Research Design II
Fruit Classification using Convolutional Neural Networks

Russell Cachia, Mario Mallia Milanes

Institute of Information & Communication Technology

Malta College of Arts, Science & Technology

Corradino Hill

Paola PLA 9032

{russell.cachia.g53991, mario.mallia.milanes, ictar}@mcast.edu.mt

I. INTRODUCTION, POSITIONING, RESEARCH ONION

A. Description of Theme and Topic Rational

In the field of computer vision and image processing, the theme of fruit classification is a very interesting area of research, with the increasing advancements in technology and its agricultural importance. Nowadays, the importance of fruit classification is present in multiple different fields, such as dietary monitoring, food processing, and agricultural automation.

With the advancements in Computer Vision and Deep Learning [1], Convolutional Neural Networks (CNNs) have emerged as a game changer in this context, offering a powerful and automated solution for fruit quality control, sorting, and also grading. By making use of the capabilities of CNNs, fruit industry stakeholders can streamline their operations, minimize manual labor, reduce post-harvest losses, and also ensure consistent product quality, ultimately leading to profitability and customer satisfaction.

In today's world, where the visual complexity and uniqueness of fruits present significant challenges, harnessing the power of Convolutional Neural Networks (CNNs) [2] emerges as a promising solution.

B. Positioning and Research Onion

This study positions itself and the researcher at the intersection of computer vision techniques and practical applications which in this case is fruit classification. With the industry ever-expanding, the aim is to improve fruit classification accuracy.

Considering the given nature of the research problem and objectives, a positivist philosophy is best suited. This is due to the study primarily being quantitative, relying on a dataset of 60,000 images for fruit classification. The large-scale quantitative approach aligns with positivism's emphasis on empirical evidence and the scientific method. By adopting a positivist stance, our study aims to uncover objective truths about fruit classification using Convolutional Neural Networks (CNNs), contributing to the empirical knowledge base in this field.

The research approach taken for this study was a deductive one, starting from established theories and then extending the knowledge to classify fruit using CNNs. This deductive approach allows the researcher to formulate hypotheses based on existing knowledge and test them using quantitative analysis of the dataset.

The research strategy employed was experimental research. By forming a hypothesis, experimental research enables the researcher to systematically test the hypothesis through controlled experiments. Experimental research allowed for the control of variables and conditions during the classification process. Since the study relies on quantitative data and aims to evaluate the performance of CNN models, the experimental research provides a suitable framework for conducting rigorous quantitative analysis.

For the time horizon of this study, a cross-sectional approach was adopted, collecting data from a sample of fruit images. This approach offers valuable insights into the performance and applicability of CNNs in real-world fruit classification scenarios.

In terms of data collection methodology, the researcher adhered to a mono method. The use of the mono method ensures consistency and reliability in data collection, maintaining uniformity throughout the study's execution. Employing such techniques enhances the credibility of the dataset, finally leading to strengthening the research outcomes without repeating information unnecessarily.

C. Background to this Research Theme

Diving into the background of Fruit Classification by using Convolutional Neural Networks is of utmost importance to highlight the evolution of computer vision techniques and their application in real-world situations. Fruit classification using Convolutional Neural Networks has gained significant attention in recent years due to its potential applications in agriculture, food processing, and computer vision. CNNs have proven to be effective in image classification tasks, leveraging their ability to automatically learn and extract meaningful features from raw image data. The architecture of CNNs,

consisting of convolutional, pooling, and fully connected layers, allows them to capture spatial hierarchies and patterns present in fruit images [2]. Various studies have explored the use of CNNs for fruit classification, employing different methodologies and data sets. Previous studies have shown high levels of accuracy when it comes to testing these CNNs.

In this study the researcher intends to provide an overview of some existing studies on fruit classification using CNNs. By analysing the strengths and limitations of these studies, the researcher seeks to identify areas for further improvement and future directions in fruit classification using CNNs. These studies are as follows:

1) Xiong et al. (2018) developed an algorithm for fruit-picking robots using artificial illumination to recognize grapes. Their system's accuracy was 92% [3].
2) Another study conducted by Katarzyna and Pawel performed fruit classification for supermarket retail sales systems. They suggested using a 9-layered deep neural network to classify six different apple cultivars. They claimed 99.78% accuracy [4].
3) In another study, Kumari and V. Gomathy have classified fruits using color and texture characteristics. To extract the region of interest, they used HSV color space thresholding. After using a three-level discrete wavelet transform, they then retrieved color data from the hue and saturation channels and texture information from the luminance channel. They used an SVM classifier to categorize 10 fruit types from the supermarket produce data set. Their method was 95.3% accurate [5].
4) A CNN based classifier was developed by Sakib, Ashrafi and Siddique which was able to recognize 25 classes of fruits on Fruits 360 data set with 100% test and 99.79% train accuracies [6].

TABLE I
STATE OF THE ART RESULTS

#	Study	Citation	Metrics	Results
1	AI Robots recognizing grapes	[3]	Accuracy	92%
2	Fruit Classification in Retail Systems	[4]	Accuracy	99.78%
3	HSV Thresholding for Fruit Classification	[5]	Accuracy	95.3%
4	CNN based Classifier	[6]	Accuracy	99.79%

D. Hypothesis

The objective of this study is to explore the application of computer vision and machine learning techniques in fruit classification. The primary focus is on assessing the accuracy of fruit evaluation, with the choice of datasets and algorithms serving as independent variables to analyze their influence on the accuracy of classification. Therefore, the hypothesis posits that through the utilization of computer vision technologies, it is viable to achieve precise identification of various types of fruits.

E. Research Aim and Purpose Statement

The primary aim of the study is to explore the potential of computer vision techniques in improving fruit classification

accuracy. Monitoring the impact of different datasets and algorithms on the performance of CNN models for fruit classification. By evaluating these variables the study will assess the feasibility and effectiveness of these computer vision techniques.

The feature extraction process is important in order to obtain information in data. This process is to determine the performance of the machine learning [7]. By focusing on the accuracy of fruit evaluation as the main dependent variable, the study aims to understand how the choice of datasets and algorithms influences classification performance. Through rigorous analysis, the study seeks to validate the hypothesis. This study addresses two specific research questions:

1) How does the choice of data set impact the performance of CNN models for fruit classification?
2) How much of a difference do layers create with regard to accuracy?

By addressing these research questions the researcher aims to contribute valuable insights to the field of automated fruit classification and help inform future research and projects in of this domain.

II. REVIEW OF RESEARCH METHODOLOGIES AND MAP

A. Short Literature Review about the Methodologies Used in Other Studies

Upon viewing different relevant literature to the topic at hand, various approaches can be used.

1) **CNN-Based Models**
   Several studies have leveraged Convolutional Neural Networks (CNNs) for fruit classification. These models have shown high accuracy in categorizing fruits as "fresh" or "rotten," with the proposed CNN model achieving an accuracy of 98.23% [8].
2) **Transfer Learning Models**
   Transfer learning models like AlexNet, LeNet-5, VGG-16, and VGG-19 have been compared with CNN-based models for fruit categorization. The results indicate that the proposed CNN model outperforms transfer learning approaches due to achieving a classification accuracy of 98.2% [8].
3) **Support Vector Machines**
   This paper reviews various fruit identification methods, including the use of SVMs. In this study, a method that uses multi-feature fusion to identify five kinds of fruits was presented. The authors used global histogram, LBP, HOG, and GaborLBP for feature extraction and managed to achieve 81.35% accuracy using LibSVM [9].

B. Difference between Academic and Non-Academic Material

The difference between academic and non-academic material lies in their intended audience and purpose.

Academic material is aimed towards scholarly audiences, featuring formal language and a structured format, it is based

on facts, evidence, and always contains citations [10]. Authored by experts in the field, these materials undergo a rigorous peer-review process to ensure accuracy and contribute to the field's knowledge base. Common forms include academic journals, textbooks, and conference papers.

In contrast, non-academic material is written for a general audience, employing a more informal, personal, and subjective tone and less structure. These materials, which can include news articles, blogs, and magazines, are typically written by journalists or enthusiasts without comprehensive citations or a peer-review process. Their primary purpose is to inform or entertain rather than to fulfill scholarly criteria [10].

C. Recommendation of 5 articles from Peer-Reviewed Journals

In order to dive deeper and grasp a better understanding of Fruit Classification, the researcher has selected five articles from peer-reviewed journals. These articles have been carefully chosen given their relevance and contribution to the subject. By understanding these sources, the researcher aims to enrich his understanding which eventually leads to a more accurate Fruit Classification model.

1) Fruit Maturity Classification Using Convolutional Neural Networks Method. [11]
2) Implementation of Fruits Recognition Classifier using Convolutional Neural Network Algorithm for Observation of Accuracies for Various Hidden Layers. [12]
3) Application of Convolutional Neural Network-Based Detection Methods in Fresh Fruit Production: A Comprehensive Review. [13]
4) Fruit Disease Classification using Convolutional Neural Network. [14]
5) Fruits Classification using Convolutional Neural Network. [15]

D. Contextualised Literature and Research Material

E. Add a good element of critical literature arguments
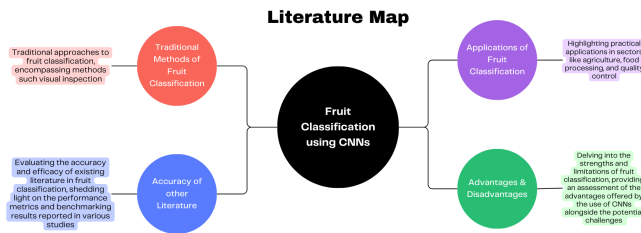
F. Literature Map

Fig. 1. Literature Map

Figure 1 helps give a better understanding of the literature relevant to this study, by mainly focusing on four aspects; The

Traditional Methods of Fruit Classification, The Comparison of Accuracy and metrics of other literature, Applications of Fruit Classification in the field, and lastly The Advantages and Disadvantages of using CNNs to classify fruits.

III. REFLECTION OF THE CHOSEN METHODOLOGY

A. Definition of Research Questions

In this study 2 research questions were identified:

1) How does the choice of data set impact the performance of CNN models for fruit classification?
   This research question aims to investigate the influence of the dataset on the performance of Convolutional Neural Network (CNN) models in the task of fruit classification. Specifically, it seeks to understand how variations in dataset characteristics such as size, diversity, and quality of images, and lighting scenarios all affect the accuracy of CNN models trained for fruit classification. By examining different datasets and their corresponding performance metrics, this question seeks to uncover insights into the optimal dataset choices for achieving high accuracy in fruit classification tasks using CNNs.
2) How much of a difference do layers create with regards to accuracy?
   This research question focuses on exploring the impact of CNN architecture, particularly the number of layers, on the accuracy of CNN models for fruit classification. By systematically comparing CNN models with varying numbers of layers and analyzing their corresponding classification performance, this question aims to explain the relationship between network depth and classification accuracy in fruit classification tasks. Understanding the significance of network architecture can provide valuable insights for optimizing CNN models to achieve higher accuracy in fruit classification.

B. Definition of Objectives

The primary objective of this study is to investigate the factors that impact the performance of Convolutional Neural Network (CNN) models in fruit classification tasks. More specifically, this study aims to assess the influence of dataset selection and network architecture on the accuracy and generalization capabilities of CNN models for fruit classification. By systematically examining different studies with datasets that vary in characteristics and network architectures with different depths, this study seeks to identify the optimal combinations of dataset and network architecture that yield the highest accuracy in fruit classification.

Additionally, this study aims to provide insights into the practical implications of these findings for real-world applications of fruit classification. By understanding how dataset choice and network architecture affect classification accuracy, this study aims to offer guidance to researchers and practitioners in selecting appropriate datasets and designing optimal CNN architectures for fruit classification tasks. Ultimately, the objective is to contribute to the advancement of techniques

for automated fruit classification, with potential applications in agriculture, food processing, and quality control.

C. Show an early understanding of research philosophies, approaches and main research paradigms

D. Choose a suitable methodology from those reviewed

E. Initial description of your chosen research methodology, experiment design and method of analysis and why this fits your research objectives

F. Reflections on Validity, Reliability & Generalizability/Transferability

G. Ethical Considerations for this Study

IV. RESULTS, ANALYSIS AND DISCUSSION

V. CONCLUSION

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