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fundamental Computing

Detection of Oligonychus afrasiaticus McGregor (Boufaroua): Building a date palm dataset

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Dedication

“

To All people who supported us

”

- Maria and Alaa

Acknowledgment

First and foremost, I would like to express my gratitude to God for all the blessings bestowed upon me in my life. Then, I would like to extend my deep appreciation to my family and friends for the support they have provided me. I cannot forget all the teachers who have helped me throughout my years in college. Additionally, our mentor, who came up with the idea for our first project, deserves special recognition. I want to particularly highlight the support of my dear friend, Zainab, who has been a pillar of support throughout my academic journey. I would also like to thank my mother, who has been one of my strongest supporters in my academic pursuits. Lastly, I want to express my gratitude to my partner, who worked diligently and served as an excellent teacher for future generations.

Moudjahed maria

Acknowledgment

First I thank Alah for completing my desertation . I would experess my gratitude and apreciation to all my family members for their support .May Alah bless and protect them .Also, I can not forget thanking my friend Zaynab for both help and collaboration . To my friend Marya who did well to finish this work successfully thank you very much may God reward you

Ben cheikh Alaa Erahmen

Abstract

Dates are found in an advanced position among different fruit crops dueto their high nutritional value and their entry into many food industries, andmost parts of the palm tree are involved in some other industries that farmershave developed over the years, such as the manufacture of some types of furniture .

Perhaps one of the most important obstacles that can limit this expansion in palm cultivation is plant diseases of various kinds, and The spidermite (OligonychusafrasiaticusMcGregor) One of the most famous diseases threatening palm and the most widespread due to climatic factors helping in that.

In this work, we used some methods using artificial intelligence in detecting of this pest, aiming at first to build and improve the dataset and then investigate some different CNN model architectures. Then we tried different models for training and compared between results of them. In the last we tried to investigate the fusion of the three models results, to see if there would be any improvements.

Keywords : Data collection , preprocessing, datasets ,Boufaroua , artificial intelligence , machine learning , deep learning , ANN ,CNN.

Résumé

Les dattes occupent une position avancée parmi les différentes cultures fruitières en raison de leur valeur nutritionnelle élevée et de leur entrée dans de nombreuses industries alimentaires, et la plupart des parties du palmier sont impliquées dans d'autres industries que les agriculteurs ont développées au fil des ans, comme la fabrication de certains types de meubles .

L'un des obstacles les plus importants qui peut limiter cette expansion dans la culture du palmier est sans doute les maladies des plantes de toutes sortes, et le tétranyque (OligonychusafrasiaticusMcGregor) L'une des maladies les plus célèbres menaçant le palmier et la plus répandue en raison de facteurs climatiques aidant.

Dans ce travail, nous avons utilisé certaines méthodes utilisant l'intelligence artificielle pour détecter ce ravageur, visant d'abord à construire et à améliorer l'ensemble de données, puis à étudier différentes architectures de modèles CNN. Nous avons ensuite essayé différents modèles de formation et comparé leurs résultats. Dans le dernier, nous avons essayé d'étudier la fusion des résultats des trois modèles, pour voir s'il y aurait des améliorations.

Mots clés : Collecte de données, prétraitement, ensembles de données, Boufaroua, intelligence artificielle, apprentissage automatique, apprentissage profond, ANN, CNN

ملخص

تعتبر التمور في وضع متقدم بين محاصيل الفاكهة المختلفة بسبب قيمتها الغذائية العالية ودخولها في العديد من الصناعات الغذائية، وتشارك اجزاء كبيرة من شجرة النخيل في بعض الصناعات الأخرى التي طورها المزارعون على مر السنين، مثل صناعة بعض أنواع الأثاث

ربما تكون إحدى أهم العقبات التي يمكن أن تحد من هذا التوسع في زراعة النخيل هي الأمراض النباتية من مختلف الأنواع، و يعتبر (Oligonychus afrasiaticus McGregor) أحد أشهر الأفات التي تهدد النخيل وأكثرها انتشارًا بسبب العوامل المناخية المساعدة في ذلك.

في هذا العمل، استخدمنا بعض الأساليب باستخدام الذكاء الاصطناعي في اكتشاف هذه الآفة، بهدف في البداية بناء وتحسين مجموعة البيانات ثم التحقيق في بعض بنى نماذج CNN المختلفة. ثم جربنا نماذج مختلفة للتدريب ومقارنة نتائجها. في آخر مرة حاولنا التحقيق في اندماج نتائج النماذج الثلاثة، لمعرفة ما إذا كان سيكون هناك أي تحسينات.

كلمات مفتاحية : جمع البيانات، المعالجة المسبقة، مجموعات البيانات، بوفروة، الذكاء الاصطناعي، التعلم الآلي، التعلم العميق، ANN، CNN.

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General Introduction

General introduction

The palm wealth in Algeria is distributed over an area of about 167. 000. 000 hectares equivalent to 19. 000. 000 palm trees distributed over some of the country‘s wilayas, most of which were concentrated in the four wilayas of Biskra, Ghardaia, El Oued and Ouargla at a rate of approximately 12 million palm trees .

The rapid detection of The spider mite (Oligonychusafrasiaticus McGregor) is very important in the speed of its elimination, as the method adopted in this depends on the farmers and their waiting for the season of the appearance of the pest and the start of the healing process through the intervention of control teams and spraying the palm manually using chemicals, this detection process is not useful, especially in large areas and will affect the speed of the spraying process, which is in itself a bigger problem.

Problematic

Over the last 10 years, about 4,000,000 palm trees treated annually across the country, and the number of intervention teams has decreased in recent campaigns from 51 teams in 2010 to only 17 teams during the last three campaigns (2019-2020-2021)[14]. We have proposed changing the manual processing method because of its risks and changing it by treatment by drone. This requires Drone to identify infected trees from others to do the treatment .

Recently, many countries are using deep learning in the detection and treatment of plant diseases, but it is still not common in Algeria, although the pest is one of the most prevalent pests in the country and it has become necessary to control it.

Motivation

Regarding the massive improvement AI has been introduced in many fields over the past few years we are motivated by the pontential of the use of machine learning in the detection of the pest and huge impact it has on overcoming the burdens and difficulties existing in the treatment of palm trees .

Contribution

The contributions of this thesis can be summarized as follows:

Building and expanding a dataset starting with collecting, improving and working on images as a valid basis and adopting them in detecting pests .

Work on training dataset with different CNN models , and to result and compare training accuracy and improve results using method of ensemble learning and transfer learning

Chapter 1

Oligonychus afrasiaticus(Boufaroua) and palm Dates

1.1 Introduction

The Boufaroua mite, scientifically called Oligonychus afrasiaticus, is a significant threat to date palms and can cause extensive damage to their fruits, particularly when in the immature green stage. This damage appears as scarring on the fruit, which can worsen and give the dates a brown, scab-like appearance. The mites feed by extracting sap from the date palm tissues and lay eggs on the fruits. The hatched larvae then feed on the fruits, creating webs that trap small particles. The presence of white or grayish silken webs indicates the presence of mites. The attacks start on the stem and spread to all the fruits, puncturing and destroying the outer layer of the green fruit rapidly. Infested dates are surrounded by a silky web that collects sand from the wind [2]. As a result, the affected dates do not mature properly, leading to premature fruit drop. To address the significant damage caused by the Boufaroua mite, researchers are exploring biological solutions, including the potential use of aqueous extracts from indigenous plants found in the southeastern region of Algeria to control this pest.

1.2 Palm Dates

The world boasts approximately 3,000 types of palm trees, the majority of which are found in countries renowned for their abundant production of this particular species. The range of varieties varies from 17 to 1 (percent). In the past, farmers relied on selecting stable varieties from high-quality seedlings, which were then propagated through vegetative means such as offshoots and suckers resembling the original palm tree. This method ensured the preservation of desired varieties. The use of seeds for propagation led to significant diversity in palm tree varieties, each possessing distinct characteristics. The most widely recognized and popular variety globally is the Majhoul (from Morocco), while the most extensively exported variety is the Deglet Nour (from Algeria and Tunisia) [4].

number of varieties	country	number of varieties	country
244	Moroco	800	Algeria
300	Oman	250	Saudi Arabia
250	Pakistan	26	Egypt
22	Sudan	370	Iraq
250	Tunis	400	Iran
196	United states	300	Libya

Table 1.1: Number of palm varieties in the world
[2]

But let's first recognize the palm tree parts

1.3 Morphological description of date palm

The importance of morphological description lies in knowing the parts of the palm tree and identifying them

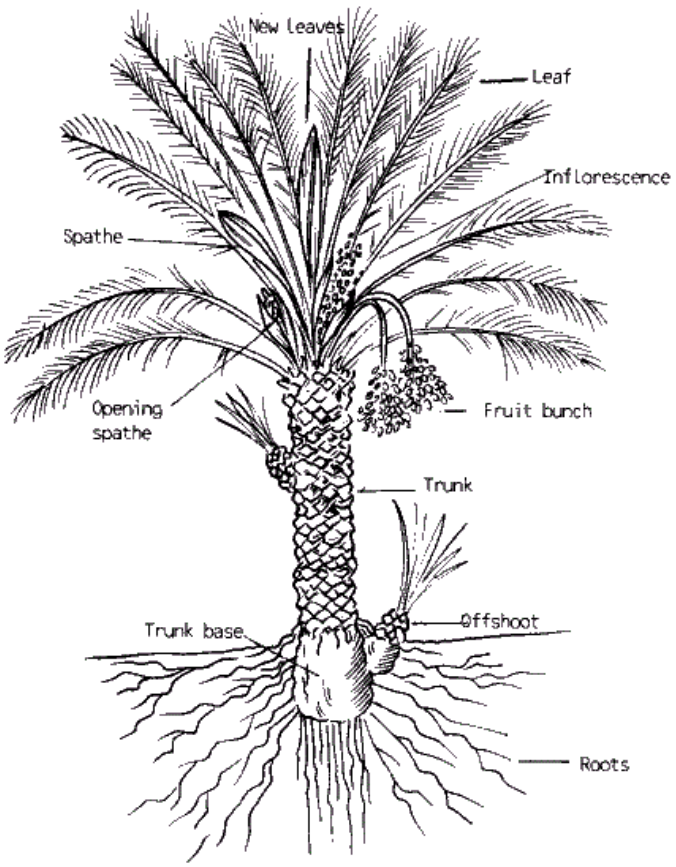

Figure 1.1: Morphological of palm date
[4]

1.3.1 Roots:

The date palm possesses a clustered and fibrous root system that emerges from a bulb at the trunk's base. The main roots, averaging around 4 meters in length, can reach up to 10 meters in loose soil conditions. These primary roots generate secondary roots, dividing and forming shorter and narrower tertiary roots. While primary roots primarily develop from seeds, they can continue to grow if the date palm is propagated from an offshoot or a seedling produced through tissue culture[57].

1.3.2 Torso:

The trunk of the date palm is a straight and cylindrical structure that maintains a consistent diameter (typically around 1 meter) throughout its entire length, which can extend up to 30 meters. The trunk is surrounded by leaf bases enveloped in fibrous material,

serving as a protective shield against herbivorous insects and animals. Additionally, this fibrous covering acts as insulation, reducing water loss from the trunk. Vascular tissue comprises closely-packed vascular bundles and is responsible for transporting water and nutrients. The stem elongates vertically from the terminal bud, known as the phyllosphere or phylogeny, and also expands laterally through the activity of the fascicular cambium[57].

1.3.3 Palm leaves :

The leaves of the date palm, known as fronds, are compound leaves with a pinnate structure. They are arranged spirally around the trunk of the tree. A fully mature frond can reach a length of 4 meters, although the typical range is between 3 to 6 meters. The width of the frond is approximately 0.5 meters at the middle midrib, tapering towards both ends. The date palm leaf consists of three main regions: the petiole (leaf stalk), the spinal region (connecting the petiole to the blade region), and the blade region itself, supported by a geometrically shaped midrib. The blade region contains angular leaflets. The number of leaves produced each year can vary from 10 to 26, and a mature palm tree may have between 100 to 125 leaves, with around 50 (percent) of them actively involved in photosynthesis. After their natural life cycle, the leaves remain attached to the tree and must be manually pruned[57].

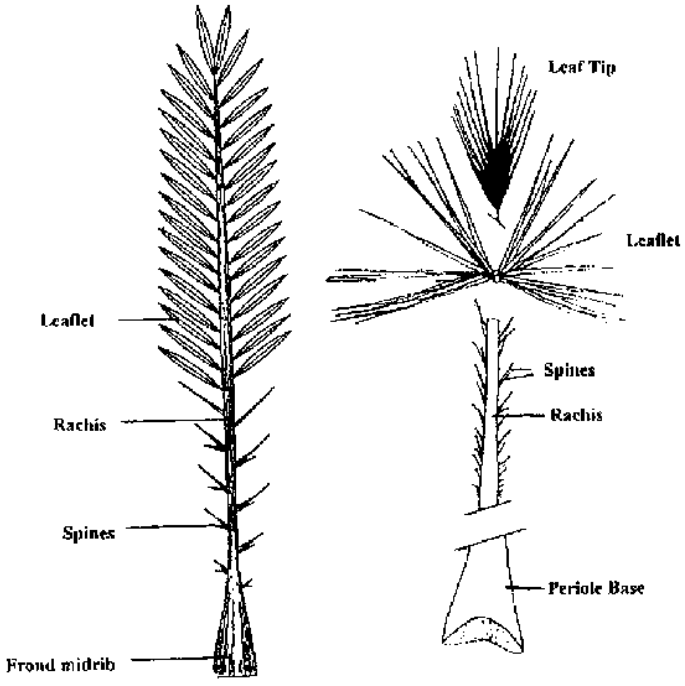

Figure 1.2: Leaves date palm
[57]

1.4 Palm Dates in Algeria :

The palm wealth in Algeria is distributed across an estimated area of 167,000 hectares, equivalent to approximately 19 million palm trees [14]. These palm trees are distributed in the following manner:

- Biskara and Aoulad DJalel : 45.000.000..... Palm
- Elouadi and Maghyer: 3.790.000..... Palm
- Ouargla and Tougouret : 2.600.000.....Palm
- Ghardaia and Elmniiaa : 13.000.000..... Palm [14]

Algeria has a vast palm farm expanse, housing millions of palm trees that produce a diverse range of dates, including the highly regarded "Deglet Noor" variety. These dates possess various characteristics that give them a competitive edge in the global market, giving Algeria an opportunity to expand its export options and generate foreign revenue. However, the date fruit industry in Algeria remains predominantly traditional and faces several obstacles.

As shown in figure 1.3 Algeria leads with the first Arab countries producing dates in 2017.

[14]

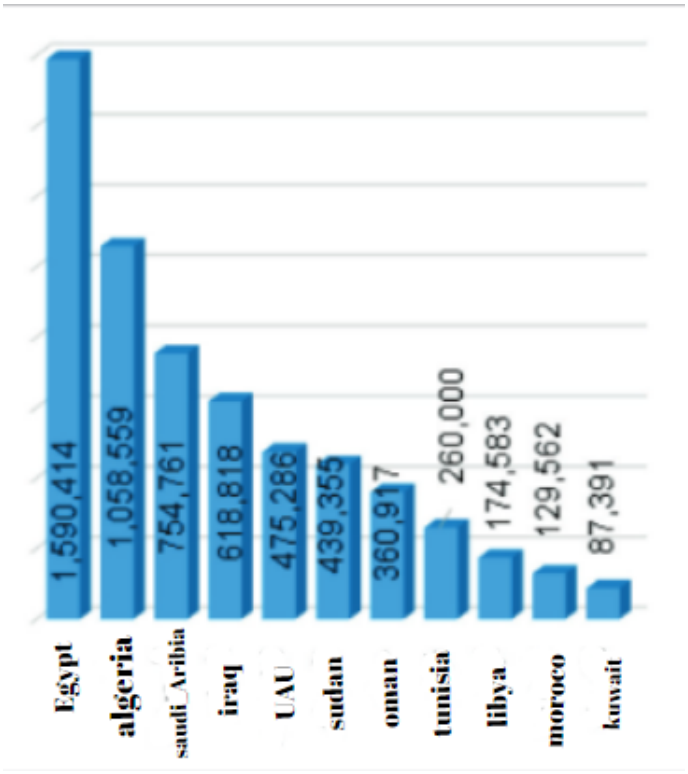

Figure 1.3: Arab Date Producing Countries (2017)

In addition, the persistent exposure of date palms to pests and their rapid spread due to climatic factors and its poor control by relying on traditional methods of control by sending seasonal campaigns for deliberations have become more expensive than useful. Although campaigns are being sent to combat, pests remain a major problem in Algeria. This indicates their ineffectiveness and the need to replace traditional methods recognized in more recent ways and relied on in other countries.

Of the threatened pests of palm trees in Algeria: beetle, date worms,O.afrasiaticus and other pests.[14] ,O.afrasiaticus is the most famous .
The statistics of the treated spaces for combating ,O.afrasiaticus pest over 10 years were estimated at 4,000,000 remediated palms per year .

year	palms
2011	3.656.451
2012	4.041.092
2013	3.823.125
2014	3.583.847
2015	3.583847
2016	3.498.261
2017	3.993.374
2018	3.895.557
2019	4.014.782
2020	4.128.800
2021	4.133.555 height

Table 1.2: Treated spaces over 10 years
[14]

Also shows in tabel 1.3 the financial costs allocated to anti-pandemic of ,O.afrasiaticus campaigns in the last 10 years.

year	cost of money
2011	96.500.000
2012	96..000.000
2013	96.607.500
2014	85.780.000
2015	88.100.000
2016	85.175.000
2017	85.035.000
2018	88.000.000
2019	88.860.000
2020	91.860.000
2021	98.100.000
2022	112.930.000

Table 1.3: Financial losses over 10 years
[14]

Some of the factors that contributed to the pest outbreak :
- Lack of farmers' organization and collective contribution to prevention and control.
- Negative effects of old abandoned palm groves on palm groves Neighboring
- Absence of coordination: Association - Farmer - Subsection.

Although the pest in recent years is in a sustained, rapid, and threatened outbreak of food security with a retroactive impact on the national economy regarding exporting dates, no solutions have been found to deter them. Campaigns are conducted over the years but the risks of processing and their methods make campaigns in constant decline and campaigns have seen a relative decline in the last three years.

1.5 Descreption of Oligonychus afrasiaticus

The date dust mite passes through four distinct developmental stages, notably egg, larva, nymph, and adult: The adult mite has an almost smooth body, oval-shaped and slightly flattened on the upper side, with four pairs of legs. Its color can range from greenish yellow to pink. Despite being extremely small and difficult to see with the naked eye, the mite measures approximately 0.22-0.44 mm in length and 0.17-0.20 mm in width.There is a noticeable difference between males and females, with the female having a rounded body end while the male's end tapers somewhat. .The eggs of the date dust mite are spherical, measuring around 0.1 mm in diameter. They can be pink, red, or yellow in color[53].

The larvae of the mite have six legs and are smaller in size (approximately 0.15-0.20 mm) compared to the nymphs and adults. They exhibit color variations, with larvae appearing in shades of orange, yellowish white, or yellow. They have three pairs of legs.

The nymphs, have four pairs of legs. They can be light yellow or light orange in color. Nymphs resemble adults in terms of their overall morphology but are generally smaller in size

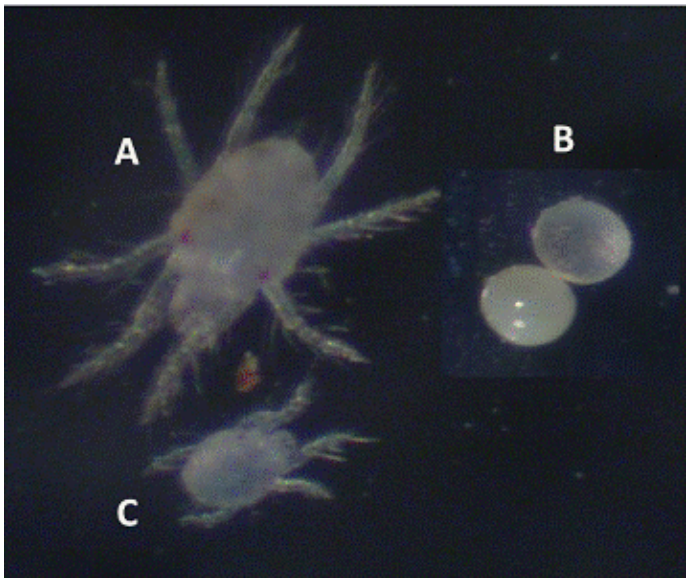

Figure 1.4: Old world date palm dust mite, Oligonychus afrasiaticus, different life stages; (A) adult, (B) egg and (C) larva
[53].

1.6 Cycle life of Oligonychus afrasiaticus

Under favorable conditions, the biological cycle of the Boufaroua mite (O. afrasiaticus) lasts approximately 10 to 15 days. A female mite can lay up to 30 eggs at a temperature of 35°C and a relative humidity ranging from 50 to 60 (percent). The incubation period for the eggs is 2 to 3 days. Larval development takes 2 days, protonymph stage lasts 1 to 2 days, and deutonymph stage also lasts 1 to 2 days. Adult females in mid-summer have a lifespan of around 20 days, while in winter, their lifespan extends to several months. Males, on the other hand, have a shorter lifespan[53].

During the winter, the Boufaroua mite overwinters as adult females. They can be found on palm trees, particularly in the fibrous material found in the upper part of the stems, as well as on weeds, other plants, and in the sand. Approximately twenty generations of mites can occur in a year, and according to André (1932), males of this mite species have a shorter lifespan compared to females[53] .

During the summer, when conditions are favorable, the summer generations of mites can last for an average of three weeks. The last generation of the year can have a longevity of up to five months, allowing them to survive through the winter. If the eggs are fertile, both male and female offspring will be produced. However, if the eggs are haploid (unfertilized), only male mites will be produced through parthenogenesis [53].

Reproduction and development of the mites are promoted and accelerated by hot and dry seasons. In summer, there is a predominance of females, but as the cold weather approaches, the two sexes seem to meet in almost equal numbers. The lifespan of adult females ranges from approximately 20 days in mid-summer to several months in winter. The duration of the mite's developmental cycle is between ten to fifteen (10 to 15) days, depending on the temperature of the environment [9] .

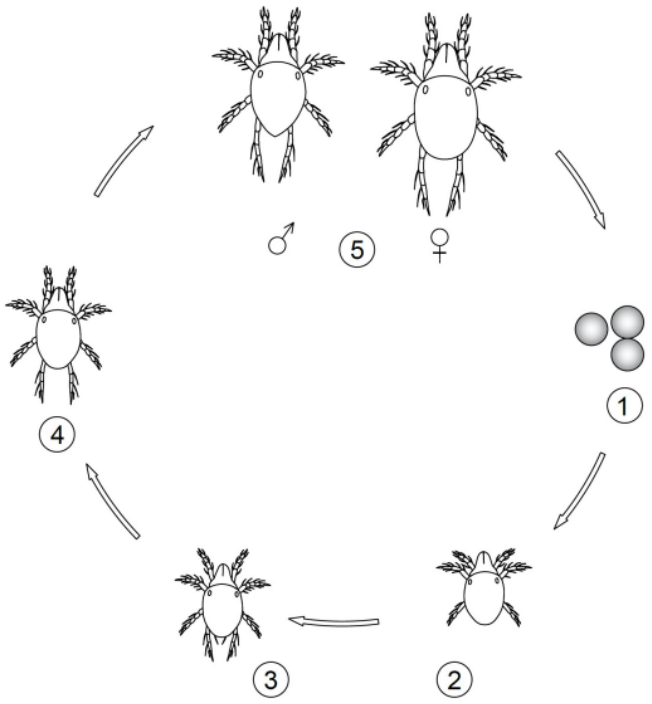

Figure 1.5: Life cycle of the date dust mite, Oligonychus afrasiaticus; (1) egg, (2) larva, (3) protonymph, (4) deutonymph, and (5) adult
[53]

1.7 Establishment and spread of O. afrasiaticus

The mite disperses through winds, insects, and fruit-eating birds. Turbulent wind carrying dust exacerbates the accumulation of dust on infested fruit bunches. The mites spread within fruit bunches through crawling, as well as to young fronds on the same palm. The initiation of the dispersal phase appears to be in response to a scarcity of food sources. In September and October, when the average temperature is around 27 degrees Celsius, the motile forms of the mite migrate to the pinnae of young fronds and ground cover of grasses, where they hibernate as deutogyne adults until April when reproduction starts[2].

During the absence of fruits, O. afrasiaticus migrates to rejections, fibers, infertile date palms, and grasses such as Cynodon dactylon. The seasonal decline of O. afrasiaticus population on date palm fruits is influenced by changes in the chemical composition of the fruits. Phenology, including the timing of appearance on date palm fruits and infestation,

is influenced by factors such as photoperiod, presence of predators, alternative hosts, date palm flowering phenology, and acaricide application. The kimri fruit stage plays a crucial role in regulating O. afrasiaticus phenology and abundance during the date palm fruiting season. Machine-learning prediction models based on be used for monitoring mite populations. Young fronds provide refuge and survival sites for overwintering mites during the off-season of fruiting [2].

1.8 Damage and losses of O.afrasiaticus

O. afrasiaticus, a date mite species, primarily feeds on developing immature date fruits in the kimri and pre-khalal stages. The mites use their stylet-like chelicerae to penetrate the fruit's outer layer and extract the cell content, disrupting the epidermal cell walls and removing chlorophyll in the process. Infestation typically begins at the calyx end of the fruit and progresses towards the tip, causing the fruits to change color from silvery-gray to reddish brown. Infested fruits shrink, crack, and eventually harden and dry prematurely. Severe infestation results in scarred fruits covered with silken webs produced by the mites, giving them a dusty appearance. These heavily damaged fruits lose their value and become unsuitable for consumption or processing[2].

Mite infestation leads to downgrading of date fruit quality, and in some cases, rehydration may be required to mitigate the extent of damage and economic losses. The copious webbings produced by mite colonies protect them from predators and acaricides, hindering control measures. Infestation can result in significant yield losses, reaching 100 (percent) in some cases, with notable losses reported in Iran, Iraq, Sudan, Algeria, and Mauritania. Mite infestation typically starts after fruit set, gradually increasing and peaking in the kimri stage. Infestation patterns can be clustered, where heavily infested bunches are found adjacent to non-infested ones. Dusty storms and proximity to dusty roadways and orchard margins contribute to severe infestation. Therefore, monitoring date palm plantations should focus on field margins and palms near roadways to detect mite infestation early on [2].

1.9 Conclusion

In this chapter, we elaborated on the body of the primary cause of the pest and the factors influencing its spread, indicating the seriousness and the importance of accelerating the finding of solutions that reduce its effect both economically and nutritionally, to be an introduction on which we are based in working to find solutions to eliminate them, reducing pre-existing losses.

Chapter 2

Building a date palm dataset

2.1 Introduction

Dataset collection is an essential phase in the process of conducting research and analysis. It encompasses the identification of pertinent variables and parameters, the selection of appropriate data collection methods, and the assurance of data quality and relevance. Various methods can be employed to collect data, with the most appropriate method depending on the specific research inquiry and available resources. After data collection, it is crucial to cleanse and process the data to ensure its accuracy and comprehensiveness. Subsequently, data analysis can be conducted to address the research question and derive meaningful conclusions

2.2 Dataset

A dataset is a collection of data. It can be structured or unstructured and can be of any size. Datasets are used in various applications, including data mining, machine learning, and artificial intelligence.

In data mining, datasets are used to identify patterns and trends in data. This information can then be used to make predictions or decisions. For example, a bank might use a dataset of customer transactions to predict which customers are likely to default on their loans.

In machine learning, datasets are used to train algorithms. Algorithms are mathematical models that can learn from data. For example, a spam filter might be trained on a dataset of emails labeled as spam or not. Once the algorithm is trained, it can classify new emails as spam or not spam[1]. .

In artificial intelligence, datasets are used to create intelligent agents. Intelligent agents are software programs that can reason, learn, and act autonomously. For example, a self-driving car might use a dataset of driving data to learn how to navigate the road safely.

Datasets can be found in various places, including online repositories, government websites, and research institutions. They can be downloaded for free or purchased [30].

When choosing a dataset, it is important to consider the following factors:

- The dataset size: Some datasets are very large, while others are relatively small. The size of the dataset will determine how long it takes to process and analyze the data.

- The format of the dataset: Datasets can be in a variety of formats, including CSV, JSON, and XML. The format of the dataset will determine how easy it is to import into a data analysis software program.

.	A1	A2	B1	B2	C1	C2	D1	D2	Total	%
Deglet nour	110	128	140	80	152	125	56	16	807	65.18
ghars	58	50	40	41	30	05	36	10	270	21.80
Deglat commune	03	10	06	0307	05	12	00	40	3.23	1.80
Dokkar	03	06	00	01	01	05	07	00	50	1.85
Djabber	16	09	05	02	07	06	12	00	50	4.03
Manquuant	21	13	29	93	19	46	107	194	522	29.65
Nbr of palm tree	119	207	191	127	201	174	113	26	1238	70.35
Total	1238+522=1760									100%

Table 2.1: Plant component of the farm

- The quality of the data: The quality of the data will affect the accuracy of any analysis performed on the data. It is important to carefully inspect the data for errors and inconsistencies before using it for analysis.[37].

Datasets are a valuable resource for data scientists, machine learning engineers, and artificial intelligence researchers. They can be used to solve a variety of problems, including fraud detection, customer segmentation, and product recommendation.

2.3 Data collection

Data collection is the first step in building a database, and here we collected data using two different methods. The first method was collecting data through photography. The second method involved using online data collection techniques

2.3.1 Own data collection

Ouargla is one of the most important places in Algeria for date palm cultivation. The ITAS's (Institute of Agricultural Technology and Sciences) Forest is a large date palm grove located in Ouargla. It is 32 hectares in size and contains 1238 date palms. The age of the trees in the forest varies from 2 years to 50 years. The ITAS is managed by the ITAS (Institute of Agricultural Technology and Sciences) ITAS at the University of Ouargla. The forest is open to the public for visits, but authorization is required. We obtain authorization to enter the ITAS forest. We contact the ITAS office at the University of Ouargla. The dates produced in the forest are sold locally and exported to other countries. The forest also provides a habitat for various wildlife, including birds, reptiles, and mammals. The ITAS forest is a valuable asset to Ouargla. It provides a source of income, food, and shelter for the city's people. It is also a popular tourist destination.[ref pdf] The table below shows the different variants that existed there:

I) **Used material** The Nikon D3100 is a 14.2-megapixel digital single-lens reflex (DSLR) camera released in 2010. It is a popular camera for beginners and en-

thusiasts alike, thanks to its affordable price, easy-to-use controls, and high image quality[33]. The AF-S NIKKOR 18-55mm is a 3x zoom lens that is compatible with the Nikon D3100 and other Nikon DSLR cameras. It is a versatile lens that can be used for a variety of photography, from landscapes to portraits [32]. Both the Nikon D3100 and the AF-S NIKKOR 18-55mm are excellent tools for collecting data for datasets. The D3100's high image quality ensures that the data will be captured in great detail, while the AF-S NIKKOR 18-55mm's versatility allows you to capture data from a variety of angles. Here are some of the advantages of using the Nikon D3100 and the AF-S NIKKOR 18-55mm for data collection:

- **High image quality:** The Nikon D3100's 14.2-megapixel sensor captures images with great detail, which is important for data collection.
- **Easy to use:** The Nikon D3100's controls are easy to understand and use, even for.
- **Versatile:** The AF-S NIKKOR 18-55mm is a versatile lens that can be used for a variety of photography, from landscapes to portraits beginners.

II) **Categories:** During this stage, we captured images of three categories:

- **The date palm** :is one of the oldest cultivated fruit trees, with evidence of its cultivation dating back to at least 5000 BC. It is a hardy tree that can withstand high temperatures and low water, making it an important crop in many tropical and subtropical regions.
  Date palms are dioecious, meaning there are separate male and female trees. The male trees produce pollen, which is used to pollinate the female trees. The female trees produce fruit, which is a drupe that contains one or two seeds [11]. Dates are a good source of nutrients, including carbohydrates, fiber, potassium, and vitamin B6.They are also a good source of antioxidants, which can help protect the body against damage from free radicals [11].
  Dates can be eaten fresh, dried, or processed into various products, such as date syrup, date paste, and date wine. They are a popular food in many countries, and they are often used in religious and cultural ceremonies.
- **Palm tree heads**: are the crown of the palm tree. It is made up of a cluster of feathery leaves that grow at the top of the trunk. The palm tree head is an important part of the tree's photosynthesis process. It is also where the tree's flowers and fruit grow.
  The shape and size of the palm tree head can vary depending on the species of palm tree. Some palm tree heads are small and round, while others are large and flat. The color of the palm tree head can also vary depending on the species of palm tree. Some palm tree heads are green, while others are brown or yellow[22].

The palm tree head is a popular feature in landscaping and gardening. It can be used to add a touch of tropical flair to any yard. Palm tree heads can also be used to provide shade and shelter from the sun.

- **Fruit brunches**: are gatherings that are held to celebrate the harvest of fruit. They are often held in the fall when many fruits are ripe. Fruit brunches are a time for people to come together and enjoy the fruits of their labor. They are also a time to learn about different fruits and their health benefits. Fruit brunches can be formal or informal, and they can be held indoors or outdoors. They often feature a buffet of fruits, pastries, and other brunch foods. Fruit brunches can be a fun and festive way to celebrate the harvest and enjoy the company of friends and family[57].

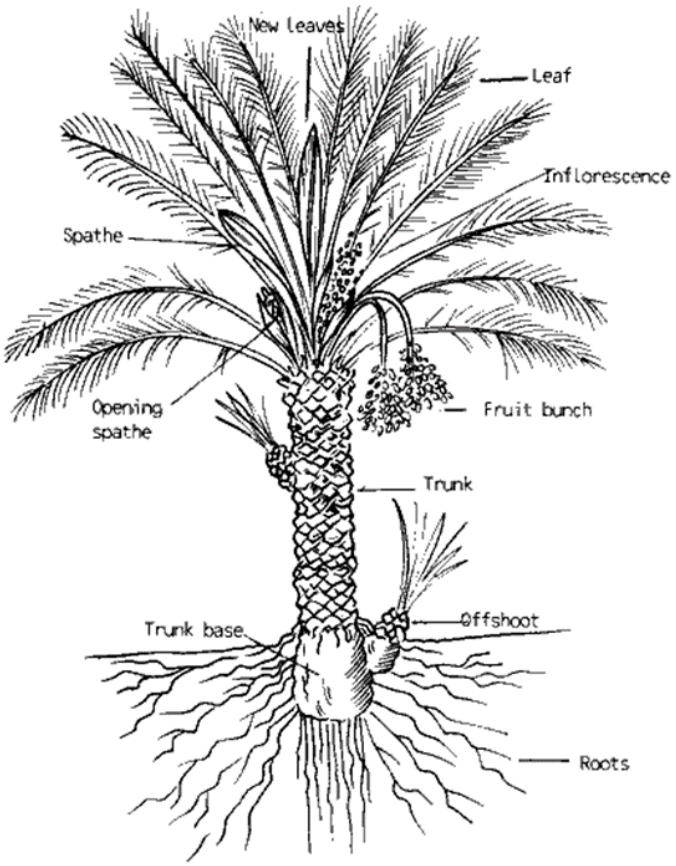

Figure 2.1: Palm trees schema

III) **Collecting Data**

In this part, we discuss the criteria for choosing palm trees to take pictures of, as well as the shooting positions for palm trees and palm tree branches. By following these guidelines, we can collect a high-quality dataset of palm tree images that can be used for a variety of purposes.

- **Criteria for Selecting Palm Trees :**

We choose 3 main criteria to select palm trees, which are:
Length: The palm tree should be of sufficient length to capture all of the important features in the image. For example, if you are trying to capture the entire crown of the palm tree, you will need to choose a palm tree that is at least 10 feet tall.
Cleanliness: The palm tree should be clean and free of any debris. This is important because debris can obscure the important features of the palm tree in the image.
Location: The palm tree should be located in a location that provides good lighting and composition. For example, you will want to avoid palm trees that are located in shady areas or that are surrounded by other objects that could obstruct the view of the palm tree.
Health: The palm trees should be healthy and free of any diseases or pests. This is important because diseased or unhealthy palm trees may not look their best in pictures

And we are looking for palm trees which are:

- **Short**: We wanted to select short palm trees so that they would be easy to photograph and so that they would not obstruct the view of other objects in the background.

- **Clean:** We wanted to select clean palm trees so that the pictures would be free of any debris or dirt.

- **Good location:** We wanted to select palm trees that were not too close together and that were locatedin an area that provided good lighting and composition.

- **Health:** We wanted to select a variety of palm trees, including healthy and sick trees (that we know its sick). This would allow us to study the effects of different diseases and pests on palm trees.

- **Shooting position for palm trees and palm tree heads :** We used a digital camera to take pictures of palm trees between 8:30 AM and 11:00 AM. This is the time of day when the sun is at its highest point in the sky, which provides the best lighting for photography.

  We selected palm trees that were not too close together and that were located in an area that provided good lighting and composition. We also wanted to select palm trees that were in good condition and that had a variety of shapes and sizes. To take the pictures, we positioned ourselves at a distance of 10 to 11 meters from the palm trees.

  This allowed us to capture detailed shots while maintaining the desired composition. We also adjusted the camera settings as needed to ensure that the images were sharp and effectively highlighted the palm tree's condition and that had a variety of shapes and sizes.

  We took a variety of shots, including close-ups, wide-angle shots, and shots from different angles. We also took pictures of the palm trees in different sea-

sons and weather conditions. By following these steps, we were able to take a variety of high-quality pictures of palm trees. These pictures can be used for a variety of purposes, such as illustrating a book, creating a website, or simply enjoying the beauty of nature.

- **Shooting position for palm trees and palm tree heads:** In this stage, we used a digital camera, and the timing was between 8:30 AM and 11:00 AM. We selected the palm trees that we would capture photos of. To achieve this, we positioned ourselves at a distance of 1 to 2 meters from the fruit bunches. This allowed us to capture detailed shots while maintaining the desired composition. This distance was adjusted as needed to ensure that the images were sharp and effectively highlighted the fruit bunches.

Figure 2.2: Image of non-existed data

2.3.2 Collected Data from the web

In the current digital era, the internet plays a significant role in the dissemination of information.Valuable information can be extracted from it and used to create a comprehensive and valuable database. The aim of this technology is to utilize the available information on the internet to build a valuable database. This database will serve as a powerful source of information and visuals, as the power of visuals lies in their ability to easily illustrate various topics[16]. The process of extracting information from the internet will be explored in this study. The tools and techniques employed in this process, the extracted data, the performed analyses, as well as the challenges and limitations that may be encountered, will be discussed. Through this study, a deeper understanding will be gained regarding the power and benefits of using the internet as a data source, and how to leverage this data for various purposes.

2.3.3 Data scraping :

In the current digital age, the internet plays a significant role in the dissemination of information. Valuable insights can be extracted from it and used to create a comprehensive and valuable database. Data scraping is the process of extracting unstructured data from websites and converting it into organized and analyzable data.

The goal of this technology is to utilize the information available on the internet to build a database of value [45] . This database will serve as a powerful source of information and images, as the visual element enhances the ease of understanding various topics.

The process of extracting information from the internet will be explored, including the tools and techniques used in this process, the data that is extracted, the analyses performed, as well as the challenges and limitations that may be encountered[12].

Through this study, a deeper understanding will be gained regarding the power and benefits of using social media platforms as a data source, and how to leverage this data for machine learning and enhancing intelligent systems

```
from simple_image_download import simple_image_download as simp
response = simp.simple_image_download
lst=['    ']
for rep in lst:
 response().download(rep  , 10)
```

I) **Working environment :**
In the era of modern technology, websites on the Internet play a fundamental role in the diversity of information, but the sites differ according to the types of offers they provide, and each has a special exploitation.

- **Google Images**: this online platform enables users to search for and explore visual content available online. It serves as a robust tool for discovering information through images[37]. By inputting specific keywords or phrases, users can access a diverse array of visual results related to their search query. These results encompass images from various sources, including websites, online galleries, and social media platforms.
  Google Images employs advanced algorithms and indexing techniques to organize and present visual content in a user-friendly manner. Users can refine their search results by applying filters such as size, color, image type, and usage rights, applying filters such as size, color, image type, and usage rights, thereby enabling them to find relevant and high-quality images. Moreover, Google Images offers additional features such as image previews, related images, and suggested search terms, enhancing the overall user experience and facilitating further exploration.

II) **The use of data scraping:**
To perform data scraping on the Google Images search engine, we utilized the

(a) (b)

Figure 2.3: Image of existing data

simple_image_download library for downloading images from the web. This library allows us to search the Google Images engine for images that meet our specified criteria and automatically them.

- Choosing the search keywords: In our implementation, we selected a list of keywords we searched for on social media platforms. We found that the popular name for this topic varies depending on the region and dialects. In Algeria, it is commonly referred to as "Boufroua" In the Middle East, specifically in Iraq and its suburbs, it is known as "Al-Gubairor" or "Abu Gubair"
  In standard Arabic, it is known as "Hilm Al-Ghubar." After setting the keywords, we used the library's download function to initiate the download process. In this example, we set the number of images to be downloaded to 10, considering the limited availability of relevant images. Therefore, we specified the number of desired images for download.
  By adopting this approach, we were able to retrieve the desired images and save them from Google Images for use in our project.

2.3.4 Real data set

The IEEE website features a research article titled "Classification of Date Fruits for Automated Harvesting in a Natural Environment Using Deep Learning" by Hamdi Al-Tahairi and colleagues from King Saud University. The original article was published on May 17, 2022, and is assigned the unique DOI number 10.21227/x46j-sk98. The article explores the classification of date fruits for automated harvesting, employing deep learning techniques in this specific context. Additionally, the article includes the accompanying database that was created The database contains 8,079 images of over 350 date clusters captured from 29 palm trees. These images were taken at various stages of maturity, aiding in creating a comprehensive database regarding the growth stages of dates[6].

Figure 2.4: The image of real data set

Not : But we did the sorting process where we chose images related to our topic because the database is comprehensive in a wide way

2.3.5 Video image set

video, it consists of an ordered set of consecutive images that are displayed rapidly to create a sequential motion. Each image in the video is assigned to a specific image space that determines its visual properties such as size, resolution, and color. When a set of images has an associated image space, it means that there is a specific classification of the images based on their visual properties. Representing the video as a trajectory means envisioning the video as a point moving through this space along the sequence of images. This point, or trajectory, represents the sequential changes in the visual properties of the images over time[36].

I) The use of video image By using the "image set" technique, we can extract and manipulate the individual images that make up the video. We can analyze the visual properties of each image separately and apply machine learning and digital processing techniques to analyze and enhance the video as a whole. Using the cv2 library in the Python programming language, we can extract the individual frames of a video. By reading the frames individually and saving them separate image files, we can create a collection of images representing create a collection of images that represent the video.

```
1  import cv2
2  import os
3  import shutil
4  from datetime import datetime
5  filename = '91.mp4'
6  if os.path.exists('output2'):
7      shutil.rmtree('output2')
8  os.makedirs('output2')
9  cap = cv2.VideoCapture(filename)
10 count = 0
11 while cap.isOpened():
                                                    #
```

```
12      ret,frame = cap.read()
                                                    #
13      if ret == True:
14          cv2.imshow('window-name',frame)
                                                #
15          t=datetime.now()
                                                  #
16          ts=t.strftime('%M%S')
                                                  #
17          cv2.imwrite("./output2/frame%s.jpg" % int(ts),
               frame)      #
18          count = count + 40000000000
                                                #
19          if cv2.waitKey(100) & 0xFF == ord('q'):
20              break
21      else:
22          break
23  cap.release()
24  cv2.destroyAllWindows()
```

By using the ”image set” technique, we can extract and manipulate the individual images that make up the video. We can analyze the visual properties of each image separately and apply machine learning and digital processing techniques to analyze and enhance the video as a whole. Using the cv2 library in the Python programming language, we can extract the individual frames of a video. By reading the frames one by one and saving them as separate image files, we can create a collection of images that represent the video.

2.3.6 social media set

In the modern digital era, social media platforms play a crucial role in communication and information exchange[18]. Valuable information can be extracted from popular platforms such as Facebook, Instagram, and Twitter, and used to create comprehensive and valuable databases .

The aim of this technology is to utilize the available information on social media platforms to build a valuable database. This database will serve as a powerful source of information and visuals, making it easier to understand and illustrate desired scenarios.

I) Social media Social media is a platform that allows people to communicate with each other and share content, such as news, photos, and videos. It is a way to stay connected with friends and family, as well as to meet new people[13].

There are many different social media platforms available, each with its own unique features. Some popular social media platforms include Facebook, Twitter, Instagram, and TikTok. Social media can be a great way to stay informed

about current events. It enables individuals to access news articles, follow trusted sources, and engage in discussions on various topics. With this diversity of news and information, it results in a vast amount of data that carries different characteristics from other data on the platform.

II) Data collection from social media To collect collecting data from social networking sites for photos of dates infected with dust fungus, the following steps are followed:

i) Define the research objectives When collecting data from social networking sites for photos of dates infected with dust fungus, the following steps are followed.

ii) Step 1: Define photo standards
- Subject: The subject of the photos to be collected is determined, which is "dates infected by boufaroua". The specific criteria for infected dates of interest, such as the presence of traces of dust or symptoms associated with a fungal infection, are specified horizontally and vertically by a screen.
- Image resolution: The images must be clear and free from any unwanted elements that cannot be removed. The feature can be used to extract snapshots from the video to obtain clear and suitable images
- Snapshot extraction: If the requested data includes video clips, the snapshot extraction feature can be used to extract images from the video. It must be ensured that the extracted snapshots clearly show the dates affected by boufaroua.

iii) Step 2:Select the appropriate platforms Select the platforms that allow me to search for photos and videos in an automatic way

- Facebook
- Instgram
- Tik tok
- youtube
- Snapchat
- Twitter

iv) Step 3:The tools that assist in research
- Filter : With the feature, it allows you to filter photos and videos with different criteria, such as the date, as it helps to display the photos that were published at the time of the date blight infestation by boufaroua .
- Hashtags : The hashtag system is a user-generated, decentralized tagging, organizing, and classification system. It assigns hashtags to messages, enhancing their searchability, and enabling connections between messages and existing communities of knowledge and action. The strength of hashtags lies in their ability to foster community engagement and collaboration [**saxton2015advocating.**]

Note: This work was done manually, as all the mentioned platforms do not allow the scraping of data without AIP permission

2.4 Preprocessing

The primary goal of preprocessing in retinal image analysis is to enhance the images and facilitate subsequent analysis.[24]

2.4.1 Data validation

After capturing the photos and storing them in a single file specific to the camera, we proceed to classify each image into its respective category manually. This is done by opening each image individually and carefully examining it. Based on the content of the image and the available information, we determine its appropriate category. For example, if the image depicts a palm tree, we classify it into the ”Palm Trees” category. If the image shows dates, we classify it into the ”Dates” category. And if the image captures a palm tree head, we classify it into the ”Palm Tree Heads” category. Once the classification process is completed, we delete unrelated or uncategorized images.

- **Rename :** We are renaming the images in an organized manner and assigning them logical names to ensure proper organization.

```
1  import os
2  import pathlib
3  source_folder = os.chdir("D:\\dataset finish\\dataset\\
       tout\\litase  \\\\New folder ")
4  counter=1
5  for item in os.listdir(source_folder):
6                  new_file = "icxmff_{}.jpg".format(
                       counter)
7                  os.rename(item ,new_file)
8                  counter+=1
9  \item {Resize :}
10 At this stage, we are resizing the images to be (244
       x244) pixels. This is done to ensure uniformity
11 in image size
```

- **Resize:** At this stage, we are resizing the images to be (244x244) pixels. This is done to ensure uniformity in image size.

```
1  import cv2
2  import glob
3  import os
4  inputFolder = os.chdir("C:\\Users\\maria\\
       PycharmProjects\\photos\\image\\test data\\good\\")
```

```
i=0
for img in glob.glob(inputFolder + "/*.jpg"):
    image = cv2.imread(img)
    imgResized = cv2.resize(image, (224, 224))
    cv2.imwrite("Resized Folder", imgResized)
    i +=1
    #cv2.imshow('image', imgResized)
    #cv2.waitKey(30)
cv2.destroyAllWindos()
```

2.4.2 Data cleaning

Data cleaning is a crucial step in enhancing image-based profiling. Cell-level quality control plays a significant role in image-based profiling and data cleaning. Outlier cells, which do not exhibit any valid biological effects, can arise from errors in various stages of the pipeline. For example, errors in the segmentation process can result in overly small or large cells, thereby heavily biasing the profiles. Detecting and removing outlier cells can greatly improve the quality of the profiles[41].

- **Data cleaning steps:**
  To perform the data cleaning process, we follow the following steps

  I) **Remove duplicate images** In data management and analysis, a common challenge is the presence of duplicate or redundant images in your database. Duplicate images are a common problem that affects data storage efficiency and complicates analysis and handling processes. To solve this problem, the concept of duplicate image removal or duplicate image detection is typically used to verify and identify duplicate images and remove them from the database.

  The process of duplicate image removal aims to identify similar or identical images based on certain criteria such as pixel-level similarity or structural similarity. Image processing algorithms and advanced search techniques are used to analyze and compare images and identify repetitions. This process is implemented in various ways and involves steps such as extracting unique features of the images, performing comparison operations, identifying similar images, and deleting duplicate images from the database[29].

  The benefits of duplicate image removal include improving storage efficiency, enhancing query performance, and reducing the strain on system resources. It also enhances the accuracy and quality of analysis and classification when it comes to image analysis and utilization in information technology and artificial intelligence applications.

  – **The use of Remove duplicate images** The process of removing similar images involves converting the images to grayscale to standardize their type. Then, we compare the images using units. This

is done by calculating the root mean square (RMS) error between the two images. If the RMS value is less than 3, it means that the images are similar or identical. In this case, one of the images is deleted. This process is performed for all images in the quot;bwdirquot; folder to ensure that there are no duplicate images in the dataset.

* **getBwLittleImgs:** This function converts original images to black and white images of size 32x32 pixels and saves them in the "bwdir" folder within each class

```
1  def getBwLittleImgs(datasetPath):
2      # Find all classes paths in directory and
          iterate over it
3      for (i, classPath) in enumerate(os.listdir(
          datasetPath)):
4
5          # Construct detected directory with
              images from MobileNET SSD
6          imgDir = join(datasetPath, classPath, "
              detected")
7          # Construct directory to write 32x32
              pix images
8          bwDir = join(datasetPath, classPath, "
              bwdir")
9
10         print(classPath)
11
12         # Create bwDir patch or delete existing
              !
13         if not os.path.exists(bwDir):
14             os.makedirs(bwDir)
15         else:
16             shutil.rmtree(bwDir)
17             os.makedirs(bwDir)
18
19         # Iterate over all images in detected
              directory
20         for (j, imgName) in enumerate(os.
              listdir(imgDir)):
21
22             # Construct patch to single image
23             imgPath = join(imgDir, imgName)
24             # Read image using OpenCV as
                  grayscale
25             image = cv2.imread(imgPath, cv2.
                  IMREAD_GRAYSCALE)
26
27             # Check if we opened an image.
```

```
28              if image is not None:
29                  # Resize opened image
30                  resized_image = cv2.resize(
                        image, (32, 32))
31                  resized_image = np.array(
                        resized_image)
32                  # Save image to bwdir. Name
                        should be the same as name in
                         "detected" directory
33                  cv2.imwrite(os.path.join(bwDir,
                         imgName), resized_image)
34              else:
35                  # remove a file that is not an
                        image. I don't need it.
36                  print(imgPath)
37                  os.remove(imgPath)
```

* **findDelDuplBw** : This function searches for duplicate or similar images in the ”bwdir” folder and deletes the duplicate copies

```
1  def findDelDuplBw(searchedName, bwDir):
2          # Join path to orginal image that we
               are looking duplicates
3          searchedImg = join(bwDir, searchedName)
4
5          # Start iterate over all bw images
6          for (j, cmpImageName) in enumerate(os.
               listdir(bwDir)):
7
8              if cmpImageName == searchedName:
9                  # If name in bwDir is equal to
                       searched image - pass. I don'
                       t wan to deletde searched
                       image in bw dir
10                 pass
11             else:
12                 # If name is different -
                       concatenate path to image
13                 cmpImageBw = join(bwDir,
                       cmpImageName)
14
15                 try:
16                     # Open image in bwDir - The
                           searched image
17                     searchedImageBw = np.array(
                           cv2.imread(searchedImg,
                           cv2.IMREAD_GRAYSCALE))
```

```
18                      # Open image to be compared
19                      cmpImage = np.array(cv2.
                            imread(cmpImageBw, cv2.
                            IMREAD_GRAYSCALE))
20                      # Count root mean square
                            between both images (RMS)
21                      rms = sqrt(
                            mean_squared_error(
                            searchedImageBw, cmpImage
                            ))
22                  except:
23                      continue
24
25                  # If RMS is smaller than 3 -
                        this means that images are
                        simmilar or the same
26                  if rms < 3:
27                      # Delete compared image in
                            BW dir
28                      os.remove(cmpImageBw)
29                      print (searchedImg,
                            cmpImageName, rms)
```

* **findDelDetected :** This function compares the images in the "detected" folder with the images in the "bwdir" folder and deletes similar images from the "detected" folder.

```
1  def findDelDetected(detectedDir, bwDir):
2      # I have to compare bw dir and detected dir
           .
3      # In bw dir I get rid of duplacates. Now I
           have to
4      # get rid of duplicates in detected dir
5
6      # List all bw files in bw dir
7      bwFiles = os.listdir(bwDir)
8
9      # Iterate over detected dir
10     for file in os.listdir(detectedDir):
11         # Check if file in detected dir can be
               found in bw dir
12         if file not in bwFiles:
13             # Deletde if not. This means that
                   that the duplicate or simillar
                   image is found
14             print (file,  " to be deleted")
15             os.remove(os.path.join(detectedDir,
```

```
                    file))
```

II) **white balance adjustment:** White balance adjustment is a process used in photography to ensure that white colors appear neutral and natural in a captured image. When taking a photo, the lighting conditions, such as natural sunlight or artificial lighting, can affect the color of the light, leading to color distortion and uneven white color appearance.

The white balance adjustment process involves modifying the balance of the three primary colors in the scene: red, green, and blue. The goal of white balance adjustment is to balance these color values, correcting the color that appears as true white in the image [**photographylife.**]

– **The use of Gray-World algorithme:** We use the 'Gray-World' algorithm to adjust the white balance in images. The white balance adjustment is performed on a set of images located in a specified folder. The algorithm calculates the average values of the 'a'(the 'a' channel)represents the range of green-red colors, where negative values represent the green side and positive values represent the red side) and 'b(The'b' channel represents the range of blue-yellow colors, where negative values represent the blue side and positive values represent the yellow side) color channels in the LAB color space and adjusts them based on these values to achieve balance. The processed image is then converted back to the BGR color space and saved in a new folder.

```
1  import os
2  import cv2
3  import numpy as np
4  import glob
5  import sys
6  #gray-world algorithm
7  inputFolder ='not'
8  def GW_white_balance(img):
9      img_LAB = cv2.cvtColor(img, cv2.COLOR_BGR2LAB
       )
10     avg_a = np.average(img_LAB[:, :, 1])
11     avg_b = np.average(img_LAB[:, :, 2])
12     img_LAB[:, :, 1] = img_LAB[:, :, 1] - ((avg_a
       - 128) * (img_LAB[:, :, 0] / 400.0) * 3)
13     img_LAB[:, :, 2] = img_LAB[:, :, 2] - ((avg_b
       - 128) * (img_LAB[:, :, 0] / 400.0) * 3)
14     balanced_image = cv2.cvtColor(img_LAB, cv2.
       COLOR_LAB2BGR)
15     return balanced_image
16 i=1
17 for imag in glob.glob(inputFolder + "/*.jpg"):
18   img = cv2.imread(imag)  # holidays.png , lake.
```

```
    png
19  image_gw_balanced = GW_white_balance(img)
20  cv2.imwrite("ligh Folder/image%04i.jpg" % i,
        image_gw_balanced)
21  i+=1
```

III) **haze removal:** Dehazing is a process used to reduce or remove the visible effect of haze or atmospheric fog in images. Haze causes light particles to scatter in images, resulting in reduced contrast, decreased color saturation, and a hazy or dull appearance.
The goal of dehazing is to restore clarity, contrast, and color vibrancy in the affected image, making it appear clearer and more true to the original scene[23].

- **The use of haze removal** In the below-mentioned line of code, the main functionality being performed is haze removal from an image. The remove-haze function from the image-dehazer module is used to execute this operation. The image containing haze is passed as input to the function, and we have used the image-dehazer library in this code.

```
1  import cv2
2  import image_dehazer
3  import glob
4  inputFolder ='images'
5  if __name__ == "__main__":
6   i=0
7   for imag in glob.glob(inputFolder + "/*.jpg"):
8      HazeImg = cv2.imread(imag)
              # read input image -- (**must be a
          color image**)
9      HazeCorrectedImg, haze_map = image_dehazer.
          remove_haze(HazeImg,
          showHazeTransmissionMap=False)      #
          Remove Haze
10     cv2.imwrite("outputImages/image%04i.jpg"% i,
          HazeCorrectedImg)
11     i+=1
```

2.4.3 Split data

Splitting the database into training, testing, and validation sets is an essential process in developing machine learning models. [27]

```
1  import splitfolders  # or import split_folder
2  input_folder = 'data'
3  splitfolders.ratio(input_folder, output="data2",
4                     seed=42, ratio=(.8, .5, .15),
```

```
5                     group_prefix=None) # default
                        values
6 splitfolders.fixed(input_folder, output="data2",
7                     seed=42, fixed=(35, 20),
8                     oversample=False, group_prefix=
                        None)
```

- The training set is used for model training [27]
- The testing set is used for performance evaluation, and.[27]
- The validation set is used to improve the model's performance.[27]

2.5 data augmentation

Data augmentation was employed in experiments to expand the size of the dataset. In order to construct effective deep learning models, it is crucial for the validation error to consistently decrease alongside the training error. Data augmentation serves as a highly effective approach to accomplish this goal.[52]

In our work, we performed data augmentation on the training dataset using the following code:

```
1  from keras.preprocessing.image import ImageDataGenerator
2  import numpy as np
3  from skimage import io
4  import os
5  from PIL import Image
6
7  # Construct an instance of the ImageDataGenerator class
8  # Pass the augmentation parameters through the constructor.
9
10 datagen = ImageDataGenerator(
11         rotation_range=45,     #Random rotation between 0
             and 45
12         width_shift_range=0.2,   #% shift
13         height_shift_range=0.2,
14         shear_range=0.2,
15         zoom_range=0.2,
16         horizontal_flip=True,
17         fill_mode='reflect', cval=125)    #Also try nearest
             , constant, reflect, wrap
18 image_directory = 'good/'
19 SIZE = 224
20 dataset = []
21 my_images = os.listdir(image_directory)
```

```
for i, image_name in enumerate(my_images):
    if (image_name.split('.')[1] == 'jpg'):
        image = io.imread(image_directory + image_name)
        image = Image.fromarray(image, 'RGB')
        image = image.resize((SIZE,SIZE))
        dataset.append(np.array(image))

x = np.array(dataset)
i = 0
for batch in datagen.flow(x, batch_size=800,
                          save_to_dir='augmented_good',
                          save_prefix='aug',
                          save_format='jpg'):
    i += 1
    print(batch)
    if i > 3:
        break  # otherwise the generator would loop
           indefinitely
```

We have chosen these settings to augment the database:

- Width Shift : Apply horizontal shifts to the images with a maximum shift of 20 percent of the image width.
- Height Shift : Apply vertical shifts to the images with a maximum shift of 20 percent of the image height.
- Shear: Apply shearing transformations to the images with a maximum shear angle of 20 degrees.
- Zoom : Perform zooming in and out on the images with a maximum zoom range of 20 percent
- Horizontal Flip: Flip the images horizontally.
- Fill Mode: Use the ”reflect” mode for filling in newly created pixels during the augmentation process, and set the fill value to 125

2.6 Conclusion

In conclusion, dataset collection is a crucial step in research, and it involves several key considerations. Firstly, it is essential to identify and select the relevant variables and parameters that align with the research question. This ensures that the collected data will be meaningful and contribute to answering the research objectives. Secondly, employing appropriate data collection methods is vital. Researchers must choose the most suitable techniques for gathering data, such as data scraping or other commonly used methods. The selection should be based on the nature of the

research and the available resources.
Furthermore, ensuring the quality and accuracy of the collected data is paramount.

Researchers need to perform thorough checks to identify and correct any errors or inconsistencies. Cleaning the data involves removing incomplete or duplicate entries and verifying its representativeness to ensure reliable analysis and valid conclusions. Additionally, the data should be processed diligently. This includes transforming it into a suitable format for analysis, such as converting it into spreadsheets or databases. Proper processing enhances the usability of the dataset and facilitates efficient analysis.

Lastly, researchers must always adhere to ethical considerations and privacy regulations when collecting data. Respecting confidentiality, obtaining appropriate permissions, and safeguarding the privacy of individuals involved are essential aspects of responsible data collection. By following these practices, researchers can collect high-quality data that supports accurate analysis, fosters reliable insights, and upholds ethical standards.

Chapter 3

Background

3.1 Introduction

AI has demonstrated impressive precision and sensitivity in the identification of image in several fields . Recently, AI techniques based on deep learning have been actively studied in the classification of images, in this chapter we introduce the main approaches from which we started our work (CNN, computer vision -VGG16....) , and the main components we based our work on

3.2 Artificial Intelligence

Artificial Intelligence is a way of making a computer, a computer-controlled robot, or a software think intelligently, in the similar manner the intelligent humans think [44], AI has been dominant in various fields such as: Gaming, Natural Language Processing, Vision Systems.
.The domain of artificial intelligence is huge in breadth and width. While proceeding, we consider the broadly common and prospering research areas in the domain of AI:

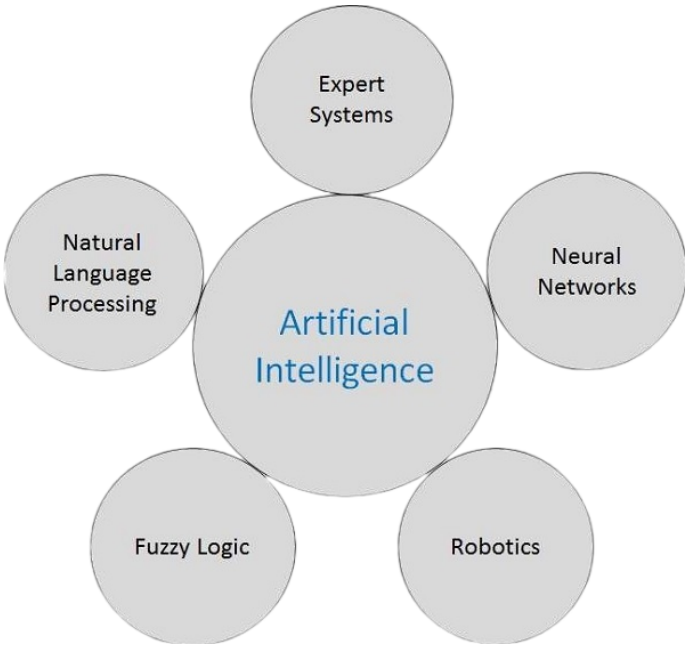

Figure 3.1: AI Domain
[44]

3.3 Machine learning

Is a part of artificial intelligence, is the study of computer algorithms that can improve automatically through experience and by the usage of some data. Machine learning algorithms create a model by analyzing sample data, referred to as training data, to enable making predictions or decisions without explicit programming.

These algorithms find applications in diverse fields like medicine, email filtering, speech recognition, and computer vision .[8]

3.4 Digital imaging

A digital image is a numerical representation of a physical image that can be stored and processed by a computer. To convert the image into digital form, it is divided into small units known as pixels (picture elements). Each pixel is assigned a specific value or set of values that represents a characteristic of that pixel, such as its brightness (intensity of light) or color. These values are typically expressed as numbers, allowing the image to be stored, manipulated, and displayed digitally .[19]

.Digital image has two types:

- Vector
- Raster

3.4.1 Pixel :

Pixels are the smallest units in a digital display. An image or video on a device's screen is made up of millions of pixels. Each pixel consists of subpixels that emit red, green, and blue (RGB) colors at varying intensities. By combining these RGB color components, a wide range of colors can be displayed on a monitor or screen, creating a gamut of different colors.[50]

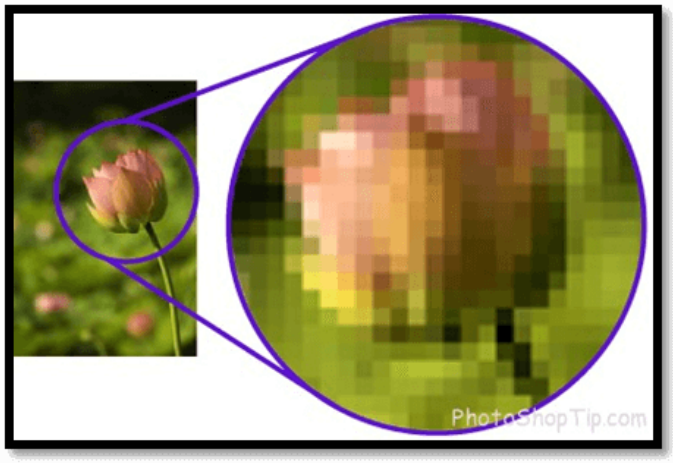

Figure 3.2: pixel
[50]

3.4.2 Characteristics

The General characteristics of any image are:

- Resolution: Resolution is a broad term and may have different meanings. Resolution most often refers to display resolution and the number of image elements (pixels or just points) that can be displayed horizontally and vertically by a screen [49].
- Color image: Visible colors can be created by combining the three primary colors: red, green, and blue. The human eye has three color receptors, each sensitive to one of these primary colors. An RGB color image consists of separate channels for red, green, and blue, resulting in a weighted combination of these primary colors for each pixel[21] .
- Dimensions: Image dimensions are the length and width of a digital image. It is usually measured in pixels, but some graphics programs allow you to view and work with your image in the equivalent inches or centimeters.
- Histogram : An image histogram is a graphical representation of the number of pixels in an image as a function of their intensity[10].

3.5 Computer vision

One of the most potent and compelling subfields of computer science is computer vision, which is a sort of artificial intelligence. It allows computers to detect and analyze items in images and videos in a manner similar to that of humans, making it comparable to the human visual system. Computer visiontechnology has advanced quickly in many areas and helped to find solutions tomany issues. Algorithms may be used to automate processes like breast cancerdetection. Computer vision has also made contributions to a variety ofdomains, including object finding ,image classification, and many more [31].

3.6 Deep learning

Deep learning is an emerging area within the realm of machine learning that is a type of unsupervised learning. Its objective is to mimic the functioning of the human brain by constructing neural networks capable of comprehending various forms of data, such as images, sound, and text, in a manner similar to human cognition[59].

The neural network represents attribute categories or features by mixing low-level features to create more abstract high-level features to determine the distributed feature representation of the data .
Deep learning is widely used in image classification, facial recognition, image search, object detection, video analysis .....

3.7 Artificial Neural Network

A neural network is a combination of hardware bonded or separated by the software system which operates on the small part as in the human brain called neuron[35].

.The integrated model should be able to accurately learn how to extract the distinguishing characteristics from the training batch of photos.

The Convolutional Neutral Network is well known for using evolutionary algorithms for hidden layers. It requiresooling and padding data to prepare them for inclusion in training models using test datasets.

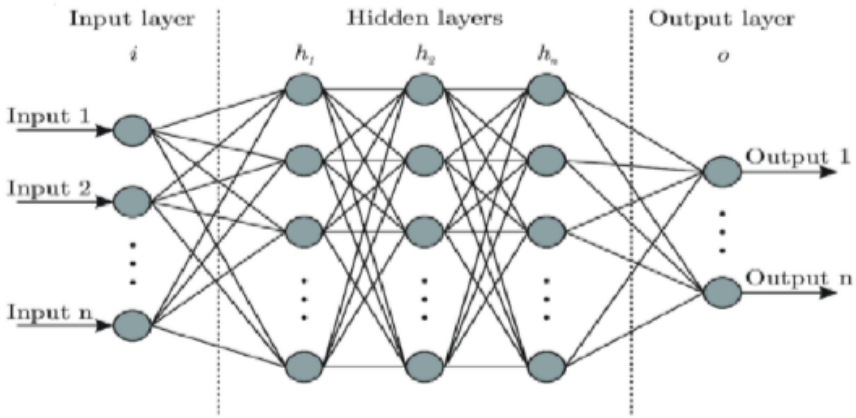

Figure 3.3: neural network
[35]

3.8 Convolutional Neural Network

Deep learning encompasses a class of deep neural networks known as convolutional neural networks (CNNs or ConvNets), which are most commonly applied to analysing visual imagery . [35] .CNNs are characterized by their architecture of shared weights and translation invariance. They find diverse applications in fields such as image and video recognition, recommender systems, image classification, medical image analysis, natural language processing [35].

CNN having three different kinds of layers to process the images. They are convolution layers, sub sampling layers and classification layers containing sigmoid neurons.

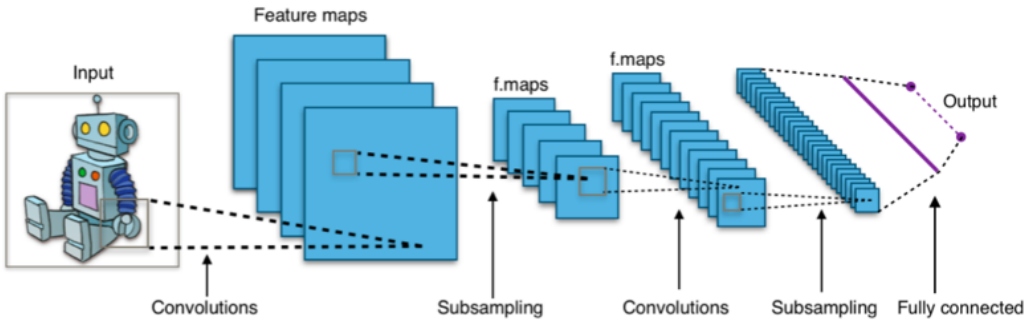

Figure 3.4: Convolutional Neural Network
[34]

- Filter: The same linguistic meaning is revision. Come see how the filter is shaped as in the photo below..

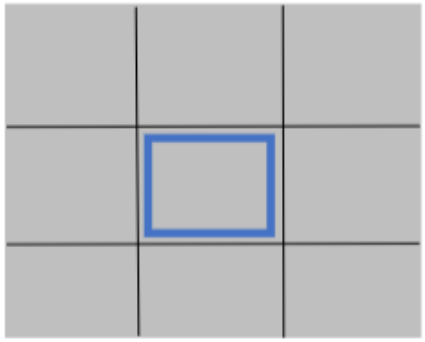

Figure 3.5: filter

The box specified by blue is the center of the filter. And the function of this filter is to extract a set of characteristics that exist in a particular image.

Takes the filter and passes it on the image In this example, we have a filter That's 3*3 , like what we're showing in figure 3.5. If we take this filter and drop it on the picture where the output is like what we see in figure 3.6.

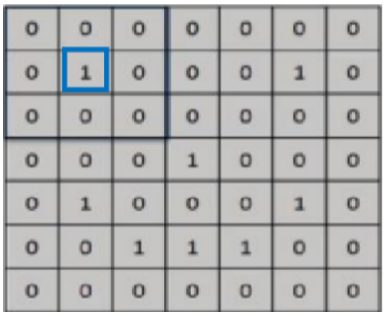

Figure 3.6: Input image
[35]

swipe the filter all over the picture. We drop and pass the filter all over the picture. Each filter will extract us different characteristics from the other filter

from the image.

For example, if I had a picture of a cat, and we dropped the filter on the picture and passed it all over the cat's image, A filter for example extracts the cat's ears and another filter extracts the eyes and so on.

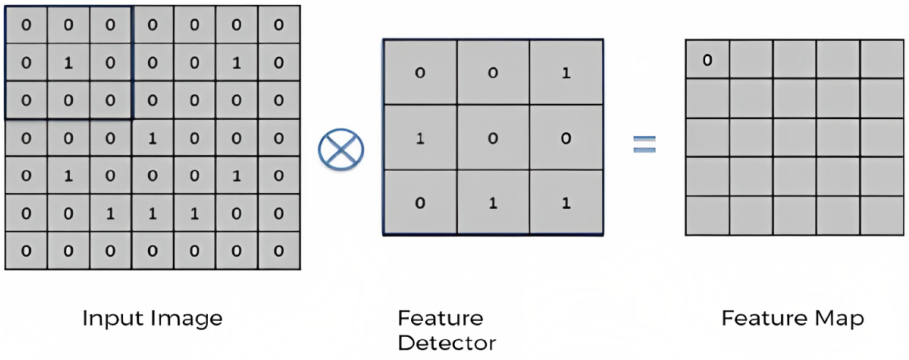

Figure 3.7: Feature detector
[35]

Extracted characteristics are what a model learns to differentiate one image from another .

- stride: is the amount of the filter passing on the image, e.g. stride = (1.1) means that it will move every time with 1 either side or under.

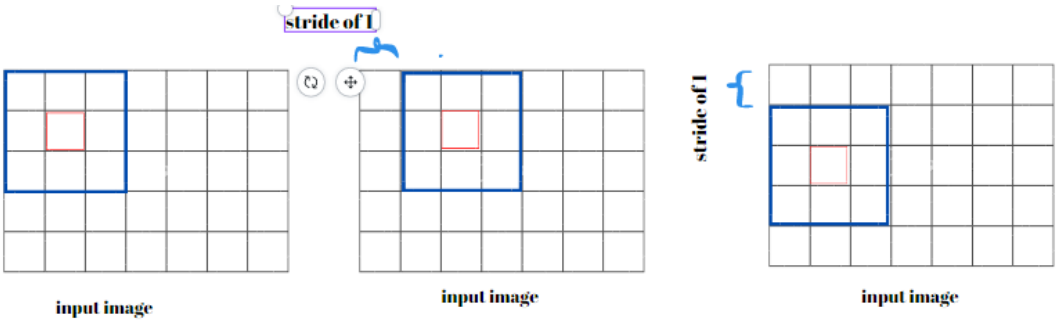

Figure 3.8: stride work

- feature map: The features map contains properties extracted by filters. The properties are extracted by dropping or by what it means to multiply the filters in the picture. .In order to better properly scan and classify pictures, the network determines what elements are crucial to it across training[43]
  .
  It builds its feature detectors based on that. The variables taken into account by the network are frequently invisible to the human eye, which is precisely why convolutional neural networks are so surprisingly useful.

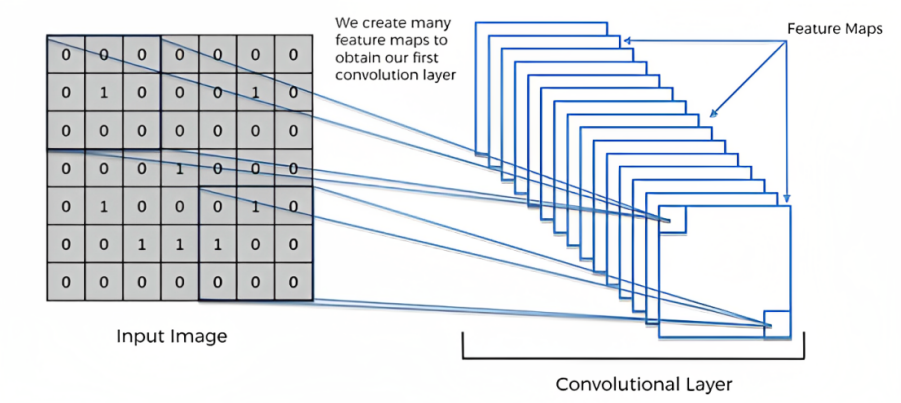

Figure 3.9: feature maps
[35]

- Relu: ReLU is a linear function that provides a matching output for positive inputs and outputs zero for negative inputs.

3.8.1 CNN Layers :

- Feature extraction: is an important process in various fields such as computer vision, object detection and localization. It is used to extract prominent features from different datasets, including images, text, and audio, and utilize them to represent and describe the data. Data contains a collection of distinctive features that hold significant value in data representation and understanding.

Convolutional layer

The convolutional layer is the first layer, and it is the core building block of CNN , where the majority of computation occurs, that is used to extract the features from the input image. It requires a few components, which are input data, a filter, and a feature map. .The operation is carried out between the input image and a filter of a specific size. The result is known as the Feature map, and it contains information about the image. This feature map is later distributed to other layers.

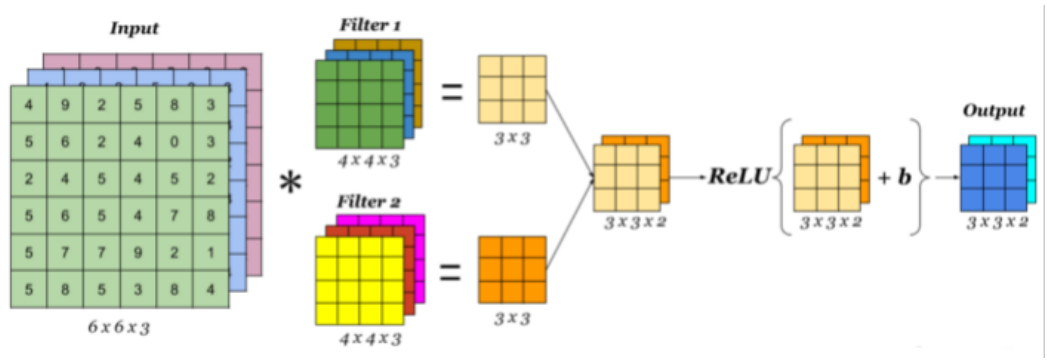

Figure 3.10: Convolutional layer
[54]

Sub sampling layer

Or what's called pooling layer, which preserves the most important features that exist. and Its role is to decrease the number of samples or inputs to take them from convolutional layer

.The goal is to raise the performance of the algorithm used means that our calculation is very fast and uncomplicated due to the reduction of samples thats means taking the most important characteristics in the picture and ignoring the rest of the characteristics.

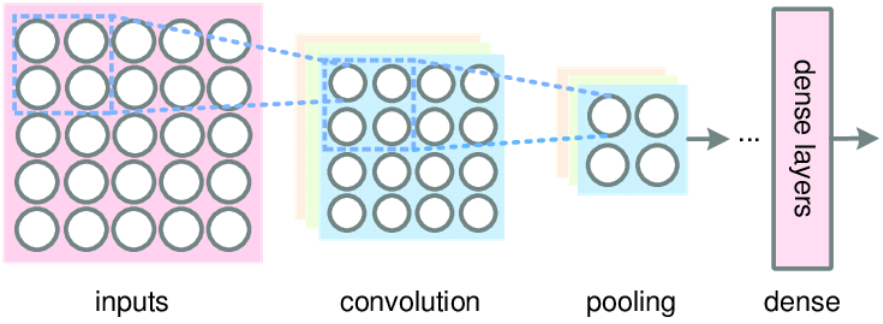

Figure 3.11: sub Sampling
[7]

There are two main types of pooling: Average Pooling Layers , Max Pooling Layers .

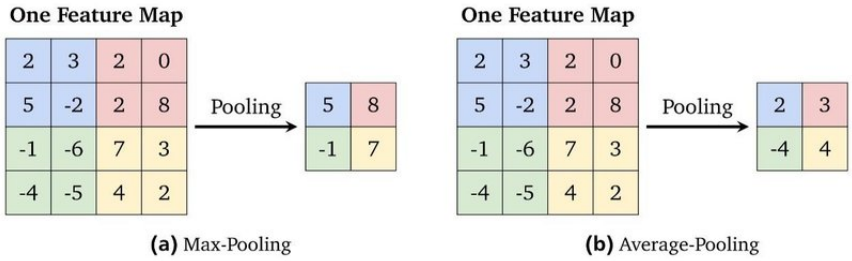

Figure 3.12: max and average pooling
[7]

Layers Classification

- Flatten layer : Flattening is used to combine all of the 2-dimensional arrays produced by pooled feature maps into a single long continuous linear vector.

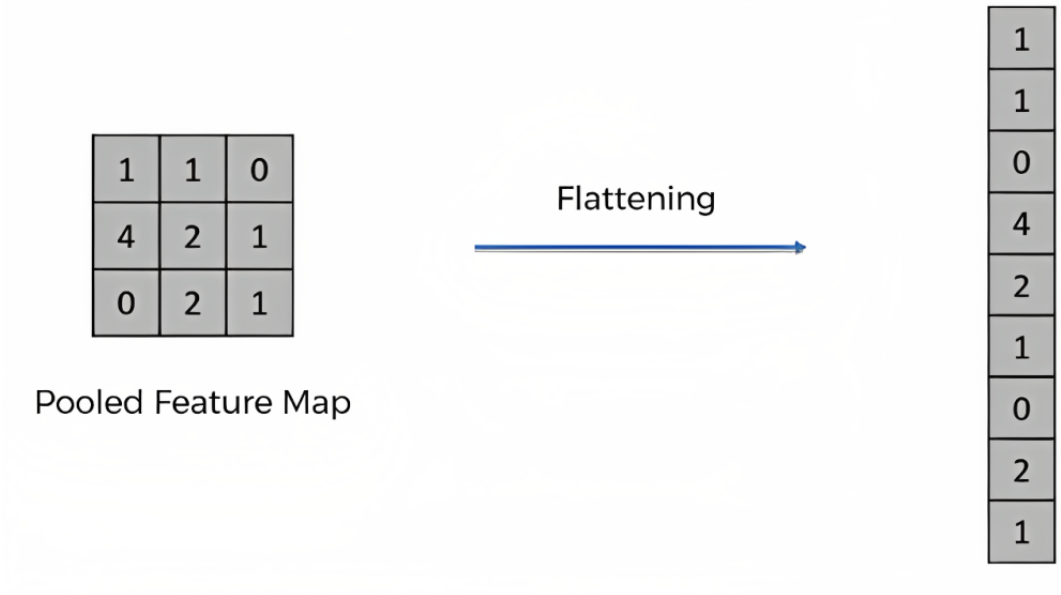

Figure 3.13: Flatten layer
[46]

- Dense layer: A Dense Layer is a layer of neurons in a neural network where each neuron is connected to all the neurons in the previous layer. This dense connectivity is the reason for its name. The main purpose of a Dense Layer is to classify images based on the output obtained from convolutional layers.
- Fully connected layers: Fully Connected layers in a neural network are layers where every input from one layer is connected to each activation unit in the following layer .

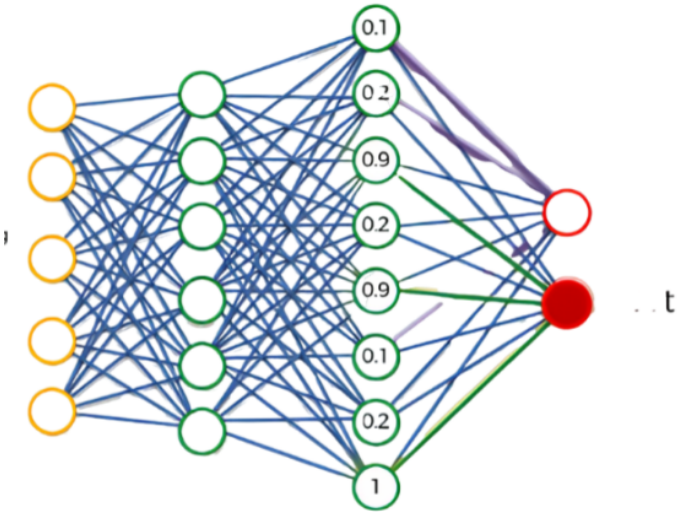

Figure 3.14: fully connected layer

- Output Layer

The output layer of an artificial neural network is the final layer of neurons that produces the program's outputs.[2]

3.8.2 CNN models for images classification

A. Image classification

Image classification has been an essential problem in computer vision for decades. While humans find it easy to identify and interpret images, computers may find it difficult. Each image is made up of a set of pixels, and each pixel is represented by a special value. In order to categorize images, it must do a bigger number of computations[25]. Several methods for classifying images were reported and compared during the past ten years. However, in general, image classification refers to theprocess of obtaining data from a picture by categorizing its pixels . Image classification is a widespread research area in the field of deep learning, Pattern recognition,Human Computer Interaction and got substantial attraction in many research scientists.[35]

B. Image Classification Models

Here are five frequently employed deep convolutional neural network architectures that are utilized for tasks such as object detection and image classification.

R-CNN

R-CNN, short for Region-based Convolutional Neural Network, is a network designed to accurately detect and extract objects in an image. However, its performance is hindered by its slow scanning and region identification processes. The

architecture's inefficiency stems from its utilization of the selective search algorithm, which generates around 2000 regions from the initial image. Subsequently, the network applies multiple CNNs to each region[42].

Fast R-CNN

Fast R-CNN is a streamlined version of the R-CNN architecture that offers faster processing while still being capable of identifying regions of interest in an image. It achieves improved performance by extracting features before identifying the regions of interest. Unlike R-CNN, which employs 2000 CNN networks for each region, Fast R-CNN uses only one CNN for the entire image. However, it should be noted that Fast R-CNN may have lower accuracy than R-CNN when it comes to accurately recognizing object bounding boxes in the image[42].

VGGNet

VGGNet is one of the most popular CNN architecture, which is introduced by SimonyanandZisserman in 2014. The authors introduced a total 6 diff erent CNN configurations, among them, theVGGNet-16 and VGGNet-19 are the most successfulones .[42]

GoogleNet

GoogLeNet is a deep convolutional neural network consisting of 22 layers and is a variation of the Inception Network, which was developed by Google researchers. The GoogLeNet architecture gained recognition in the ImageNet Large-Scale Visual Recognition Challenge 2014 (ILSVRC14) by successfully addressing computer vision tasks like image classification and object detection.[42]

ResNet

ResNet, short for Residual Neural Network, is a convolutional neural network (CNN) that can have up to 152 layers. It incorporates "gated units" to skip certain convolutional layers, similar to GoogleNet. Additionally, ResNet employs extensive batch normalization. Its innovative design allows it to incorporate a large number of convolutional layers without significantly increasing complexity. ResNet participated in the ImageNet Challenge 2015 and achieved an impressive error rate of 3.57 recent. Furthermore, it surpassed human-level performance on the trained dataset.[42]

3.9 VGG-16

The model "Very Deep Convolutional Networks for Large-Scale Image Recognition" was introduced by K. Simonyan and A. Zisserman from the University of Oxford.

It gained significant popularity when it was submitted to the ILSVRC-2014 competition. It improves upon the performance of the AlexNet model by substituting large kernel-sized filters with multiple consecutive 3×3 kernel-sized filters[15].

The architecture depicted below is VGG16.

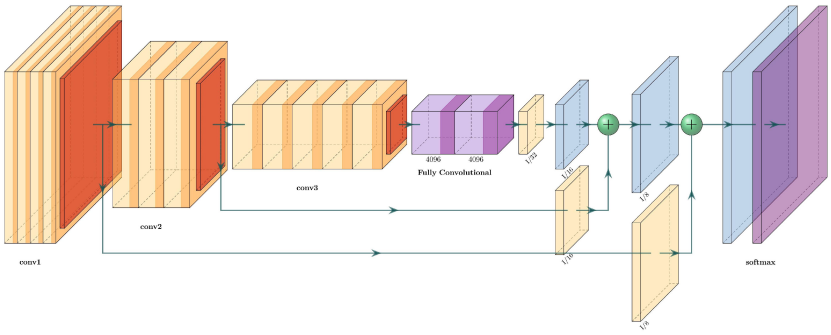

Figure 3.15: VGG-16 architecture
[15]

3.9.1 VGG-16 architecture

A VGG network consists of small convolution filters. VGG16 has three fully connected layers and 13 convolutional layers.
Here is a quick outline of the VGG architecture:

Input layer: Takes the input image of size 224x224 pixels.

Convolutional layers:
- Convolutional layer with 64 filters, each having a 3x3 kernel size.
- Convolutional layer with 64 filters, each having a 3x3 kernel size.
- Max pooling layer with a 2x2 pooling size.

Convolutional layers:
- Convolutional layer with 128 filters, each having a 3x3 kernel size.
- Convolutional layer with 128 filters, each having a 3x3 kernel size.
- Max pooling layer with a 2x2 pooling size.

Convolutional layers:
- Convolutional layer with 256 filters, each having a 3x3 kernel size.
- Convolutional layer with 256 filters, each having a 3x3 kernel size.
- Convolutional layer with 256 filters, each having a 3x3 kernel size.
- Max pooling layer with a 2x2 pooling size.

Convolutional layers:
- Convolutional layer with 512 filters, each having a 3x3 kernel size.

- Convolutional layer with 512 filters, each having a 3x3 kernel size.
- Convolutional layer with 512 filters, each having a 3x3 kernel size.
- Max pooling layer with a 2x2 pooling size.

Convolutional layers:
- Convolutional layer with 512 filters, each having a 3x3 kernel size.
- Convolutional layer with 512 filters, each having a 3x3 kernel size.
- Convolutional layer with 512 filters, each having a 3x3 kernel size.
- Max pooling layer with a 2x2 pooling size.

Fully connected layers:
- Fully connected layer with 4096 units.
- Fully connected layer with 4096 units.
- Fully connected layer with 1000 units

Output layer: Softmax activation layer to produce the final classification probabilities

- Softmax : The Softmax function is a mathematical function used in machine learning and neural networks for classification tasks. It transforms a vector of real numbers into a probability distribution. It exponentiates each element of the input vector and then normalizes them by dividing by the sum of the exponentiated values. This ensures that the resulting values represent valid probabilities, with each value between 0 and 1 and the sum of all values equal to 1. The Softmax function is commonly used in the output layer of neural networks for multi-class classification, where it assigns probabilities to each class and determines the predicted class label based on the highest probability.

3.10 InceptionV3

The Inception V3 is an enhanced version of the basic model Inception V1. It is a deep learning model based on Convolutional Neural Networks that is used for classification of images which was introduced as GoogLeNet in 2014.

3.10.1 InceptionV3 architecture

The Inception-V3 model, as described in the information you provided, consists of several building blocks and layers. Here is a summary of the main components mentioned:

1. Convolutional Layers: The model includes convolutional layers that perform feature extraction by applying filters to the input image.

2. Average and Max Pooling: Average pooling and max pooling operations are used to downsample the feature maps and capture important information from different regions.

3. Concatenation: The model uses concatenation operations to combine the outputs of different branches or layers.

4. Dropout: Dropout is a regularization technique used to prevent overfitting. It randomly sets a fraction of the input units to zero during training, which helps in reducing dependencies among the neurons.

5. Fully Connected Layers: Fully connected layers transform the high-dimensional feature maps into a vector representation.

6. Batch Normalization: Batch normalization is applied to the activation layer inputs, which helps in normalizing the inputs and improving the training process.

7. Softmax Layer: The final layer of the model is the softmax layer, which computes the probabilities for different classes based on the learned features. It provides a probability distribution over the predefined classes.

It's worth noting that the specific architecture details and configuration may vary depending on the implementation and any modifications made by researchers.

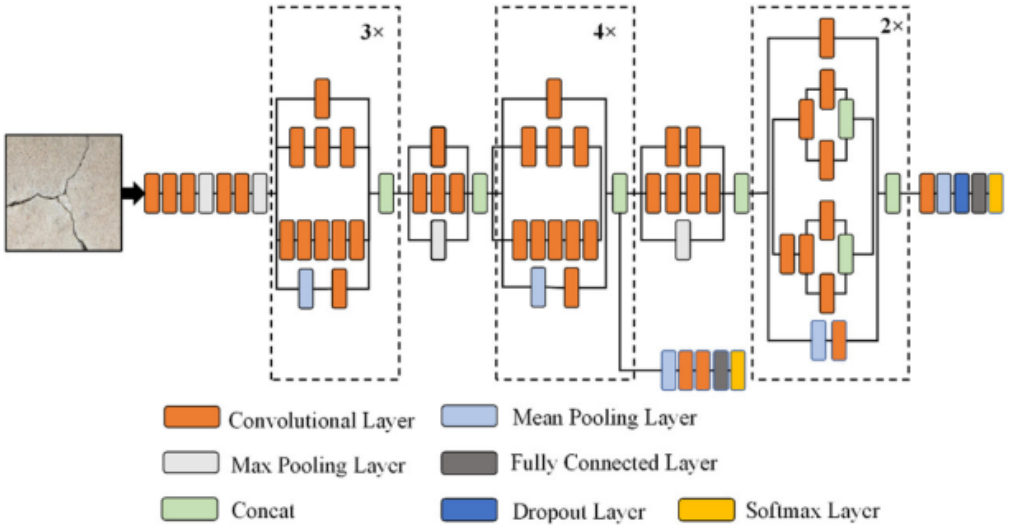

Figure 3.16: InceptionV3 architecture
[40]

3.11 ResNet-50

ResNet-50 is a convolutional neural network that is 50 layers deep. convolutional Neural Networks (CNNs) face a significant drawback known as the "Vanishing Gradient Problem." This problem arises during backpropagation when the gradient value decreases drastically, leading to minimal weight updates. To tackle this issue, ResNet was introduced, which utilizes a technique called "skip connection" or "residual connection." [38]

3.11.1 Skip connection

A skip connection, referred to as a residual connection, is a method employed in deep neural networks to address the vanishing gradient problem and assist in training deeper networks. It works by establishing a direct shortcut or bypass connection between early and later layers in the network . [38]

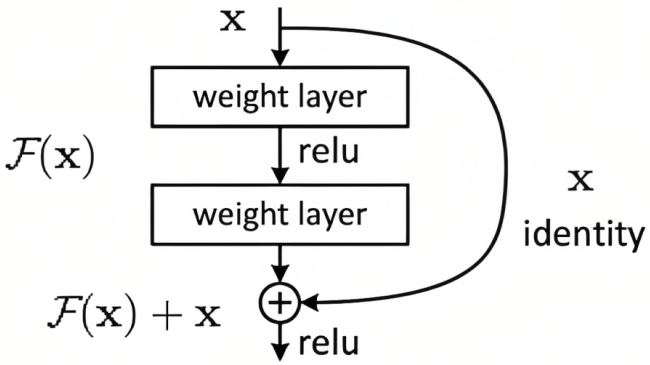

Figure 3.17: skip connection
[38]

3.11.2 ResNet-50 architecture

The ResNet50 architecture consists of several layers, including convolutional layers, pooling layers, fully connected layers, and skip connections.
- Here is a detailed breakdown of the layers in ResNet50:

Input layer: This is the initial layer that takes the input image.

Convolutional layers:
- Convolutional layer with 64 filters, each having a -kernel size of 7x7 and a stride of 2.
- Batch normalization layer.
- ReLU activation layer.
- Max pooling layer with a pool size of 3x3 and a stride of 2.

Residual blocks: ResNet50 has 16 residual blocks grouped into different stages:
- Stage 1: Three residual blocks, each consisting of convolutional layers with 64 filters.
- Stage 2: Four residual blocks, each consisting of convolutional layers with 128 filters.
- Stage 3: Six residual blocks, each consisting of convolutional layers with 256 filters.
- Stage 4: Three residual blocks, each consisting of convolutional layers with 512

filters.

o Global average pooling: This pooling layer performs average pooling over the spatial dimensions, reducing the feature maps to a single vector.

o Fully connected layers:
- A fully connected layer with 1000 units (for the ImageNet classification task).

o 6. Output layer: The final output layer uses the softmax activation function to produce the probabilities for each class.

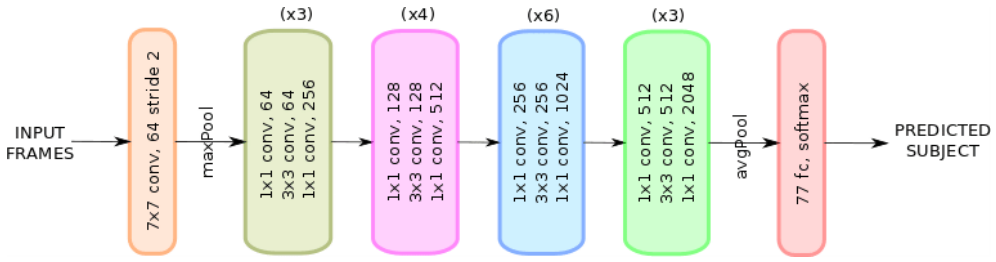

Figure 3.18: ResNet-50 architecture
[39]

3.12 Ensemble learning

Ensemble learning is a technique that combines multiple individual models to achieve improved performance and generalization. Deep learning architectures, known for their superior performance compared to traditional models, are currently at the forefront. Deep ensemble learning models leverage the strengths of both deep learning and ensemble learning, resulting in a final model with enhanced generalization capabilities. In this study, the group learning technique a popular approach in deep learning, was employed to enhance classification accuracy [13] whitch is

3.12.1 Probability Averaging

The probability scores for several models are initially generated in this ensemble approach. The results are then averaged across all models for all dataset classifications. Probability scores are the confidence in predictions by a particular model. So, here we are combining the confidences of various models to get an ensemble's ultimate probability score. The anticipated class is designated as the one with the highest probability following the averaging procedure[13].

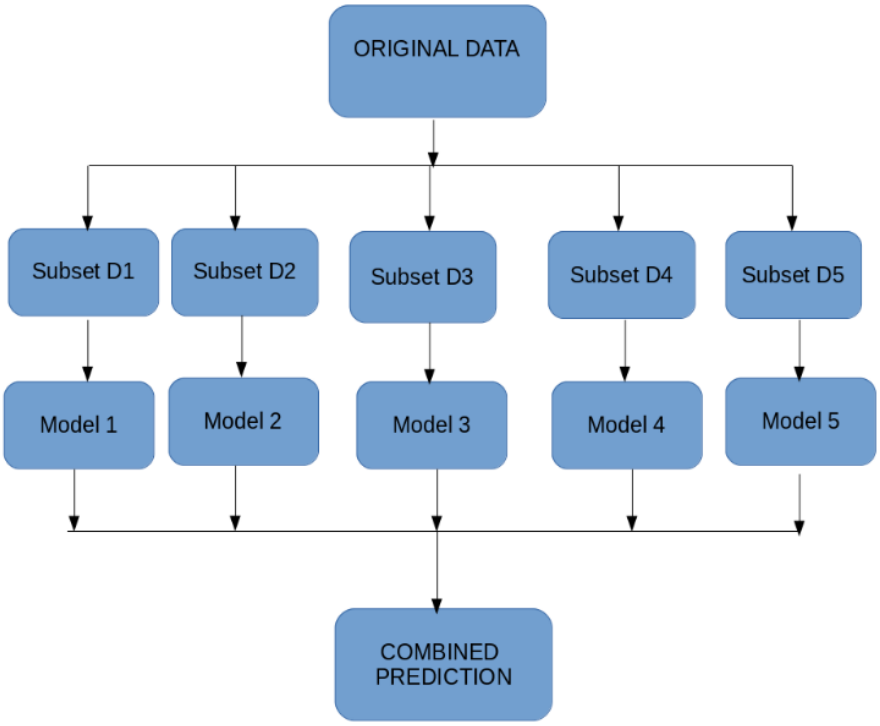

Figure 3.19: ensemble learning shema
[56]

3.13 Transfer learning

Transfer learning is a technique where the knowledge of a pre-trained model is applied to a related problem. It involves transferring the learned weights and patterns from one task to another, allowing the model to generalize better. By leveraging the knowledge gained from a task with abundant labeled data, transfer learning enables the use of this knowledge in a new task with limited data. It is commonly used in computer vision and natural language processing tasks. Although transfer learning is not a specific machine learning technique, it has gained popularity, particularly in combination with neural networks that require significant computational resources.

3.13.1 How transfer learning works

Transfer learning in computer vision involves leveraging the learned features from a pre-trained model on a related task and adapting it to a new task. In transfer learning, the earlier layers of the pre-trained model, which capture general features, are retained, while the latter layers, which are task-specific, are retrained or fine-tuned. By retraining only the latter layers, the model can specialize in the specific characteristics of the new task while benefiting from the general visual knowledge acquired from the earlier layers. This approach reduces the need for a large labeled dataset and can improve the model's performance on the new task. Transfer learning is particularly valuable when limited data or computational resources are available.

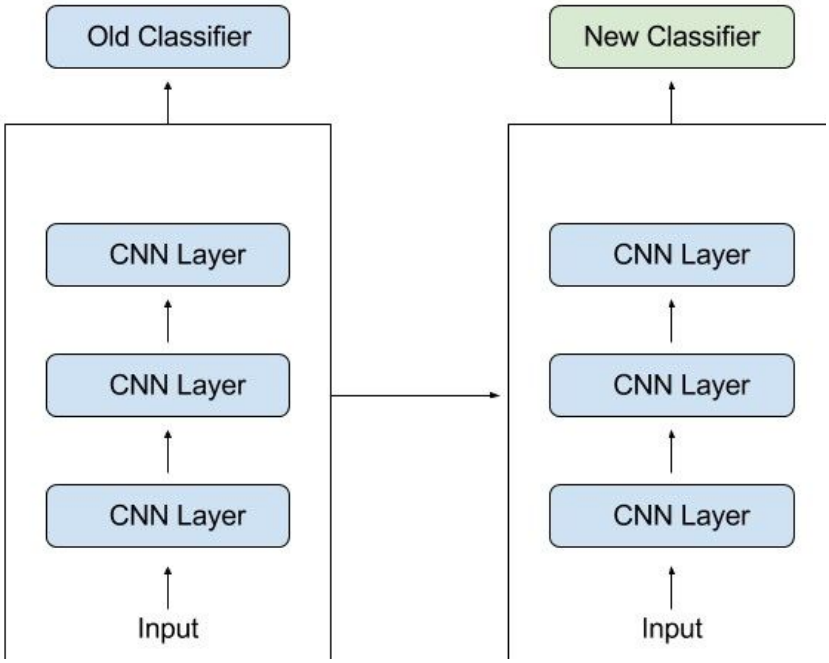

Figure 3.20: Transfer learning shema
[26]

3.14 Conclusion

This chapter provides an overview of several key ideas, beginning with AI and computer vision and progressing through Artificial Neural Network architecture and concluding with convolutional neural network models. Our objective was to offer a few details about the wor's background, making it simpler to grasp the work and its context.

Chapter 4

Experimentals

4.1 Introduction

In this chapter, we present the outcomes achieved upon implementing the suggested models. Next, we will go ahead and evaluate the obtained results.

4.2 Material

4.2.1 Working environment:

To accomplish the work, it is necessary to choose a working environment that allows us to work on machine learning projects and develop them.

- Working environment: To accomplish the work, it is necessary to choose a working environment that allows us to work on machine learning projects and develop them.
- Google Colab: It is a service provided by Google that offers a cloud-based integrated development environment (IDE) used for working on machine learning projects and software development. It allows you to run and execute Python code and work on notebooks efficiently from anywhere with an internet connection.
- Python: Python is an interpreted, object-oriented, high-level programming language with dynamic semantics. It is suitable for rapid application development and scripting tasks. Python's simple syntax emphasizes readability and reduces maintenance costs. It supports modules and packages for code modularity and reuse[20].
- Libraries:
  - NumPy: NumPy is a popular library in Python for numerical computing. It supports large, multi-dimensional arrays and matrices and a collection of mathematical functions to operate on these arrays efficiently. NumPy is widely used in scientific computing, data analysis, and machine learning tasks. It offers high-performance computations, broadcasting capabilities, and a rich set of tools for handling array data[5].
  - Tensorflow: TensorFlow is an open-source machine learning framework for all developers. It is used for implementing machine learning and deep learning applications. To develop and research fascinating ideas on artificial intelligence, the Google team created TensorFlow.TensorFlow is designed in Python programming language. Hence it is considered an easy-to-understand framework[55].
  - Keras: Keras is an API that prioritizes the needs of human users over machines. It adheres to best practices for reducing cognitive load by providing consistent and user-friendly APIs, minimizing user actions required for everyday tasks, and offering clear and actionable feedback in case of errors[28].

- Matplotlib: Matplotlib is a cross-platform data visualization and graphical plotting library (histograms, scatter plots, bar charts, etc.) for Python and its numerical extension NumPy. As such, it offers a viable open-source alternative to MATLAB. Developers can use Matplotlib's APIs (Application Programming Interfaces) to embed plots in GUI applications[3].
- OpenCV: OpenCV-Python is a comprehensive Python library valuable resource for image recognition, deep learning, and image analysis. It offers extensive functionalities and tools for efficiently processing and analyzing images[17].

4.3 Experimental settings

4.3.1 Dataset Selection:

Choosing the correct dataset is a crucial step in research and analysis, as the dataset forms the foundation for drawing conclusions and deriving insights. The process of dataset selection aims to obtain relevant and suitable data that aligns with the research question or specific objectives. Selecting a dataset involves a careful analysis

of research requirements and defined objectives. Identifying the essential variables and parameters that need to be studied and analyzed. These variables may include information such as age, gender, geographical location, behavior, interests, and more, depending on the nature of the research. Selecting a dataset involves

a careful analysis of research requirements and defined objectives. Identifying the critical variables and parameters that need to be studied and analyzed is essential. These variables may include information such as age, gender, geographical location, behavior, interests, and more, depending on the nature of the research. Once the

variables are determined, the dataset should be available and appropriate for the research. Data can be sourced from various sources, including digital environments or real-world settings. The dataset may be publicly available or require permission or licensing to access.

- Data Preprocessing: Preparing the data after collecting it is a critical stage, as it allows the production of a database that can be used for analysis and artificial intelligence. Next, we will make sure to mention the stages the images went through after the collection process.
- Data validation after capturing and storing the photos in a specific file for each camera, the classification process is done manually by examining each image individually. Based on the content and available information, the images are categorized accordingly. Once the classification is complete, any unrelated or uncategorized images are deleted.
- Rename and resize We rename all the images with meaningful names and then resize them to standardize the images.

- Remove duplicate image The process of removing similar images involves the following steps: Convert images to grayscale: This is done to standardize the image type by removing color information.
- Compare images using units: The images are compared using the root mean square (RMS) error. This involves calculating the difference between the two images' pixel values and finding the squared differences' average.
- Check RMS value: If the calculated RMS value is less than 3, it indicates that the images are similar or identical.
- Delete duplicate images: In the case of similar or identical images, one of them is deleted to eliminate duplication.
- Light At this point, we used color-processing techniques to reduce the yellowness in the photos of the dates as the sunlight was too strong. One of the methods used to adjust the white balance is the "Gray-World" algorithm by changing the color settings of the image to reduce the white color
- Haze in this stage, we have removed the haze present in the images using the haze map, which allows us to detect the locations of the haze using metrics such as haze intensity and color distribution.[23] The haze map relies on metrics like haze intensity and color distribution to determine the extent and spread of haze in the image. The haze intensity metric measures the level of haze interference in the image, with higher values indicating areas more affected by haze. This metric helps us determine the impact of haze on the image and adjust it accordingly.[23] Color distribution informs us about the distribution of colors in the image and how they are affected by haze. Haze can impact color balance and contrast in the image. Analyzing the color distribution helps us understand the changes that need to be made to remove haze effectively.[23] By utilizing these metrics, we can identify the areas most affected by haze and apply suitable haze removal techniques to enhance the image and recover lost details due t
- Data split In this stage, we divided the database into three sections: 80
- Data augmentation In this stage, we utilized data augmentation techniques to increase the size of our dataset. We applied this technique to the training dataset, focusing on images of diseased dates, as the training database was insufficient. By employing data augmentation, we enabled the model to train on images with different orientations and variations. This allowed the model to learn from a broader range of examples and improve its ability to handle diverse scenarios.

The next table will show the statistics of the database that was created without using the data augmentation technique

4.3.2 Hyperparameter Selection:

When training deep learning models, a set of hyperparameters is required, which can be considered configuration settings for the model. Adjusting these hyperparameters is typically done through multiple experiments.

category	number of image
Palme Tree	743
Palme tree head	304
infected data	1615
uninfected data	1056

Table 4.1: data set

- Batch size: Refers to the number of samples passed through the model in each training iteration. The batch size affects training speed and memory consumption, and in our work, the number of batches has been set to 39
- Epoch size: The number of epochs determines how many iterations or passes the model will make over the entire training dataset. In our work scenario, we used 70 epochs for training. This means the model will repeat the training process on the dataset 70 times.
- Loss function: Huber loss is a function used to train deep learning models. It is designed to be robust to outliers, data points that deviate significantly from the usual pattern. Huber loss works by minimizing the error between the expected values and the actual values of the data. It does this by using a piecewise function that switches between a quadratic and linear loss depending on the size of the error. This helps reduce the influence of outliers on the final loss, improving the model's performance. [58]
- Optimization algorithm: The optimization algorithm updates the model's parameters to minimize the loss. We used the Adam algorithm.[51]
- Calculate the average results: To calculate the average of the results among the outputs of the model, we used the probability layer

4.4 Work map

Using different models and forming ensemble models in our work in deep learning is an essential part of our strategy. We recognize that different models have different strengths and complexities, and therefore, utilizing a variety of models can enhance our ability to deal with diverse challenges in deep learning. Firstly, we employed three main models: VGG16, Inception V3, and ResNet50. The diversity of these models allows us to leverage their distinct strengths and varied complexities. For instance, VGG16 excels at feature extraction and image representation[60], while Inception V3 is known for its capability to handle complex classifications and geometric shapes[47]. ResNet50, on the other hand, can handle deep networks with high complexity[48]. We constructed four ensemble models from the main models to further enhance performance and reliability. These ensemble models were arranged as follows:

- Ensemble Model 1: Combining model1, model2, and model3.

- Ensemble Model 2: Combining model 1 and model 2.
- Ensemble Model 3: Combining model 1 and model 3.
- Ensemble Model 4: Combining model 2 and model 3.

In these ensemble models, we collect the probability predictions from the different models. This allows us to benefit from the average strength of the predictions and reduce the impact of individual models that may be less accurate at times. As a result, we achieve improved overall performance and make more reliable and accurate final decisions. Using ensemble models and extracting probability rates from these models is an effective method for unifying model expectations and calculating average results. Ultimately, we observe each model set's outcomes, refine them, and make comparisons. This helps us identify which results delivered good performance and more excellent reliability. By employing this strategy, we aim to leverage the diversity and integration of models to enhance the performance of our deep learning system.

4.5 Experimental results

Upon completing the training and testing of CNN models, the following outcomes were obtained:

- ResNet50 model:

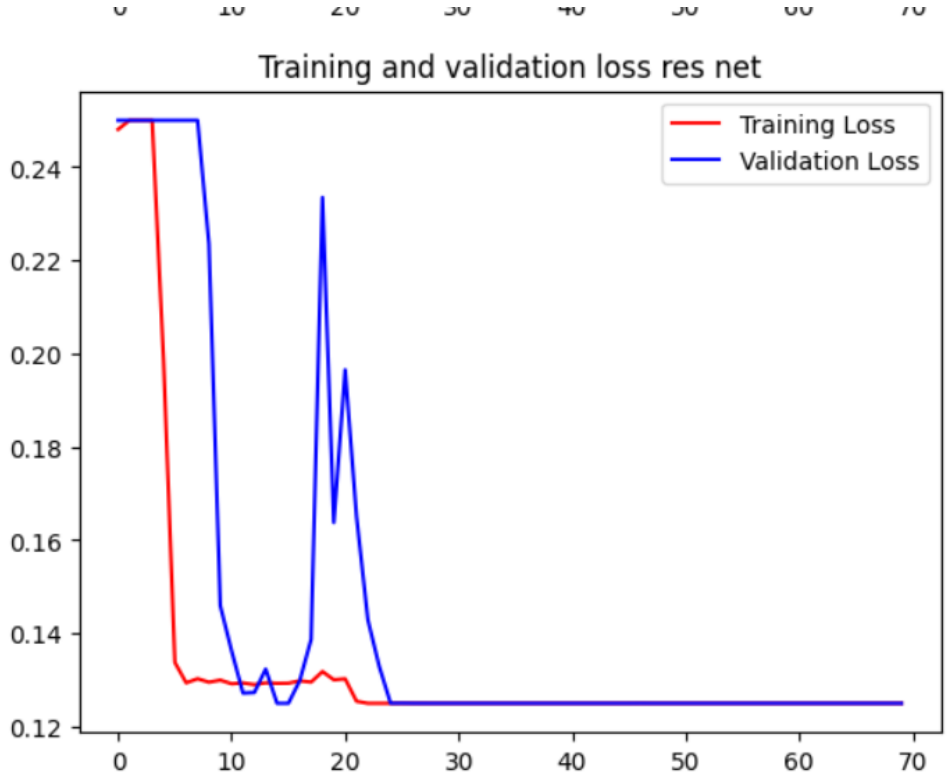

Figure 4.1: Training and validation loss (Res net50)

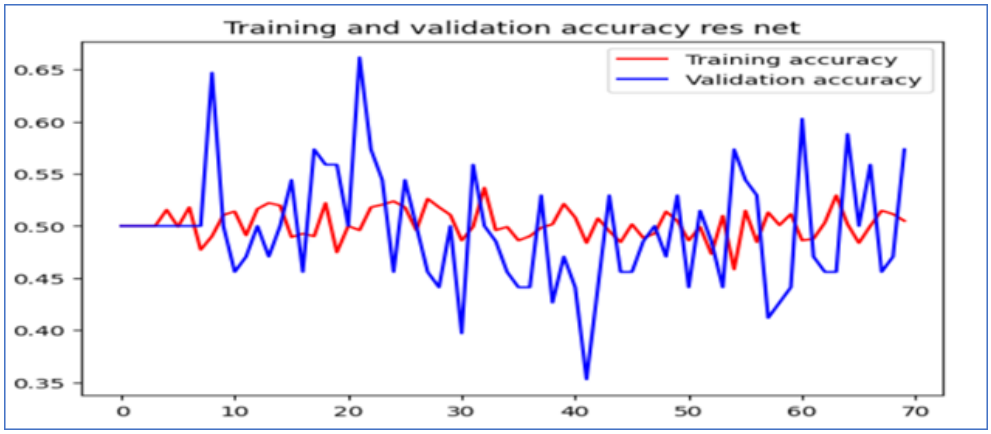

Figure 4.2: TTraining and validation accuracy (Res net50)

From the given results from figure 4.1 figure 4.2 several observations can be made: The training accuracy ranges from 0.4730 to 0.5368, while the validation accuracy ranges from 0.3529 to 0.6618. The loss value ranges from 0.1250 to 0.2500. Based on the provided results, it can be inferred that the model has difficulty accurately predicting based on the available data. The recorded accuracy during training and validation is around 0.5, indicating that the model makes random predictions between the two available classes.

II) VGG16 model:

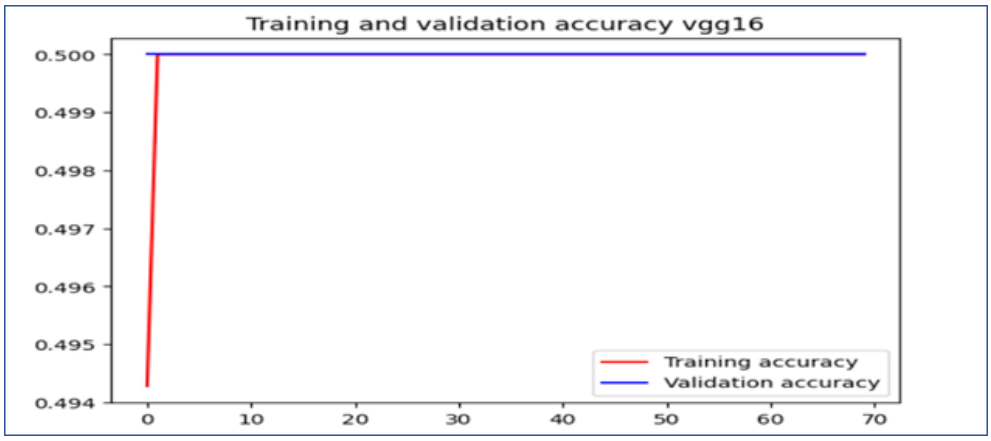

Figure 4.3: Training and validation accuracy (vgg16)

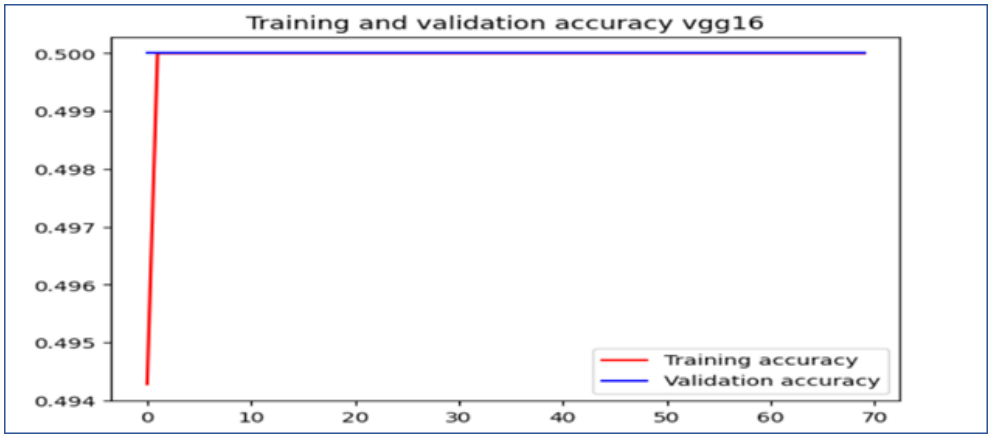

Figure 4.4: Training and validation accuracy (vgg16)

From the given results in figure 4.3 figure 4.4 several observations can be made: The training accuracy and validation accuracy in all epochs are 0.5. The loss value in all epochs is 0.25. These values indicate that the model is not learning properly and can not differentiate between the two classified categories. When the accuracy value is 0.5, it means that the model is randomly classifying the data and does not have a proper understanding of the data or the underlying pattern.

The repetition of the loss value (0.25) in all epochs suggests that the model needs to progress in reducing the loss during training.

III) InceptionV3 model:

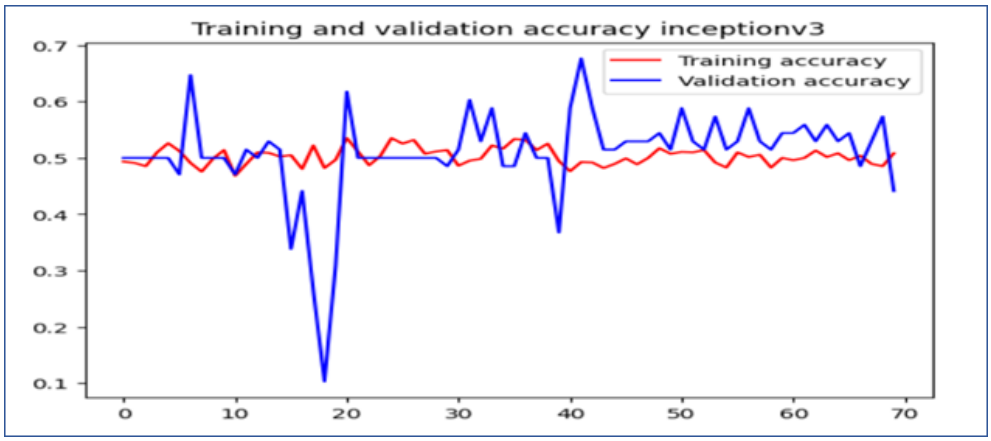

Figure 4.5: Training and validation accuracy (inception v3)

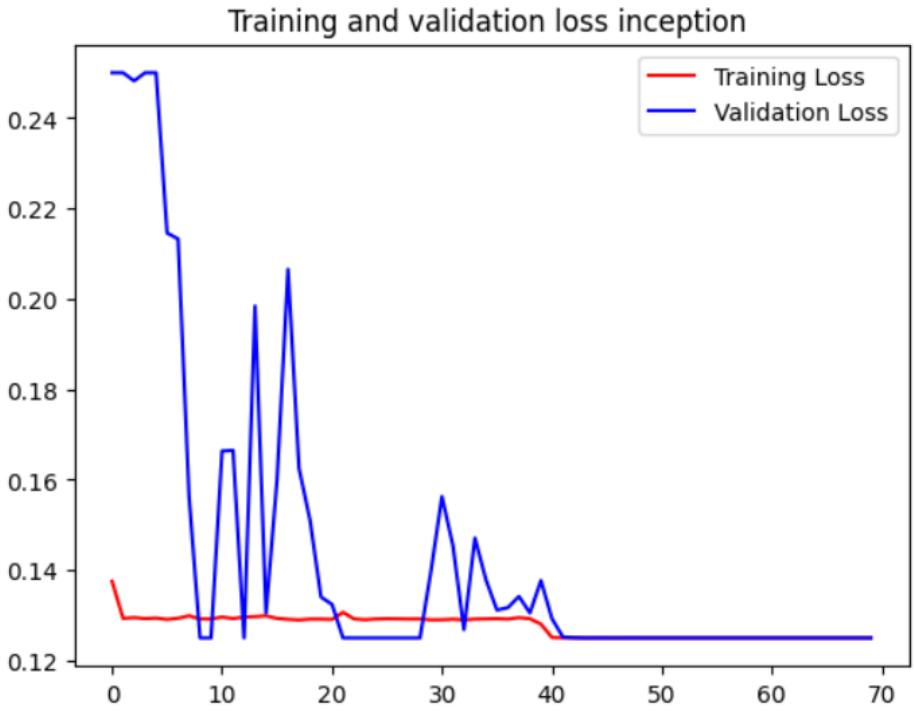

Figure 4.6: training and validation loss (inception v3))

From the given results from (4.5, 4.6), several observations can be made: The training accuracy ranges from 0.4681 to 0.5351, while the validation accuracy ranges from 0.1029 to 0.6765. The loss value ranges between 0.1250 and 0.1375. It can be observed that the model achieves a relatively high training accuracy, ranging from 0.46 to 0.53. However, the validation accuracy varies between 0.10 and 0.67, indicating that the model may be experiencing some issues with classification.

And after obtaining these results, we decided to use another technique, ensemble Learning, to improve the results.

Model	number of epochs	Accuracy train	loss train	Accuracy validation	loss validation	Accuracy
Inception v3	70	0.5082	0.1250	0.4412	0.1250	0.50
Vgg16	70	0.5000	0.2500	0.5000	0.2500	0.49
Res Net50	70	0.1250	0.5180	0.4412	0.1250	0.60

Table 4.2

4.5.1 Ensemble of model:

As we explained earlier, we have tested many learning groups, and their results are shown in the table below:

Model	number of epochs	Accuracy train	loss train	Accuracy validation	loss validation	Accuracy
Ensemble learning 1	70	0.1262	0.5000	0.5000	0.1327	0.49
Ensemble learning 2	70	0.5000	0.1252	0.5000	0.129	0.49
Ensemble learning 3	70	0.5964	0.0644	0.5000	0.0800	0.93
Ensemble learning 4	70	0.5000	0.1256	0.05000	0.1505	0.49

Table 4.3: Caption

After experimentation, we found that the third ensemble gave the best results. It is the combined result of inception v3 with res net50The. We decided that when using ensemble learning: Diverse models: Using various models contributes to improving the overall performance of Ensemble Learning. Each model has unique strengths, and by using aggregation techniques, these strengths can be combined to achieve better results. Difference in complexity and structure: The differences in complexity and structure of each model can contribute to developing a model that benefits from the strengths of each. For example, Inception V3 is skilled at extracting comprehensive information from images, while ResNet50 excels in handling complex data and fine details. Averaging: Calculating the average of the models' results can help improve the final outcome. Collecting models predicationthe and calculating their average, the shared knowledge is leveraged, and the impact of individual deviations is reduced. Proper use of loss function: Utilizing and properly adjusting the loss function contributes to improving the model's performance. By selecting the appropriate loss function and fine-tuning it, the model's ability to minimize loss and enhance overall performance is enhanced. Proper use of optimization function: Employing a suitable optimization function helps build a strong model during the learning process. The model's ability to learn and adapt to data is improved by selecting the appropriate optimization function.

And figure 26 shows the confusion matrix results and is considered very good.

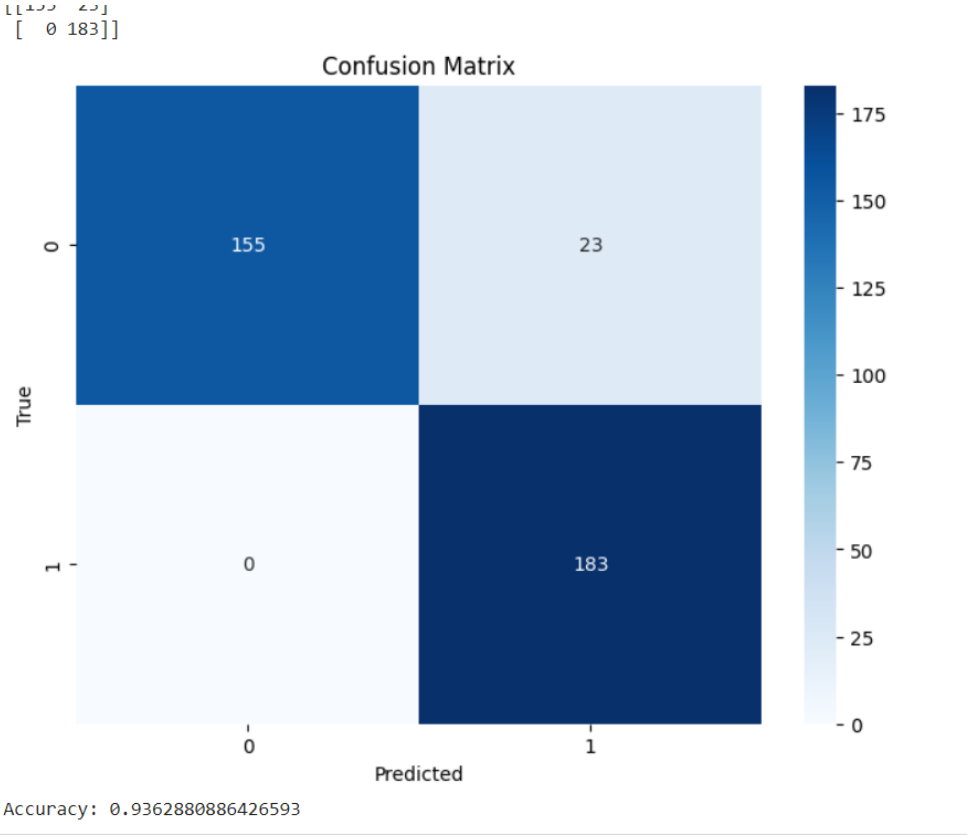

Figure 4.7: Confusion matrix (ensemble learning 3)

4.6 Conclusion

In this chapter, we'd like to present specific information about implementing the proposed method. This includes details about the libraries employed and the programming language utilized. Furthermore, we report on the experimental outcomes obtained from conducting experiments on the dataset. Additionally, we provide insights to facilitate comprehension of the results achieved.

Conclusion

General conclusion

he use of artificial intelligence in the detection and classification of natural images has witnessed extensive evaluation. Artificial intelligence techniques have demonstrated remarkable accuracy and sensitivity in identifying and classifying images. Artificial intelligence is applied to natural images in various fields, such as terrain analysis, animal and plant recognition, plant disease detection, weather and climate classification, and more. In our study, we focused on three main approaches: VGG-16, Inception V3, and ResNet50, aiming to enhance early detection and classification of palm trees infected with spider mites (OligonychusafrasiaticusMcGregor).

Initially, we implemented these methods from scratch using a dataset that we collected , modified, improved and expanded through different strategies to ensure a better outcome. Our main objective was to building a comprehensive and correct dataset that can be relied upon to detect pests affecting the plant. We worked to prepare them for (boufaoua)as the most prevalent pest in the country. Although the three models training were implemented equally quickly, the results were not effective at first when we use each model separately, but the work on experimenting to ensemble the results of each model with the other resulted in satisfactory results.

We faced challenges in collecting the necessary images in order to build the data set, the images of the uninfected palm were easy to find, but the infected one was not available because the pest had not yet been struck, but our introduction could be considered as a reliable preliminary result in the future. We also had difficulty dealing with hardware constraints. In addition, we experienced minor difficulties in understanding CNN concepts and engineering. We believe that the application of machine learning in the natural field is still in its nascent phase, and there are ongoing developments to deliver more useful upgrades. Moreover, we are optimistic that resource constraints will become less important in the future, as newer machines are very advanced and capable.

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