Research Design II

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I. Introduction, Positioning, Research Onion

Nowadays botanical research and flower classification have become crucial for conservation efforts, various fields and medicinal research. Moreover, as research suggests, flowering plants are one of the more important species in the world, providing a source of life and food for a multitude of other living creatures like birds, insects, animals and also humans, furthermore there exist around 369000 different species of flowering plants, found across the world [1]. Thus, this study presents an approach of using deep learning models and Computer Vision to conduct flower image classification.

A. Description of Theme and Topic Rationale

The theme of the paper is on the use of deep learning models, in particular Convolutional Neural Networks (CNN), for the classification of Maltese endemic and non-endemic flowering plants. Furthermore, by comparing different iterations of the same model, through the application of data augmentation layers and preprocessing techniques, different results were created and evaluated. Ultimately, the goal of this study is to evaluate the feasibility and efficiency in using a CNN model to classify various flowering plants.

The topic rationale stems from the need to promote botanical research, protect biodiversity and support the process of identifying various flowering plant species. Most traditional classification methods found in the botanical sector, tend to be very labor-intensive and subjective, therefore the application of computer vision through a CNN model is a great step towards automating and subsequently improving the accuracy and efficiency of plant recognition, especially for the unique flora in Malta.

B. Positioning and Research Onion

1) Positioning: The positioning of this research situates itself within the interdisciplinary fields of botanical science, computer vision and environmental conservation. Its forefront ideology includes the application of deep learning technologies, specifically CNNs in the field of plant classification, specifically focusing on the diverse existing flora, Maltese endemic and non-endemic. This research sought out to bridge the gap between traditional methods of botanic classification and the more modern computational approaches, in aim of finding a more efficient and accurate plant identification process.

2) Research Onion:

a) Philosophical Stance: The Philosophical Stance at the outermost layer of this study, approaches a positivist methodology, relying on measurable data which is obtained from quantifiable data coming from the image classifier itself, in order to make unbiased and objective conclusions regarding the feasibility and effectiveness of using machine learning models in classifying Maltese endemic and non-endemic flowering plants.

b) Research Approach: The Research Approach layer reflects a great commitment to a direct and clear methodology. Wherein general theories of deep learning and computer vision are applied to the specific context of flowering plant classification. This approach is based on existing theories and literature, as it intends to test the hypotheses regarding the plausible use of CNNs in plant identification tasks.

c) Research Strategy: Moving inward, the Research Strategy layer of the study employs an experimental design by constructing different variations of the same deep learning model. By slightly changing variables and applying different preprocessing layers and data augmentation techniques, different accuracy results are presented and the model with the best performance data is gathered. Thus, this strategy is aligned with the scientific method, allowing for a systematic investigation into what creates a better performing CNN model and what are the important variables to be considered, in the context of their use in botanical classification.

d) Research Choices: Delving deeper into the Research Choices layer, the study engages in a mono-method quantitative kind of research. By utilising numerical data generated by the image classification models themselves, the performance of said CNN model is evaluated. Thus the choice is driven by the research questions, which are best answered through quantitative analysis and evaluation of results and testing, this clearly depicts whether the model is accurately and effectively providing a solution to the problem in hand, botanical classification.

e) Time Horizon: This study adopts a cross-sectional design in terms of time frames, capturing data at a single point in time, that being primarily after the model itself has been trained and is given flower images to classify. This design is appropriate to this study given the scope and objectives of the project, that focuses on how various implementations of image preprocessing techniques produce classification accuracy.

f) Techniques and Procedures: At the core layer, the Techniques and Procedures layer details the particular methods used in this study. The creation of the dataset,the building of the CNN model and the testing of its performance is discussed in detail. The deep learning model of this study follows the Keras Sequential model, running on the TensorFlow platform, and is designed to be able to learn train and predict on a dataset made up of 8 different flowering plant classes, combining a total of 6511 images. Furthermore, study variables such as; the preparation of the data and how the dataset was created, the construction of the model, the training and how it was executed, the validation of the training, and other testing and training procedures, were meticulously and deeply described to ensure study transparency and replicability.

C. Background to this research theme

1) Overview of Computer Vision and Image Recognition: Computer Vision and Image Recognition are two very powerful tools which are nowadays widely used in a lot of different fields, even in everyday applications and scenarios. An evident example of this would be the use of image recognition in the application called Facebook, this world-renowned application uses image recognition in order to recognise a human's face, with only a few labeled images and it has last been reported to have an approximate 98% of accuracy [2].

2) Overview of Image Classification within Deep Learning models: Building a neural network for the use of Image Classification is usually comprised of various structured steps. Firstly, the process starts by finding or building a sufficient dataset which the model will be able to use for training and validation, next an architecture is chosen, usually the Convolutional Neural Networks (CNN) architecture is chosen, if Image Classification is the target goal. According to [3], the CNN architecture has plausible evidence to be prominent and efficient for this particular task. The model is then initialised, optimised and trained with the existing dataset. Finally, testing with new data is carried out to evaluate the model's accuracy and performance [1].

3) Flower Classification: The term flower classification is defined as arranging different flowering plants, according to their unique characteristics. In order to successfully identify and group a specific plant's taxonomy, various characteristics are analysed, these characteristics include, petal arrangement, shape, size, colour, and overall structure. Expert taxonomy is considered to be a field with shortcomings, as there is not enough professionals in this area, thus the implementation of automated recognition and classification has provided a great alternative [1].

4) Exploring the use of Image Classification to classify flowering plants: Given its broad variety of applications in different areas such as, plant observation, gardening, botanical research, and ayurvadic treatment, the application of Image Recognition in Flower Classification proves to be a necessity of high importance [1] [4]. Authors in [5], conducted a study in which they aimed to address the use of Neural Networks in conjunction with image processing, for the understanding of unique flower image features, particularly the Malaysian Blooming Flower. They accentuated that since Neural Networks were designed with the aim to *"solve complex problems such as pattern recognition and classification"*, hence we can deduct that such Neural Networks are more than capable of classifying complex datasets, such as flower datasets. In another study conducted by [6], the authors investigated the process of carrying out Flower Image Classification through a system that uses edge and color characteristics of a flower image, in order to classify it. The final results of this study showed their system obtaining an accuracy greater than 80%, and the system was deemed to be successful at flower image classification.

D. Hypothesis

This paper hypothesizes that the use of deep neural networks and image classification methods can be used to classify Maltese endemic and non-endemic flowering plants. Furthermore, it proves that classification is improved through the incorporation of various data augmentation and preprocessing layers. This study suggests that by enhancing the quality, variation and size of the dataset, it will lead to a model which is able to learn and generalize from the input images better, leading to improved flower image classification.

E. Research Aim and Purpose statement

The aim and main focus of this research is to develop and test a deep leaning CNN model, which is able to carry out image classification on Maltese endemic and non-endemic flowering plants. The purpose behind this study is twofold. Firstly, to propose a technological solution that can assist in accurately and efficiently identifying and classifying various plant species, and secondly, to investigate how various data augmentation layers and preprocessing methods can improve the accuracy of said deep learning models, in the field of botanical image classification, therefore further informing the fields of computer vision and machine learning.

II. Review of research methodologies & Literature Map

A. Review of Methodological Approaches in other Studies

The methodological literature in the field of botanical species classification shows a popular trend towards the use of Computer Vision and Deep Learning, as a technically automated solution for this problem. In specific, studies have concentrated on the use of Convolutional Neural Networks (CNNs), for automating the process of identifying different plant types. Thus, depending on the nature of the research, multiple research approaches could be used.

Authors in [1] utilised a CNN model in order to classify flowering plants, they validated their study by using a publicly available Kaggle dataset, for the efficiency of their model approach. This suggests a practical approach which involves an experimental design in order to test the efficacy of the CNN model. With the achieved results, this study underscores the high reliance and efficiency of CNNs for complex image classification tasks, and thus demonstrating their superiority over other traditional image processing methods.

Additionally, various studies have also compared the use of different models, and established benchmarks for their accuracy and efficiency. In one study, in a system designed for the classification of flower images, recognised through colour and edge characteristics, an accuracy greater than 80% was achieved [6]. This implies an applied research methodology. Such findings reinforce the potential and feasibility of using deep learning algorithms for processes similar to flower or plant image classification. Finally, in a study by Kothari [2] in which the author discusses a case study of image classification, it is indicated that an approach which involves the use of deep learning to solve a classification problem is viable and feasible, therefore aligning the study with an applied methodology.

B. Differentiating Academic and Non-Academic Sources

In academic writing, academic sources or materials are characterised through a rigorous peer-review process. This is where experts in the field scrutinize and deeply analyse the work, before it can be published. This is an essential part in research as it ensures to the reader and the researcher, that the paper being written or referenced has been peer-reviewed and is reliable. Academic sources usually include extensive detail, are authored by scholars or researchers and most often have a formal structure and writing tone. The target audience of such sources are usually experts in the field, academics, or students.

Non-academic sources are on the other hand not typically subjected to peer-review processes, include a wider range of content and are usually intended for a more general audience. While these kind of materials are also a good source of information, they do not offer the same reliability and depth as academic sources do, due to the lack of scholarly validation.

C. Five Peer-Reviewed Articles and their Contextual Relevance

In the context of my study and its academic sources, the following are the top five references used in the study which are all scholarly, peer-reviewed studies, ensuring quality and reliability on the provided research;

[1] was foundational to the study as it provided powerful insight on the use of CNN and transfer learning for flower classification, which technically provided to be very similar to this study. [2] utilised the Tensorflow framework to present a case study on image classification, this was essential in helping in the understanding of how deep learning models function and how they can be applied in the context of botany, thus informing our model's structure. The research conducted by [3], also contributed to the study through its research on medical image classification, by showcasing the adaptability of CNNs across various different fields. The literature review on flower classification in [4], helped in framing this study's context of research within the broader scientific dialogue. Finally, the study by [5], which specifically talked about the digital classification of the Malaysian blooming flower, was particularly relevant and helpful in the cultural aspects of botanical classification, supporting this study's perspective.

D. Critical Evaluation and Synthesis of Existing Research

A critical evaluation of the existing literature in the context of my study reveals a landscape where the application of CNNs in image classification has proved to be an effective and reliable solution towards botanical research and classification, yet still ripe with potential improvements and enhancements. For instance, while the authors in [1] managed to successfully apply a CNN model for flower classification and achieve a high accuracy percentage, their methodology could still benefit highly from a broader dataset to ensure image generalization across even more plant species. Furthermore, the use of the Tensorflow framework in [2] shows the flexibility and power of deep learning tools, however it overlooks the computational complexity needed for such an implementation, a level of complexity which can present to be a barrier for new practitioners in the field. Finally, the work of [5], on the classification of the Malaysian blooming flower highlights how culturally significant such image classification may be, but also implies a gap in the literature regarding the possibility of cross-cultural applicability of such models.

Collectively, these insights highlight the need for more research which is able to close the gaps between technological advancements and their practical implementation, in real-life scenarios. Even though the robustness of CNNs in such applications is well-documented and researched.

E. Literature Map

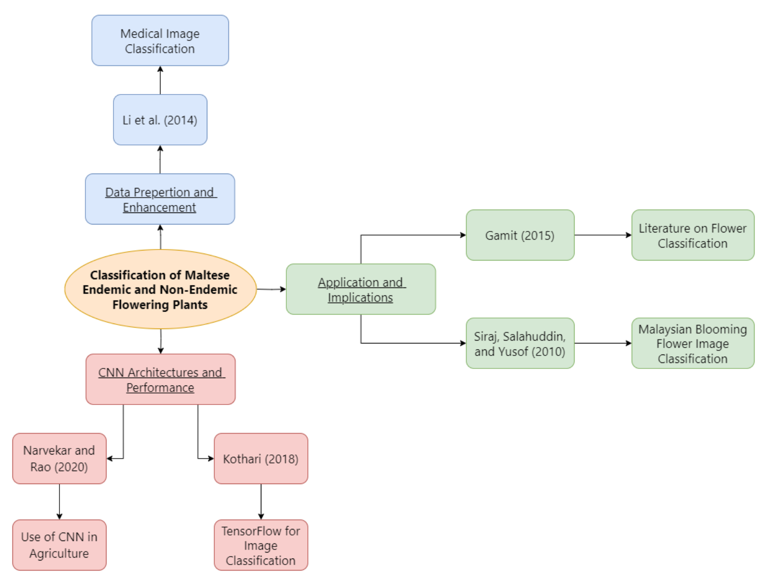

Fig. 1. Literature Map

The literature map for this study on image classification with deep learning involves the central topic of 'Classification of Maltese Endemic and Non-Endemic Flowering Plants' and branches out into more specific yet related research areas covered in the literature review of the study. The first subtopic of this literature map would be the 'CNN Architectures and Performance' branch, which includes key study sources such as [1] who explored the use of CNN with deep learning in the context of agriculture. Moreover, [2] designed and showcased a case study, utilizing TensorFlow for image classification. Another subtopic branch is the 'Data Preparation and Enhancement' branch, this branch cites studies such as the one by [3] in which the authors delved into medical image classification, this indicated cross-disciplinary methodological influences. Lastly, the 'Application and Implications' branch highlights how studies like in [4], which reviewed literature on flower classification, and in [5], which conducted and emphasized the use of image classification for the Malaysian Blooming flower, both suggest cultural and geographical expansion in the application of CNN models. This literature is depicted in 1, where each leaf node represents a distinct subtopic, with lines connecting the related nodes, all anchored to the central research topic.

III. Reflection on the chosen Methodology

A. Research Questions and Objectives

This study's general hypothesis believes that image classification with deep learning models can be used to classify both Maltese endemic and non-endemic flowering plants. Given this hypothesis, this study came up with two research questions; *"How effective is image classification in classifying Maltese endemic and non-endemic flowering plants?"* and subsequently *"How is the accuracy of image classification affected in deep learning models when using different types of data augmentation preprocessing layers?"* [7].

Following these research questions, the objectives for this study become clear. Firstly, to compile a sufficient enough dataset that represents a wide variety of flora, both Maltese endemic and non-endemic. Following that, to create a suitable CNN model that is able to handle and recognise the different classes of flora. Creation of the model includes adding the appropriate preprocessing layers to optimise the model and prevent it from overfitting. Subsequently, rigorous testing is carried out with unseen image data in order to gather the resulting accuracy that the model has achieved. Each objective is specifically designed to ensure that the research questions are addressed accordingly.

B. Early Understanding of Research Methodology

This study exhibits an early understanding of specific research philosophies and approaches. Drawing more on the positivist philosophy, the study leans towards quantitative methods to prove its hypothesis. The approach of the study is deductive and aims to test the hypothesis and answer the research questions it initially stated. It generally aims to test and prove that CNN deep learning models are an efficient method for classifying Maltese endemic and non-endemic flowering plants, additionally the study sought out to test whether the use of different preprocessing layers better the accuracy of CNN models in the goal of image classification, as also suggested by other study's findings, such as [1].This showcases a strict use of hypothesis-driven approaches, which proves to be indicative of the positivist nature of this study. Furthermore, this study also aligns with the pragmatic paradigm, as it focuses on finding the best solution in the context of trying to solve a real-world problem. This is done through its focus on the practical applications of this research and the possible usefulness of the findings in utilising CNNs for flowering plant classification, alternatively to other existing, more labor intensive methodologies. This aligns also with works like [4], in which the author emphasizes real-world applications.

C. Chosen Methodology

After extensive research and evaluation into selecting the most suitable methodologies for this study, it was deduced that the quantitative approach would be the most sufficient, given the nature of the study. The quantitative method emphasises the importance of collecting and analysing numerical data coming from results, in this case, results that come from the CNN model's final predictions. More specifically, in the context of this study, the quantitative methods enable the study to use numerical modeling to classify and assess the percentage of accuracy that the model achieved in classifying Maltese endemic and non-endemic flowering plants,

D. Description of Chosen Methodology, Experimental Design and Method of Analysis

1) Description of Chosen Methodology: This study utilises a quantitative methodology, focusing primarily on the analysis of numerical quantitative data coming though the CNN model for the classification of flowering plant images. This method involved rigorous data collection from singular unseen images from which the model was designed to predict based on its previous learning and validation training. Statistical tools were also used to generate charts to depict the results in numeric data and finally percentages were calculated to define the most beneficial and accurately predicting approach, between the two models and their data augmentation layers setup.

2) Experimental Design: The experimental design of this study is structured around a systematic approach of data gathering and model training. The study collects a diverse range of both Maltese endemic and non-endemic flora imagery, ensuring that the data is sufficient enough for it to be representative of the eight different flowering plant species being classified. These images were then processed through the built CNN model, where each flower class was quantified and classified through its specific flower qualities, performance metrics were also recorded each step of the way in order to monitor the model's effectiveness and training loss.

3) Method of Analysis: In the analysis phase of this study, this research employs a statistical software that interprets the CNN model's training output. The resulting graphs help to depict actual accuracy results which were outputted after training and validation. This graph figure, as seen in Figure. 2, depicts the accuracy and loss plotted against the number of epochs. The outcomes are highly essential as they are, not only indicative of the model's positive resulting performance but also informs the potential areas of enhancements and shortcomings of the model.

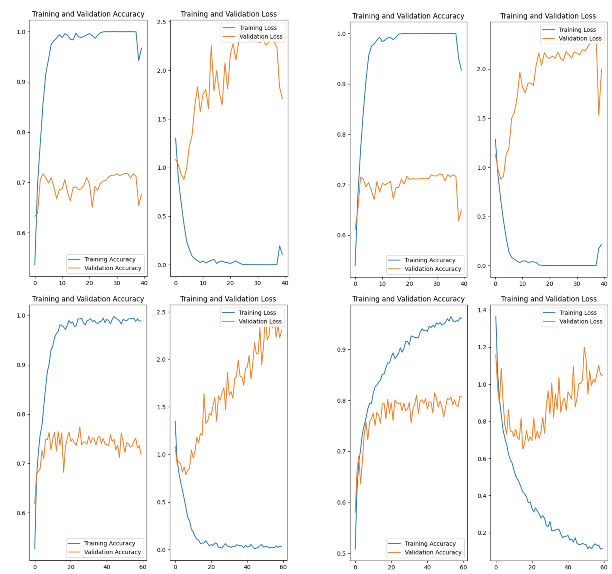

Fig. 2. Accuracy Results

4) Research Objectives: By providing a quantifiable measure to the CNN's performance in classifying various flowering plants, the chosen method of statistical analysis directly supports the study's research objectives. By using accuracy and precision measures, the research thoroughly assesses the model's outcome and effectiveness, which is of crucial importance in monitoring and more importantly achieving this study's goal of developing a deep learning CNN model that is capable of classifying various Maltese endemic and non-endemic flowering plants. Furthermore, this method ensures that the results are objective and verifiable and therefore provides a great value of transparency and reliability to the study, aligning perfectly with the aim of the study to benefit and improve botanical research and conservation efforts.

E. Reflections on Validity, Reliability & Generalizability/Transferability.

Reflections on the study's validity is found in the CNNs ability to accurately classify Maltese endemic and non-endemic flowering plants, this is based on the transparency and accuracy of the data collection phase of the study and the adequacy of the model's training. The reliability of this study is outlined through the reproducibility of the classification results across multiple prediction phases. The results were gathered with a hefty amount of training iterations, which all produced almost identical results, suggesting that the findings of the experiment were both consistent and reliable. As for generalizability and transferability of the CNN deep learning model, this study proves to be a prominent proof of concept and also to be transferable to other botanical classification tasks outside the scope of this study. With that being said, while the model performs well for this particular scenario, further testing and model enhancing needs to be carried out for the model to work as efficiently in other botanical specific tasks. Transferability is therefore also dependant on the model's flexibility and adaptability to new unseen data. These study reflections are important in understanding the broader implications and possible contributions that this study offers to the field of computational botany.

F. Ethical Considerations

In this study of image classification for Maltese endemic and non-endemic flowering plants, ethical considerations are paramount. Given the ecological nature of this topic, its vital to consider the potential impact on local ecosystems and biodiversity, ensuring that a commitment to conservation and the respect towards natural heritage is upheld. Furthermore, since the study makes use of publicly available datasets, it is essential to ensure that the privacy and copyright claims for the images are fully respected and maintained, also intellectual property rights should be honoured. Since the results coming from the model are gathered through a hefty amount of single image testing, it is an important ethical consideration to ensure that full transparency is always maintained in order to prevent the potential misapplication of the research findings or also the fabrication of results.

IV. Results, analysis and discussion.

A. Presentation, Analysis, and Interpretation of Results

1) Training and Validation Results: Since validation accuracy is the most affected variable while testing data augmentation within image classification, focus was given to these variables.

As shown in Table I, two iterations of this model were created and tested against each other, the main difference between the iterations is that the model in Iteration 2 had more augmentation preprocessing layers added to it in order to study the effect that this has on the model's performance, and hence answer one of the aforementioned research questions. Each iteration went through 2 phases, the first one containing 40 epochs of training and the second containing a newly implemented data augmentation preprocessing layer and also 60 epochs of training. Iteration 1 obtained a 65% Validation accuracy in phase 1 of training whereas in phase 2 it managed to obtain a significantly higher result of 75% Validation accuracy, this change in accuracy percentage can therefore be directly associated with the addition of new preprocessing layers and slightly more training. Iteration 2 phase 1 wasn't any different from that of Iteration 1 phase 1, it was the initial training with 40 epochs and was done to simply mirror the first phase of Iteration 1. As expected this iteration phase achieved an identical accuracy percentage of 65%. However, in Iteration 2 phase 2 the; *layers.RandomZoom* and *layers.RandomRotation* preprocessing layers were added to the model and just like in in the other iteration phase, trained for 60 epochs. Here the model showed a significant improvement of 80% validation accuracy.

TABLE I
VALIDATION ACCURACY RESULTS

	Iteration 1	Iteration 2
Phase 1 Validation Accuracy	65%	65%
Phase 2 Validation Accuracy	75%	80%

The Validation Accuracy results were also extracted from the graphs shown in Figure. 2. These graphs were generated through the Tensorflow model while training and represent the exact accuracy or loss plotted against the number of epochs, respectively. In both Iterations in phase 1, it can be seen that the model kept a linear amount of accuracy from start to finish, therefore we can observe a sort of flat validation accuracy line. This changes drastically in Iteration 2 Phase 2 (bottom right graph) as we see that the Validation accuracy starts low at the first few epochs but increases up to 0.8 (80%) towards the end of the 60 epochs. Additionally the representation of the training and validation accuracy lines being closer together, indicate that there was less overfitting present, in that specific phase and that the model performed better as was depicted by Table I.

2) Prediction Confidence Results: As can be seen in Figure. 3, confidence percentages were extracted from each class, this result came from the prediction that the model made when it was given three new images for each of the eight classes. In Iteration 1, the model obtained irregular results as classes such as Daisy, Lavender, and Rose predictions were very high whereas other classes such as Tulip and Sunflower obtained very poor predictions. Overall, we see that the majority of the classes gain a very significant confidence increase in Iteration 2 when compared to Iteration 1, it can be deduced that this change occurred because of the addition of the augmentation preprocessing layers. Furthermore, since there were no significant variations in the averages of the predictions, the findings in Iteration 2 became more consistent.

Another significant finding was that the Maltese Centuary flower managed to obtain a prediction average of around 66.50%, with only 88 images in its dataset class, a significantly lower amount than a class such as the Tulip which had 800 images in its dataset class, yet only obtained a prediction average of 31.55%. This can hinder the question if in Flower image recognition specifically with a Sequential model, is the quality of images in the dataset more important that the size of the dataset. It can be deduced that the Maltese Centaury flower managed to obtain such result with a very small dataset class, for the reason that it is a very unique looking flower when compared to the rest of the classes, hence the model was able to distinguish it more easily. This theory can also be supported when we further analyse the table results in Figure 3. As the model made wrong predictions of flowers which share characteristics such as the Daffodil the Daisy and the Sunflower, therefore supporting even further the fact that flower classification in this manner, is more effective on flowers with unique characteristics.

Iteration 1 - Data Augmentation (RandomFlip)

	Daffodil	Daisy	Dandelion	Lavender	Rose	Sunflower	Tulip	Maltese Centaury
Image1	Daffodil 99.47	Daisy 100.00	Lavender 97.61	Lavender 100.00	Rose 100.00	Daffodil 99.74	Dandelion 63.48	Maltese Centaury 99.97
Image2	Daisy 98.82	Daisy 99.68	Dandelion 99.53	Lavender 100.00	Rose 68.96	Sunflower 100.00	Rose 99.51	Lavender 99.87
Image3	Daffodil 100.00	Daisy 100.00	Dandelion 99.99	Lavender 100.00	Rose 100.00	Dandelion 99.85	Daisy 74.20	Maltese Centaury 99.41
Average (%)	66.49%	99.89%	66.51%	100.00%	89.65%	33.33%	0.00%	66.46%
Overall %	65.29%							

Iteration 2 - Data Augmentation (RandomFlip, RanadomZoom and RandomRotation)

	Daffodil	Daisy	Dandelion	Lavender	Rose	Sunflower	Tulip	Maltese Centaury
Image1	Daffodil 100.00	Daisy 100.00	Dandelion 90.68	Lavender 100.00	Rose 100.00	Tulip 57.28	Tulip 57.28	Maltese Centaury 99.69
Image2	Daisy 99.12	Daisy 99.82	Dandelion 91.37	Lavender 83.88	Rose 98.38	Sunflower 99.99	Rose 50.87	Rose 75.58
Image3	Daffodil 77.21	Daisy 100.00	Dandelion 88.77	Lavender 98.33	Rose 100.00	Sunflower 73.56	Tulip 99.88	Maltese Centaury 99.90
Average (%)	59.07%	99.94%	90.27%	94.07%	99.46%	57.85%	63.10%	66.53%
Overall %	78.79%							

Fig. 3. Prediction Results

The overall average percentage which represents confidence was also calculated for each class, this was done by adding up all the three percentages and dividing by the amount of correct classification predictions. Overall percentages were further calculated by adding up all the average percentages of the classes and dividing by the number of total classes. Iteration 1 obtained an overall of 65.29%, whereas Iteration 2 managed to obtain 78.79%, meaning there was a delta of 13.50% between the two iterations.

B. Comparative Evaluation and Critical Assessment

This study's results demonstrate that the implementation of data augmentation preprocessing layers do in fact significantly enhance and benefit the validation accuracy achieved from a deep learning model, specifically used for classifying Maltese endemic and non-endemic flowering plants. This finding aligns with other research and suggests that data augmentation is effective in improving model performance through the inclusion of more diverse training examples. However, while this model managed to achieve a 78% confidence rate, it is important to note that other broader botanical research studies possibly achieved higher confidence results, which may be the cause of various variables like, variations in data volume, model complexity, or augmentation techniques. At a critical stand point, the study's validity is robust and provides clear improvements in accuracy results attributed to methodological adjustments (augmentation preprocessing layer adjustment). In terms of generalizability, the model proved to be proficient enough in identifying both Maltese endemic and non endemic flowering plants without the need of any without additional region-specific adaptations given to the model, this can deduce that this model can be generalised and used for other botanical context at a practical level but will need further adjustments to perform at a high confidence and accuracy rate. Thus further research and model refinement is required for this model to be utilised at a high level for other botanical research experiments or other practical real-world uses.

C. Synthesis of Results with Hypotheses and Related Studies

In relation to the original hypothesis and research questions of this study, with the achieved training and validation results the question was answered that, the validation accuracy is in fact affected and in this case improved when data augmentation preprocessing layers are added to a deep learning model conducting image classification. Furthermore, with the achieved prediction confidence results we deduced that using image classification with a deep learning model is in fact successful in classifying Maltese endemic and non-endemic flowering plants with a 78% confidence rate.

When comparing the achieved results with another very similar study, the following outcome is drawn. Authors in [1] who conducted a similar study, trained and tested a model on the Kaggle flower dataset. Their dataset was significantly smaller than the one used in our study which contained 6511 images in total. Similarly, this study made use of a CNN framework, but with a total of four convolutional layers instead of three, as used by this study. The architecture used by this study's model can be seen in Figure. 4.

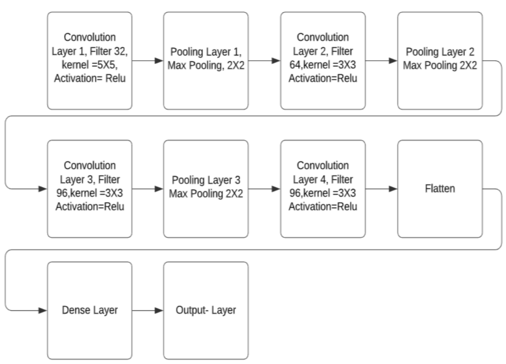

Fig. 4. Four-layer Framework

With this we deduce that both models used very similar architecture frameworks and libraries. The model in this study managed to obtain higher Validation accuracy results, the highest being 95%. It can be concluded that the study conducted by [1] managed to obtain higher results than ours because of a number of different factors, mainly being the use of pre-trained weights (ImageNet) and also the use of a four convolutional layer architecture, as opposed to a three convolutional layer architecture used in this study, while also not condemning the possibility of the quality of the dataset used being superior to the one in this study.

V. Conclusion

This study sought to develop and test a deep learning based model to classify flowering plants. The results achieved in this study supports the idea that Maltese flowering plants, both endemic and non-endemic, may be classified using a combination of image classification and deep learning model techniques. Validation accuracy and Prediction confidence results demonstrate the model's ability to be able to classify various flowering plants. Furthermore, the results in this study indicate how the effectiveness of the model is in-fact enhanced when appropriate preprocessing layers are added to the model. These results address both research questions as specified before.

As a proof-of-concept, this performance is encouraging, however it might not yet meet the sophisticated standards needed to be applied in more complex flower classification applications.

A. Methodological Limitations

This study also encountered some methodological limitations specifically relating to the dataset, publicly available datasets on flowering plants were not very available which hindered the need for creating a robust and highly accurate dataset, especially the one pertaining to the Maltese Centaury flower class, hence why there was an imbalance in the amount of images this class had, when compared to the rest of the classes in the dataset. Documentation and literature on this topic and the use of deep learning models for the purpose of flower classification was also not very robust and available.

B. Further Implementation and Research

Further research and implementation to the prototype can certainly make this prototype more accurate and able to achieve better results. For this to be achieved, a larger dataset which preferably uses more precise photography techniques, would be essential. Further implementation towards data augmentation could also eliminate completely the overfitting issue present in the current version of the prototype.

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