# Chapter 8

# Conclusion and Future Work

The final part of the research work is briefly summarized here. The first section describes the conclusion of the research work and the second section discusses the future work that can be done.

## 8.1 Summary

Food identification is the first step for proper dietary assessment. Proper identification of food can be done with good-quality images. Through literature study it has been observed that no work has been done to identify Gujarati food. No work has been done to find CNN model's time complexity.

The problem statement was as follows:

***"To design and develop a model for Gujarati Food image classification with improved accuracy and performance by making the network lightweight.'***

As per the problem statement a detailed literature survey has been conducted and a model has been developed. All the objectives outlined in the research study were successfully attained. In the subsequent section, we provide a comprehensive account of the objectives that were initially established for this study and elaborate on the precise manner in which they were accomplished.

## 8.2 Outcome of the Research work

The primary aims of this research was to design and develop a model for accurate identification of Gujarati food. The model is supposed to be lighter in terms of memory and time both. The following section provides a comprehensive description of each objective and its corresponding achievement:

**Objective: 1**

*'To do detailed study on existing techniques for preprocessing, different methods for food classification, different datasets, deep learning frameworks, different CNN models to compare the advantage and limitations of each in order to find the research gap'*

***Attainment: 1***

In order to accomplish the aforementioned objective, extensive research papers focusing on classification of different food using different approaches were thoroughly examined and studied.

Different preprocessing techniques has been studied and implemented. Different classification techniques for different types of food has been studied. The correctness and effectiveness of each classification techniques were thoroughly analyzed, and a comprehensive comparative summary was conducted. This ensured a detailed assessment of their respective strengths and weaknesses.

This has been covered in Chapter 2 of the thesis. One survey paper, which is directly relevant to the research conducted, has been published in SCOPUS indexed journal. The detail of the paper has been given in publication section.

**Objective: 2**

*'To design and develop an algorithm to remove impulse noise while preserving edges and contours'*

***Attainment: 2***

To remove impulse noise from food images detailed study has been done on various types of preprocessing techniques. A thorough analysis of the strengths and weaknesses of each preprocessing technique was conducted, and an extensive comparative study was carried out to provide a detailed examination. A new preprocessing algorithm "ISMF" has been proposed which eliminates the limitations of existing techniques.

A comparison has been done on proposed algorithm with existing methods by increasing noise in images. The result proves that ISMF is better than existing filters. This has been covered in Chapter 4 of the thesis.

**Objective: 3**

*'To design and develop a model(s) that can recognize Gujarati Food and lighter in terms of memory and time both. A model that can give better performance with a greater number of food classes or a dataset of different food items.'*

***Attainment: 3***

Based on the detailed literature study, there is no dataset available for Gujarati food and hence, a dataset for Gujarati food has been created. A model has been developed which can classify Gujarati food items accurately. A comparison with five fine-tuned existing model's performance has been compared with the proposed model DRCNN in terms of accuracy, F1 score, precision and recall. The proposed model is lightweight in terms of parameters and hence takes less time than all existing prebuilt models which saves memory and time both. The performance of the DRCNN model has been checked by a greater number of Gujarati food classes and for different types of food dataset.

This has been discussed in chapter 3, chapter 5 and chapter 6. One research paper has been published related to this work in SCIE indexed journal. The details of the paper has been given in the publication section.

**Objective: 4**

*'To find time complexity of a CNN model and to evaluate the performance of the model based on various parameters'*

***Attainment: 4***

Detailed analysis has been conducted to find the factors that directly affect time complexity of any CNN model. Complexity analysis has been done on eight different CNN models which vary by number of convolutional layers, size of filters, size of the kernel, number of filters, size of the neuron, and the number of fully connected layers. Based on the proposed formulas time complexity has been found for DRCNN and existing prebuilt models.

This has been discussed in chapter 7. A paper related to this work has been published in SCOPUS indexed journal. The details of the paper has been given in the publication section.

## 8.3. Research Output

- The first attempt to classify Gujarati food items is made in this research work. A new dataset named TGFD has been developed, consisting of five items: Dhokla, Handvo, Khakhra, Khandvi and Patra.
- Transfer learning has been implemented on pre-trained models, namely Alexnet, VGG19, Resnet50, VGG16 and Inceptionv3 in order to see the performance on TGFD.
- Fine-tuning has also been applied to increase the accuracy by changing the feature extraction part along with the classification part and the results have been compared.
- To further improve classification accuracy and to design a lightweight model a Depth Restricted Convolutional Neural Network has been proposed. The model has been built by tuning several hyperparameters. Hyperparameters have been selected using empirical research, KerasTuner and by doing multiple experiments. The TGFD dataset is trained and tested on the DRCNN and achieves 95.48% of remarkable classification accuracy with a loss rate of 0.8041. The DRCNN model size is 48 times smaller than the Inception v3 model. The model's outstanding

results on extended TGFD and different types of food datasets prove its versatility.

- The time complexity of any CNN model is a practical issue that all researchers find nowadays. Finding time complexity helps the researchers decide the impact of each hyperparameter they choose for building a model. This research work tried to find the time complexity of the model and determined the crucial parameters for calculating time complexity of the model.

## 8.4 Future Work

In this work, the focus is on correctly identifying Gujarati Food. The suggestions for future enhancements are as follows:

- In the future, more items can be added to the dataset. This work focuses on single food items. The work can be further extended to identify mixed food items and liquid food items.
- One can divide the food domain into two categories. Accurately identifying foods followed by calculating calories. The work can be further extended to count the calories from the identified Gujarati food. Being aware of the calorie count of the foods people can efficiently manage their weight. Understanding the calorie count of various foods might help with portion control and balanced nutrient intake. Calorie tracking allows people to maintain a healthy diet for specific needs and goals and helps to maintain energy balance.
- Another issue is spatial complexity. The CNN model takes more memory than the traditional model. Fortunately, the memory requirement is less demanding, but it is still an interesting topic to investigate in the future.

The publication details related to this work and references follow in subsequent sections.