6 types.As follows:

- Fruits:

1. Mango
2. Banana
3. Star fruit
4. Jackfruit
5. Guava
6. Papaya

- Vegetables:

1. Carrot
2. Potato
3. Calabash
4. Cucumber
5. Eggplant
6. Cauliflower

TABLE I. THE DATASET WHICH WAS USED FOR TRAINING AND TEST

Name **of Fruits & Vegetables**	**Number of Training Data**		**Number of Testing Data**	
	Fresh	**Rotten**	**Fresh**	**Rotten**
Mango	**160**	**160**	**40**	**40**
Banana	**160**	**160**	**40**	**40**
Star fruit	**160**	**160**	**40**	**40**
Jackfruit	**160**	**160**	**40**	**40**
Guava	**160**	**160**	**40**	**40**
Papaya	**160**	**160**	**40**	**40**
Carrot	**160**	**160**	**40**	**40**
Potato	**160**	**160**	**40**	**40**
Calabash	**160**	**160**	**40**	**40**
Cucumber	**160**	**160**	**40**	**40**
Eggplant	**160**	**160**	**40**	**40**
Cauliflower	**160**	**160**	**40**	**40**

B. View and Check Data

View data means that the data we collect is all we see one by one. After the dataset collection process was completed successfully, the information was assessed and scrutinized in addition to making it more useful by removing unnecessary information.

C. Data Preprocessing

Data processing is a method of changing information from a given form to one that is considerably more useful and desired making it more instructive and useful. This procedure may be managed using Machine Learning techniques, numerical methods, and analytical expertise. Data preprocessing is a very important term which is showed in Fig 2 . We have divided data preprocessing into different parts in our research. It helps us to get out expected output. Looking at the images of fruits and vegetables, our main task is to determine the percentage of good and bad.

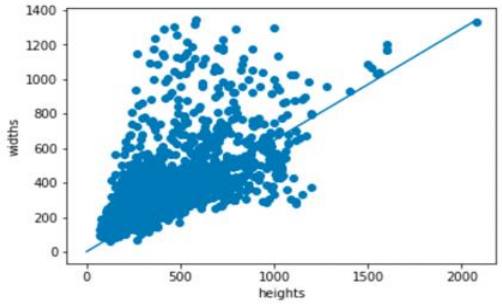

Fig. 2. Preparing dataset

D. View and Check Dataset

At first, look over everything and double-check the dataset. View data means that the data we collect is all we see one by one. After the dataset collection process was completed successfully, the information was assessed and scrutinized in addition to making it more useful by removing unnecessary information.

E. Remove Unnecessary Image

We have 2 categories of data in our dataset and there are some more types of these 2 types. For this reason, we have to ensure 1st, datasets are divided class by class. And one class of data is not in another class. If there is any such unnecessary

data then it should be removed. We collected the dataset in a random way. But to get the best accuracy the data must be fresh. For this reason, this step is very essential.

F. Remove Background

Removed all image background. To remove the background from the dataset, a third-party library was utilized which is 'rembg'. This library makes our task much easier than it was previously. It would be extremely tough and time consuming to complete this investigation in Photoshop. Due to the size of our data set This library solved our problem quickly and easily.

G. Mark Spot

Then the next term is mark spot on all dataset. Here we also use a 3rd party library which is 'contours. When fruits or vegetables start to spoil, a variety of spots and color changes occur. The machine basically determines whether the fruit or vegetable is good or bad based on the color that has changed from its normal color or this type of spots. so spot detection plays a vital role here. Depending on the size of the spot, the machine will decide exactly what percentage is good. Because in our collected dataset fresh fruit or vegetable is looking good and fresh and the rotten part is totally opposite.

H. Convert Image Data and Save for Trainset

After that convert image data into image dataset class by class. Here Not all images in the dataset are the same size, so here all images are resized according to their category. Images are transformed to NumPy arrays for easier analysis. Input size in Neural Network is 500*500 pixels. The resized image is converted to NumPy because the computer does not understand the RGB value, only Float, integer types of value can understand and NumPy converts one by one pixels to float value. Because our input layer is one dimension, all values are first in three dimensions and then converted to one dimension.

I. Classification

Data are classified into classes or categories using classification methods. Both organized and unstructured information may be used to conduct it. We've used three kinds of algorithm in our Research which is CNN, KNN, SVM.

CNN:

In our research, we used OpenCV in Python to develop an image classifier for recognizing fresh vs. rotting fruits and vegetables. Instead of analyzing the complete picture, CNN focuses on finding useful elements within it. CNN has a number of levels that aren't visible to the human eye. As both an input and an output level. To attain our destination, Convolutional Neural Networks (CNN), one of the most widely popular machine learning methodologies for service was introduced, will be used. Convolution is a method for combining two analytical operations in a single function. As we all know, CNN is a machine learning technique that allows machines to detect and recall picture attributes in order to estimate if the name of a new picture is provided to the system. The operating procedure of our CNN model is represented in Fig. 3.

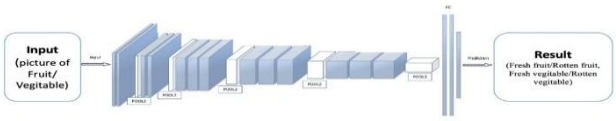

Fig. 3. CNN model

J. Output

Here we have shown some of our experimental outputs. We have put 6 types of Bangladeshi fruits and vegetables in our research. Here are some output examples. our system can easily detect rotten fruits and vegetables. We can see here from Fig 4 and Fig 5 when we selected fresh jackfruit then our system detects it and provide 99.28% accuracy beside when we select a rotten jackfruit then our system checked how many percent rotten and it was 87.27% rotten. In this same way is followed by other fruit and vegetable. Fresh cucumber, potato, and carrot identification from dataset photos. Again from Fig 6 and Fig 7 we see fresh cucumber accuracy is 98.12%, potato is 95.28% and carrot is 99.69% similarly rotten percentage is cucumber 68.84%, potato 70.59% and carrot is 68.91%.

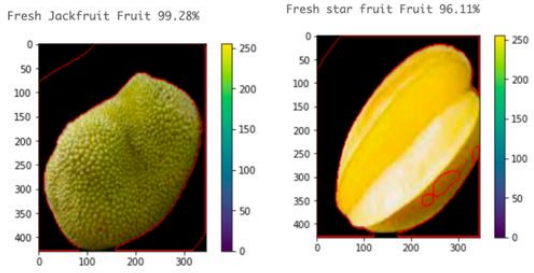

Fig. 4. Detection of fresh Jackfruit and star fruit from dataset images

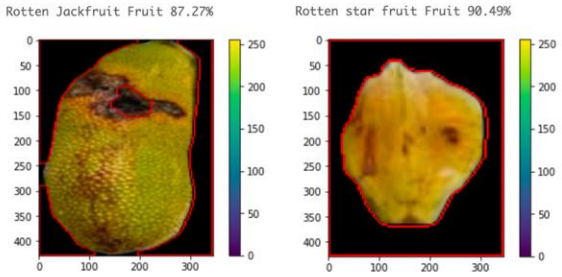

Fig. 5. Detection of rotten Jackfruit and star fruit from dataset images

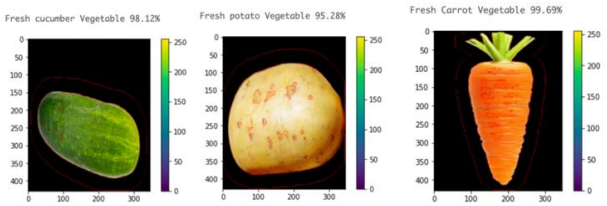

Fig. 6. Detection of fresh cucumber, potato and carrot from dataset images.

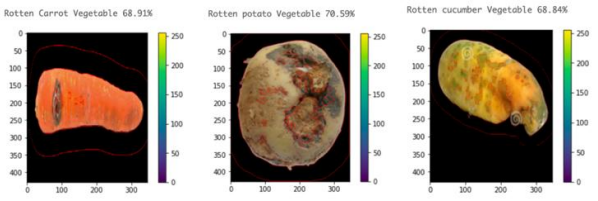

Fig. 7. Detection of rotten cucumber, potato and carrot from dataset images

IV. Implementation

We have created an Android application to make our work easier and more user friendly.

Register and login to the firebase cloud:

In our application this is the first part. At first user have to create his/her profile using name, E-mail address, phone number and a password. After completing registration successfully user can log in by using phone number and password which was already sated in Fig 8.

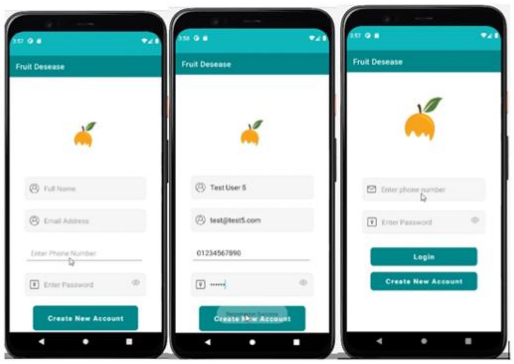

Fig. 8. Register and login

Select the target photo & send the photo the rest API server:

After that select a targeted photo from gallery or directly capture picture then Send the photo the rest API server for getting accuracy as shown in Fig 9. Like If we select a fruit affected by a disease, then the application will test and tell how many percent of it is good.

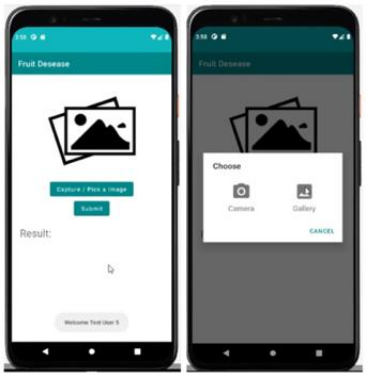

Fig. 9. Select the target photo

Fetch the result & show the result:

The application that demonstrates how we will choose the fruit image and display our results is given below. Similarly, we can choose a picture of a vegetable. In order to achieve the desired outcome, we chose the image in the image from the gallery. In this manner, we can use the camera to capture a real-time image in order to obtain a result which is shown in Fig 10 and Fig 11.

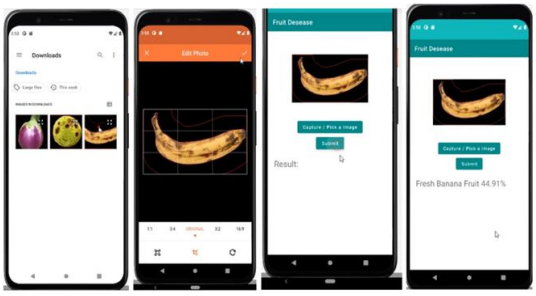

Fig. 10. Fetch the result & show for Banana

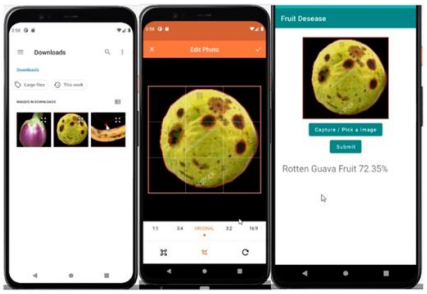

Fig. 11. Fetch the result & show for Guava

V. Experimental Result

Model accuracy:

Model accuracy is a statistic used to assess that what model is most effective in detecting patterns and correlations among data samples depending on the information, or trained, information. In every phase of the process, we see that the overall accuracy keeps rising. Then, we reach an accuracy of up to 95 percent, which is training accuracy, as well as an appropriate Val accuracy of 78 percent which is visible in Fig 12.

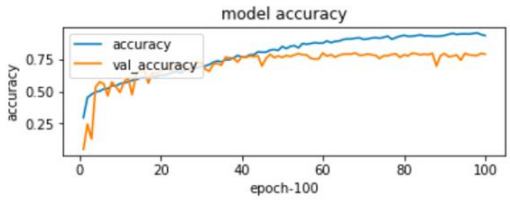

Fig. 12. Model accuracy

Model loss:

In other words, loss is a measure of how poorly the model predicted a particular case. This loss-v-loss (validation loss) method graph demonstrates that the loss is falling. This equates to 7% which is shown in Fig 13. The validation loss can be calculated on the v-set once our data has been processed (validation set).

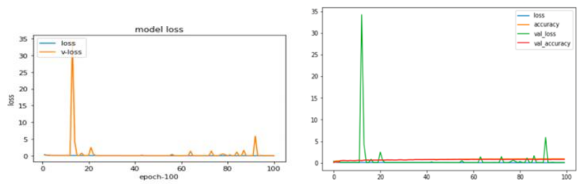

Fig. 13. Model loss, validation loss &validation accuracy

Our CNN model has a 95 percent training accuracy, a 7 percent validation loss, and a 78 percent validation accuracy. Additionally, the SVM obtained a 66 percent training accuracy, a 5 percent validation loss, and a 58 percent validation accuracy. KNN model improved its training accuracy by 64%, while seeing a 56% increase in validation accuracy. CNN model has the maximum accuracy in this analysis, thus. TABLE II has been updated with a brief explanation.

TABLE II. ALGORITHM TECHNIQUES

Algorithm	Epoch	Training Accuracy	Validation Accuracy	Training Loss	Validation Loss
CNN	100	95%	78%	2%	7%
SVM	23	66%	58%	4%	5%
KNN	23	64%	56%	5%	6%

VI. CONCLUSION & FUTURE WORK

In this study, a unique method for classifying fruits and vegetables and to use a convolutional neural networks technique is proposed. The results displayed above were acquired using 40 images for evaluation and training and 24 testing sets out of a total of 160. The abovementioned technique was coded and put to the test using Anaconda software. For research and testing, numerous fruit and vegetable varieties from varied backgrounds were chosen. The accuracy of the suggested approach was 95%. This article utilizes the CNN approach to categorize fruits and vegetables. The fully connected layers from the dataset were combined in multiple ways to create the performance and loss lines. This study addresses several methods and algorithms for the identification and classification of rotting fruits and vegetables depending on the machine learning methodology. Upcoming work on the project is envisioned to include a wider data set with more diverse fruits and vegetables. To assess reliability within the same information source using alternative CNN-based models, anticipate putting them. It is also possible to study other aspects for categorization, identify different illness kinds, and/or analyze the underlying texture structure. All of this points in the right way. One of the main future works will be usability testing for evaluating the app. For this testing, the SUS (System Usability Testing) for evaluating the system. In this process, the evaluation data is through SUS feedback questions and also interviews are done for each of the users, preferably with as many people as possible. The application UI could then be improved, based on the acquired SUS score.

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