CLASSIFICATION OF HEALTHY SEEDS USING DEEP LEARNING

SYNOPSIS

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CANDIDATE DECLARATION

I hereby certify that the work which is being presented in the synopsis entitled "**CLASSIFICATION OF HEALTHY SEEDS USING DEEP LEARNING"** by **"Ayush Jaggi"** in partial fulfilment of requirement for the award of degree of MTech (Computer Science and Technology) submitted in the department of Computer Science and Information Technology at **University of Jammu** under the supervisor Prof. Vinod Sharma.

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This is to certify that the above statement made by the candidate is correct to the best of my knowledge.

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1. INTRODUCTION

Agriculture is an important sector in India, contributing significantly to the country's economy and providing employment for a large portion of the population. India is one of the world's leading producers of a wide variety of crops, including rice, wheat, sugarcane, cotton, tea, and many others. Agriculture in India is characterized by a diverse range of crops, soil types, and farming practices, reflecting the country's varied geography and climate. India has a long tradition of agriculture, with a history dating back to ancient times. Today, agriculture continues to be an important part of the country's economy, accounting for about 15% of India's gross domestic product (GDP). Despite its importance, the agricultural sector in India faces several challenges, including low productivity, limited access to technology and inputs, and poor infrastructure.

There are many factors that influence agriculture in India, including the country's diverse geography, climate, and culture. India has a wide range of soil types, ranging from fertile alluvial soils in the plains to rocky and hilly soils in the mountains. The country also has a varied climate, with hot and dry conditions in the desert regions, monsoon-influenced conditions in the coastal and central regions, and cold and dry conditions in the northern mountainous regions. These factors, along with a long history of traditional farming practices and the influence of modern technology, contribute to the diversity of agriculture in India. [1].

1.1 Seeds

A seed is a basic part of any plant. The ovules after fertilization, develop into seeds. A seed is made up of a seed coat and an embryo. The embryo is made up of a radicle, an embryonal axis and one (wheat, maize) or two cotyledons (gram and pea). A seed is found inside a fruit which converts into a new plant when we plant it. Hence, the seed is the most important part.[2]

1.2 Healthy Seeds

An edible seed is a seed that is suitable for human or animal consumption. Of the six major plant parts, seeds are the dominant source of human calories and protein. A wide variety of plant species provide edible seeds; most are angiosperms, while a few are gymnosperms. Healthy edible seeds are seeds that can be eaten as a food and are nutritionally beneficial. They come from a variety of plants and can be eaten either raw, roasted, or ground into flour. These are convenient foods that can provide numerous health benefits.[3]

1.3 Benefits

Seeds contain all the starting materials necessary to develop into complex plants. Because of this, they are extremely nutritious. Seeds are great sources of fibre. They also contain healthy monounsaturated fats, polyunsaturated fats and many important vitamins, minerals, and antioxidants. When consumed as part of a healthy diet, seeds can help reduce blood sugar, cholesterol, and blood pressure.

“Seeds are good sources of plant-based, healthy fats, fibre and minerals,” says registered dietitian Kate Patton, RD. And for such a tiny package, the impacts on your body are massive. Seeds are loaded with:

- Iron – Which helps you make proteins that carry oxygen-rich blood throughout your body.
- Calcium – Critical for bone health.
- Magnesium – A mineral that helps with hydration and bowel and brain health — and one we often don't have enough of.
- Phosphorus – Important for many body functions, including repairing cells and filtering waste.

Some of the potential benefits of consuming healthy edible seeds include:

1. Support Weight Loss

Incorporating a variety of healthy seeds for weight loss into your diet can be incredibly beneficial. This is because seeds are loaded with fibre and protein, both of which are key to promoting healthy weight loss. Fibre moves through the digestive tract slowly to help keep you feeling fuller for longer. Meanwhile, protein works to decrease levels of ghrelin, the hormone that stimulates feelings of hunger in the body. In one 2017 study out of Turkey, consuming chia seeds as part of a mid-morning snack increased satiety, reduced hunger and decreased cravings for sugary foods, all of which could potentially lead to weight loss.

2. Boost Digestive Health

In general, the healthiest seeds are typically high in dietary fibre, a nutrient that plays a central role in digestive health. Not only does it add bulk to the stool to promote regularity, but fibre has also been shown to protect against issues like haemorrhoids, diverticulitis, intestinal ulcers, and constipation. Fibre also helps feed the beneficial bacteria in the gut, which can have a huge impact on immune function, mental health, nutrient absorption and more.

3. Regulate Blood Sugar

The fibre found in seeds helps slow the absorption of sugar in the bloodstream, stabilizing blood sugar levels to prevent sudden spikes and crashes. Not only can this help prevent diabetes symptoms, but it may also protect against the development of chronic conditions like heart disease. Certain types of seeds, such as flaxseed, have also been shown to improve insulin sensitivity. This allows insulin to work more efficiently in the body to keep blood sugar steady.

4. Fight Free Radical Formation

Most of the healthiest seeds are jam-packed with manganese, an important micronutrient that plays a vital role in health. Not only is it used as a cofactor for many enzymes in the body, but manganese also acts as a powerful antioxidant to fight free radicals and protect cells against oxidative damage. This can have far-reaching effects on nearly every aspect of health and may be especially beneficial in the prevention of conditions such as cancer, heart disease and diabetes.

5. Good Source of Plant-Based Protein

Adding a few servings of the healthiest seeds into your diet can bump up protein intake to help you meet your daily needs. Protein is vital to wound healing and tissue repair, immune function, muscle growth and more. Not getting enough protein in your diet can have detrimental effects on health, resulting in symptoms like an increased risk of infection, greater appetite, and stunted growth. Although the protein content of different seeds can vary widely, most varieties offer around five to 10 grams of protein in each serving.

6. Incredibly Nutrient-Dense

In addition to providing a good amount of both protein and fibre in each serving, seeds also supply a wide range of other micronutrients as well. Hemp seeds, for example, are a great source of manganese and vitamin E, while sesame seeds are rich in copper and calcium. One thing that all seeds have in common, however, is that they are incredibly nutrient-dense foods and excellent additions to a healthy, balanced diet.[4]

1.4 Types of Healthy Seeds

Seeds are a versatile ingredient that can be used to add a quick pop of texture and nutrition to nearly any meal. The following are the different types of healthy seeds:

- **Flax Seeds**

  These fibre-packed seeds are rich in healthy omega-3 fats and provide a substantial amount of protein to boot (five grams per one ounce serving). The flaxseeds support regularity and can keep you feeling fuller for longer. Incorporating flaxseed into your diet can also reduce your blood sugar, as well as your risk of cancer and heart disease. That said, the whole seed is difficult to digest. For this reason, It is recommended using *ground* flaxseed instead, which can be added to oatmeal, smoothies and baked goods for a nutritional boost.
- **Chia Seeds**

  Just two tablespoons of these itty-bitty seeds provide a whopping 10 grams of dietary fibre. Chia seeds are loaded with healthy Omega-3 fats, and can increase ALA in the blood, which is an omega-3 fatty acid that can help reduce inflammation. Chia seeds can also absorb up to ten times the amount of water that they're put in, which means that just a small one ounce serving added to yogurt can go a long way towards making you feel full for longer.
- **Sesame Seeds**

  Sesame seeds are one of the best dietary sources of lignans—molecules that have antioxidant and anti-inflammatory effects—and may reduce inflammation and oxidative stress. There are many other healthy ways to make use of sesame seeds—like by sprinkling them into a veggie stir-fry or atop a slice of avocado toast, for example.

- **Sunflower Seeds**

  Sunflower seeds are “abundant in monounsaturated fats, Vitamin E, and protein…and eating [them] a few times a week has been shown to reduce inflammation.” Adding sunflower seeds to your diet is an easy way to boost your intake of vitamin E, thiamine, and manganese. Sunflower seeds are a great way to keep your skin healthy, maintaining healthy cholesterol levels, and lowers blood sugar.

- **Pumpkin Seeds**

  Pumpkin seeds, also known as pepitas, are a popular seed with an obvious origin. They’re also loaded with monounsaturated and omega-6 fats and boast serious health benefits for the bladder and urinary tract. Indeed, A research—like this 1987 study published in the *American Journal of Clinical Nutrition*—shows pumpkin seeds can reduce the risk of bladder and kidney stones and might alleviate the symptoms of an overactive bladder in postmenopausal women as well.

- **Hemp seeds:**

  These relatively large and pleasantly crunchy seeds from the hemp plant are a complete protein source, which means they contain all the essential amino acids that your body is unable to make. These seeds are a lovely addition to rice, salads, and all manner of vegetable dishes. You can also enjoy numerous research-backed health benefits—like improved heart health and skin.

- **Watermelon seeds**

  Its seeds are super-rich in various nutrients. These seeds have a low-calorie count and are rich in micronutrients like zinc, magnesium, potassium, etc. Watermelon seeds boost immunity and heart health and help to control blood sugar levels, thereby occupying a prominent place in the Diabetes Food Chart. [5]

1.5 Deep Learning in Classification of Fruits and Vegetables

Consuming good, healthy, and quality fruits and vegetables are the utmost requirement of the consumer. Hence, automation in food industries is growing in recent times. Because it is impractical for humans to manually inspect the fruits and vegetables as it requires many labours as well as requires a lot of time and effort. In recent years numerous deep learning techniques for example, Classic Neural Networks (Fully Connected), Convolutional Neural Networks (CNN), Recurrent Neural Networks (RNN), and Deep Reinforcement Learning have been exploited with many different feature description methods for fruit and vegetable classification in many real-life applications. Deep learning is the study of computer algorithms that can improve automatically through experience and using data. It is seen as a part of artificial intelligence [6].

2. LITERATURE REVIEW

The main aim of proposed research is to classify Healthy Seeds by using deep Learning Techniques. The literature related with proposed topic has been studied and a general review of the same is presented as under:

Sanjayan et al. (2013) [7] aimed to assess the nutritional value of ripened fruits of a popularly known medicinal plant Morinda tinctoria. The study focused on the estimation of Ash content, Protein, carbohydrate, vitamins, and mineral content of Morinda tinctoria fruit. The difference in nutritional content between fresh and dried fruits were also assessed. The ash content is 4% and 1.6% for fresh and dry fruits respectively. The fresh fruit is rich in protein and carbohydrate than the dry fruit. The fresh fruit is rich in Ascorbic acid and Niacin whereas the dry fruit showed the presence of Riboflavin and Thiamine Page7 in high concentration. The dry fruit is rich in calcium whereas the fresh fruit is rich in both iron and copper. Both the fresh and dry fruits showed complete absence of phosphorous. Thus, the Morinda tinctoria fruits could be used as a source of protein, vitamin and minerals.

Femling et al. (2018) [8] described an approach of creating a system identifying fruit and vegetables in the retail market using images captured with a video camera attached to the system. The system helps the customers to label desired fruits and vegetables with a price according to its weight. The purpose of the system is to minimize the number of human computer interactions, speedup the identification process and improve the usability of the graphical user interface compared to existing manual systems. The hardware of the system is constituted by a Raspberry Pi, camera, display, load cell and a case. They have evaluated different convolutional neural networks (Inception and MobileNet) as classifiers of 10 different kinds of fruits or vegetables. Images for the classifier are provided by a Raspberry Pi Camera Module v2, connected to a Raspberry Pi. To test the usability, a heuristic evaluation has been performed with several users, concluding that the implemented system is more user friendly compared to existing systems. MobileNet has a top accuracy of 97%.

Rojas-Aranda et al. (2020) [9] presented an image classification method, based on lightweight Convolutional Neural Networks (CNN), with the goal of speeding up the checkout process in stores. A new dataset of images is introduced that considers three classes of fruits, inside or without plastic bags. To increase the classification accuracy, different input features are added into the CNN architecture. Such inputs are, a single RGB colour, the RGB histogram, and the RGB centroid obtained from K-means clustering. The results show an overall 95% classification accuracy for fruits with no plastic bag, and 93% for fruits in a plastic bag.

Shaikh et al. (2021) [10] proposed a system which can detect and classifying the fruits as affected or not based on surface using Faster R-CNN model. As this system is automatic, it cuts down the manual method of fruit inspection, which takes a lot of time, labour, and effort. This system will not only save the cost of labours but will also give a high accuracy. By implementing this system, we can say that Faster R-CNN is the quite fastest model and gives most accurate results. Accuracies for different categories of fruits lies between: 'Healthy apple

= (60-75) %', 'Bad Apple = (60-70) %', 'Healthy Pear = (85-99) %', 'Bad Pear = (80-98) %', 'Healthy Banana = (80-97) %', 'Bad Banana = (70-80) %'. Hence, this system can be very useful in automatic sorting machines where it can detect as well as classify the fruit and their defects. Therefore, it will help in ensuring the quality and richness of the fruit.

Agrawal and Dahiya et al. (2018) [11] conducted a comparative study on ML algorithms aimed to classify various grain seeds by using logistic regression (LR), Linear Discriminant Analysis (LDA), k-Nearest Neighbours classifier (kNN), a decision tree classifier (CART), Gaussian Naïve Bayes (NB) and support vector machine (SVM). This study reported performance rates for both linear (LR and LDA) and non-linear (kNN, CART, NB and SVM) algorithms. The accuracy rates for these six algorithms were as follows: the rate of LR was 91.6%, the rate of LDA was 95.8%, the rate of kNN was 87.5%, the rate of CART was 88%, the rate of NB was 88.05% and the rate of SVM was 88.71%. From these results, LDA had the superior performance.

Ferhat Kurtulmuş (2020) [12] used DL models for the identification of sunflower seeds. They overcome the problem of overfitting by using optimization algorithms. The authors claimed that the optimized Google Net model achieved an accuracy of 95%. But the model requires human intervention for arranging the seeds rather than keeping them in a voluminous lot. Also, the authors considered only one view of seeds for training the model. So, there is a scope to improve the robustness and reliability of the model by training it on multiple views of seeds.

Guoyang Zhao et al. (2021) [13] considered the full surface of soybean seed. They followed circumrotating mechanism for full surface detection and reported an accuracy of 98.87%. They improved the classification accuracy by employing the MobileNet model on the dataset comprising defected seeds.

Shaolong Zhu et al. (2020) [14] proposed the method for the identification of Soybean seeds. They applied Pretrained CNN models viz. AlexNet, ResNet18, Xception, Inception-v3, DenseNet201 and NASNetLarge to showcase the impact of transfer learning. The authors claimed that among all models NASNetLarge reported the highest accuracy of 97.2%. The authors also claimed that integrating hyperspectral imaging with transfer learning gives higher accuracy in lower computation costs.

Douglas F. et al. (2016) [15] extracted seed vigor that includes the properties of seeds. They employed the ML algorithms viz. K-Nearest Neighbour (KNN), Random Forest (RF), Multi-Layer Perceptron (MLP) , SVM and Optimum-Path Forest OPF for detection of the damaged seeds. The authors claimed that OPF and SVM outperformed all the above-stated ML models and achieved an accuracy above 80%. Further, they analysed that considering only the features extracted based on the shape reports low accuracy. Therefore, they employed DL techniques for automatic feature selection and classification of damaged seeds

Jamuna et al. (2021) [16] employed machine learning techniques (e.g., Naïve Bayes classifier, a decision tree classifier and MLP) to train the model in feature extraction using a sample of 900 cotton seeds. They reported that the decision tree classifier and MLP gave the same accuracy in classifying the seed cotton, with a rate of 98.7%, and Naïve Bayes classifier had an accuracy rate of 94.22%. Their results show that Naïve Bayes classifier had the highest error rate, as it made incorrect classification 52 times, whereas the decision tree classifier and MLP made 11 incorrect classifications each.

Feature extraction in traditional ML techniques mainly relies on user-specified features that may cause the loss of some important information, due to which researchers are then faced with difficulty in getting accurate results. Deep learning techniques determine the features of the images in different layers instead of relying on the self-made features of the images.

For example, in a study by **Rozman and Stajnko (2015) [17],** the quality of tomato seeds was reported in terms of their vigour and germination. In their study, they proposed a computer vision system and reported a detailed procedure for image processing and feature extraction by incorporating a Gaussian filter, segmentation, and Region of Interest (ROI). This study incorporated machine learning classification algorithms including Naïve Bayes classifiers (NBC), k-nearest neighbours (k-NN), decision tree classifiers, support vector machines (SVM) and artificial neural networks (ANN) to sort a sample of 700 seeds. Among these algorithms, the ANN (MLP architecture) showed the best performance in seed classification, with an accuracy of 95.44%. Other accuracy rates were NBC at 87.89%, k-NN at 91.66%, DT at 93.66% and SVM at 93.09%.

Vlasov and Fadeev (2017) [18] carried out research on grain crop seeds by used a machine learning approach over mechanical methods. They elaborated the details of feature extraction by using traditional machine learning, which included image feature extraction, descriptors retrieval, clustering and finishing with a vocabulary of visual words. Although their major focus was on the traditional ML approach, they also reported deep learning as a second method for seed classification and purification. Their results showed that the deep learning approach reached 95% classification accuracy, where traditional learning had a rate of around 75%.

Xiulin Bai et al. (2020) [19] used near-infrared hyperspectral imaging for classifying common maize and silage seeds. Both types of seeds are slightly different in appearance but considerably vary in internal structure and characteristics. They applied SVM and radial basis function neural network (RBFNN) for classification. RBFNN outperformed in all cases in identifying common or silage seeds of maize. But the authors reported accuracy of only 88.41% for the classification of 8 varieties of maize seeds.

Lei Pang et al. (2020) [20] achieved an accuracy of 90.11% using the DCNN technique. Similarly, the Seed quality tester developed by [10] divides the maize seeds into five clusters based on their quality labelled as average, bad, excellent, good, and worst. The model achieved an accuracy of 81% on the training dataset. But the model could not segregate a voluminous lot of bad seeds from good and worst categories.

2.1 Problem Statement

By reviewing the relevant works of literature and the problems related to the previous research papers, it is noticed that there is a requirement of applying a suitable Deep learning algorithm for classification of Healthy Seeds. This study can help to build a better classifying model of Healthy seed types using a suitable Deep learning algorithm.

2.2 Hypothesis

Deep learning technique can accurately classify Healthy seeds.

3. EXPECTED CONTRIBUTION OF THE STUDY

The proposed study will help in the classification of Healthy Seeds using Deep learning with good accuracy.

3.1 Area of Study

The proposed study will be done on a real dataset as the domain of work is new and no dataset is available on internet and will be carried out on Python platform by the implementation of Deep learning technique.

3.2 Justification

In recent years numerous deep learning techniques have been exploited with many different feature description methods for fruit, vegetable, and seeds classification in many real-life applications. There are very few numbers of works related to Healthy Seeds image classification. The recognition of these healthy seeds used in our daily basis food is gaining more importance in our daily life. Research on healthy seeds recognition and classification is very important for several economic sectors, both for the wholesale and retail markets, as well as for the processing industries. Classifying a particular variety of seed will enable us to distinguish it from another variety. Hence, there is a need of a better model, to accurately classify healthy seeds.

3.3 Objectives

- To carry out thorough study on Healthy seeds and its benefits.
- To analyse deep learning techniques in the classification of seeds and evaluate the performance of implemented undertaken deep learning techniques based on parameters such as accuracy, recall, precision, f-score.
- To develop a Healthy seeds Recognition framework based on Deep learning to recognize different seeds.

4. RESEARCH METHODOLOGY

The main purpose of this research is to classify Healthy seeds using deep learning algorithms, first the data will be collected and pre-processed. Pre-processing steps include filtering, and resizing of the image to pixels. The pre-processed dataset will be partitioned into Training data and Test data. Model will be trained on Deep learning algorithm, and then trained model will be tested using Test dataset. After that performance assessment of implemented algorithms will be carried out. The flow diagram for the undertaken research project is presented in figure 1.

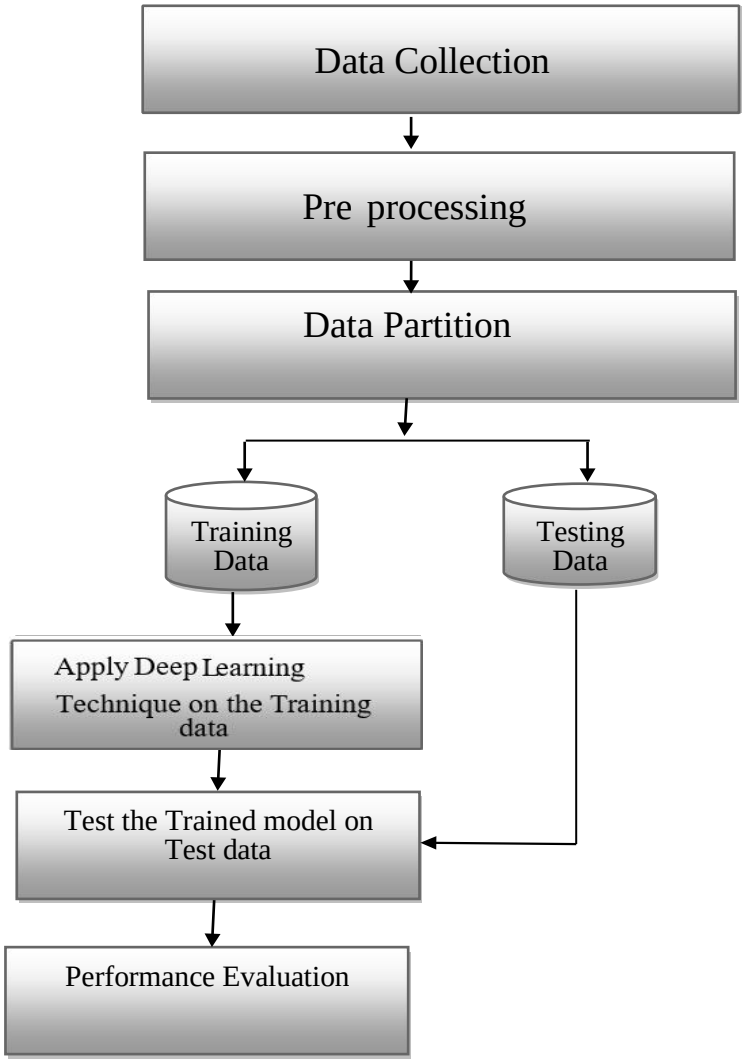

Figure1: Workflow of the proposed research

4.1 Performance Measures

The performance of the model will be analysed on the basis various parameters derived from its confusion matrix represented as under:

		Actual Result	
Predicted Result		LOW	HIGH
	LOW	True Positive	False Positive
	HIGH	False Negative	True Negative

True Positive (TP):

Interpretation: These are the correctly predicted positive values which means that the value of actual class is yes, and the value of predicted class is also yes.

True Negative (TN):

Interpretation: These are the correctly predicted negative values which means that the value of actual class is no, and the value of predicted class is also no.

False Positive (FP):

Interpretation: When actual class is no but the predicted class is yes.

False Negative (FP):

Interpretation: When actual class is yes but the predicted class is no.

Based on these metrics various performance measures can be calculated as shown in the table below:

Parameter	**Formula**
Accuracy	(TP+TN)/ (Total Cases)
Recall	TP/ (TP+ FN)
Precision	TP/ (TP+ FP)
F1-score	(2*Recall*Precision)/ (Recall + Precision)

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