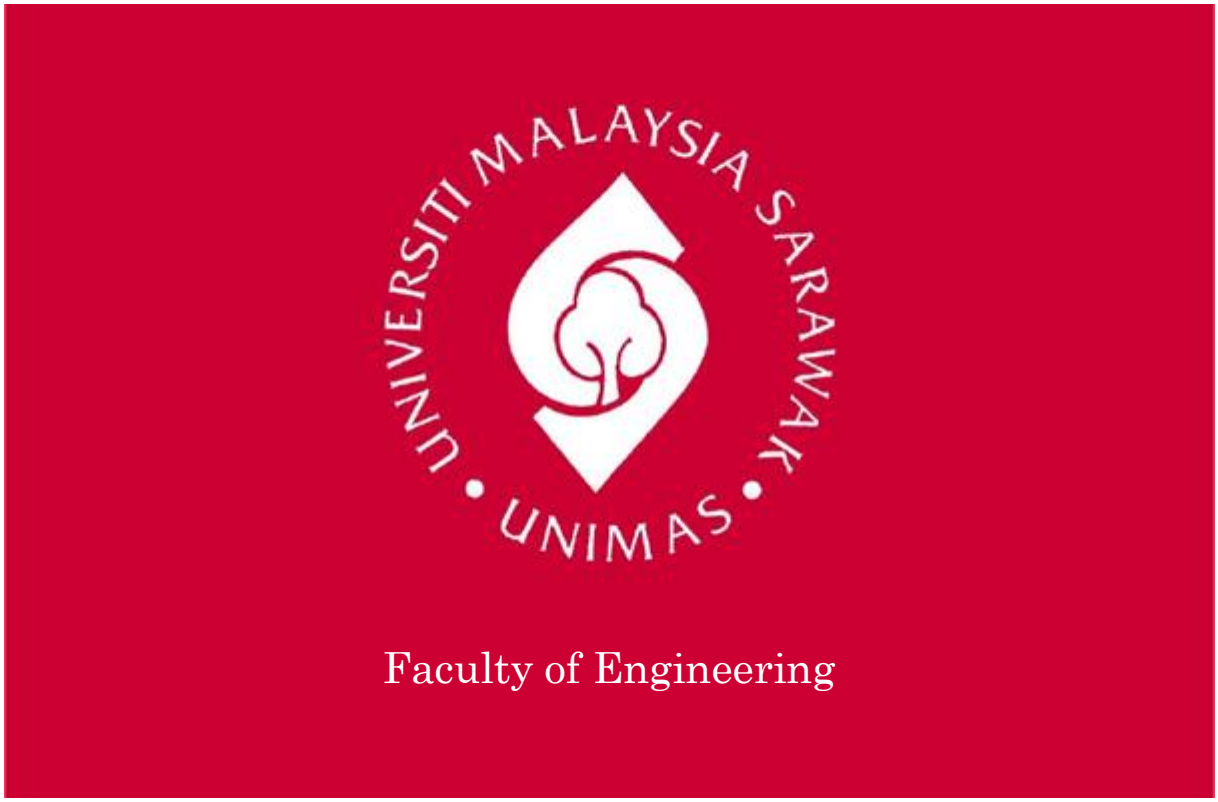

DETECTION OF FAULT INSULATOR BASED ON IMPROVED CONVOLUTION NEURAL NETWORK

Mohd Rahul bin Mohd Rafiq

Bachelor of Engineering

Electrical and Electronics Engineering with Honours

2023

UNIVERSITI MALAYSIA SARAWAK

Grade: _____

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PhD	

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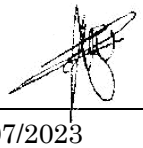
Supervisor signature:  Date: 20/07/2023

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DETECTION OF FAULT INSULATOR BASED ON IMPROVED CONVOLUTION NEURAL NETWORK

Detection Of Fault Insulator Based On Improved Convolution Neural Network

MOHD RAHUL BIN MOHD RAFIQ

A dissertation submitted in partial fulfilment
of the requirement for the degree of
Bachelor of Engineering
Electrical and Electronics Engineering with Honours

Faculty of Engineering

Universiti Malaysia Sarawak

2023

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.

ABSTRACT

An insulator is an essential component of a transmission line, serving to prevent the leakage of electricity flow from the conductors into the ground. It accomplishes this by creating a barrier between the conductors and the supporting structure. The insulator's atomic structure consists of electrons that are strongly bound and exhibit limited mobility. Researchers have researched a variety of methods for detecting insulators through the use of image processing in previous studies. The majority of contemporary detection systems use classifiers for this purpose. These methods use a classifier trained on a training set of images to recognise an object in a test image, despite the fact that there are a few drawbacks in terms of detection precision and speed. This thesis proposes a method for constructing a hybrid YOLOv5-Resnet50 system, with Resnet50 serving as the backbone of the YOLOv5 architecture. Using a hybrid of alternating and altering the backbone of the YOlOv5s structure, the proposed method achieves an accuracy of 99.0 ± 0.233% and a training time of 25 minutes for a set of 1,000 insulator images. This proposed method has the potential to aid in the inspection of high-up insulators, and it aims to reduce the manpower required to perform this task, which is one of the most dangerous and has a high fatality rate due to its high-voltage field and high-altitude placement. Future plans include expanding the dataset size in order to enhance the system further. Next is utilising a very high-end Specification of equipment by utilising a very excellent GPU and CPU to train the data more effectively.

ABSTRAK

Penebat adalah komponen penting dalam talian penghantaran, berfungsi untuk mengelakkan kebocoran arus daripada konduktor ke dalam tanah. Ia mencapai ini dengan mewujudkan penghalang antara konduktor dan struktur sokongan. Struktur atom penebat terdiri daripada elektron yang terikat kuat dan mempamerkan mobiliti terhad. Pengkaji telah meneliti pelbagai kaedah untuk mengesan penebat melalui penggunaan pemprosesan imej dalam kajian lepas. Majoriti sistem pengesanan kontemporari menggunakan pengelas untuk tujuan ini. Kaedah ini menggunakan pengelas yang dilatih pada set latihan imej untuk mengecam objek dalam imej ujian, walaupun pada hakikatnya terdapat beberapa kelemahan dari segi ketepatan dan kelajuan pengesanan. Tesis ini mencadangkan kaedah untuk membina sistem YOLOv5-Resnet50 hibrid, dengan Resnet50 berfungsi sebagai tulang belakang seni bina YOLOv5. Menggunakan hibrid berselang-seli dan mengubah tulang belakang struktur YOlOv5s, kaedah yang dicadangkan mencapai ketepatan 99.0 ± 0.233% dan masa latihan selama 25 minit untuk satu set 1,000 imej penebat. Kaedah yang dicadangkan ini berpotensi untuk membantu dalam pemeriksaan penebat tinggi, dan ia bertujuan untuk mengurangkan tenaga manusia yang diperlukan untuk melaksanakan tugas ini, yang merupakan salah satu yang paling berbahaya dan mempunyai kadar kematian yang tinggi kerana medan voltan tingginya. dan penempatan altitud tinggi. Pelan masa depan termasuk mengembangkan saiz set data untuk meningkatkan lagi sistem. Seterusnya ialah menggunakan Spesifikasi peralatan yang sangat canggih dengan menggunakan GPU dan CPU yang sangat baik untuk melatih data dengan lebih berkesan.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

CNN – Convolution Neural Network YOLO-You Only Look Once

SPP-Spatial Pooling Pool

RPN- Regional Proposed Method PANET- Path Aggregation Network FPN- Featured

Pyramid Network UAV- Unmanned Aerial Vehicle MAP- Mean Average Precision

FPS-Frame Per Second AP- Average Precision

IoU- Intersection Over Union RoI- Region of interest

CPU-Central Processing Unit GPU-Graphic Processing Unit TPU-Tensor Processing Unit

CHAPTER 1

INTRODUCTION

1.1 Background

Transmission lines are used to transmit electricity from the generating substation to the distribution units. It sends voltage and electric flow waves from one end to the other. The transmission line consists of a conductor with a constant cross-section over its length. Between the conductors, air acts as an insulator or dielectric medium.

The space between the cable and the floor is significantly larger to ensure the workers' safety. Transmission line wires are supported by the electrical tower. Steel is used in the construction of the towers so that the conductor has maximum support. Long-distance transmission of high voltage uses direct current and a transmission line that uses high voltage.

Insulators are the materials that hold and separate the conductors from each other and from ground, shield the conductors from environmental impacts, and allow for the conductors to be connected to the apparatus. Glass, ceramics, rubber, and plastic are only a few of the materials used to create insulators. Many different things rely on them, including high-voltage power transmission and distribution, electronic gadgets, and the insulation of buildings and other structures [1].

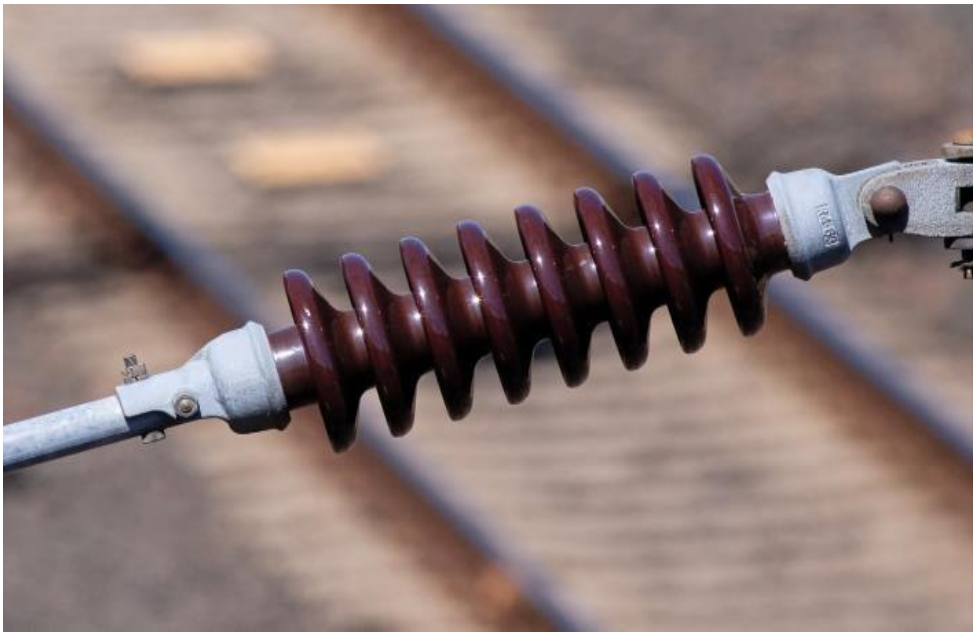

Figure 1.1 1 Insulator image [1]

In a nutshell, materials that have a high resistance to electric current are classified as electrical insulators. They stop the flow of electricity, preserve the integrity of electrical systems, and guarantee the security and effectiveness of a wide range of applications. Insulators are designed to have a high dielectric strength and resistivity, and in order to ensure that they meet the requirements and standards that have been set for them, they are put through rigorous testing.

From the past study, there are a lot of ways that have been studied by researchers regarding the detection of insulator by using image processing method. Most modern detection systems adapt classifiers for this purpose. These methods use a classifier trained on a training set of images to recognize an object in a test image. Recent methods, such as R- CNN, first use region proposal algorithms to build possible bounding boxes in an image before running a classifier on them. Classification is followed by post-processing to improve the bounding boxes by removing duplicate detections and rescoring them basedon the context of the scene. There is a limitation on using these R-CNN because every part of such extensive pipelines needs to be trained independently, they are slow and difficultto optimize.

By utilizing a single pass of an image, this convolutional neural network (CNN) architecture can recognize objects without resorting to area suggestions or further processing steps. To make its predictions, YOLO segments a picture into a grid of cells, where it then makes bounding box and class probability predictions for each cell individually [2]. This system also incredible quick because of it has more straightforward structure, this system able to complete its tasks far more quickly than faster RCNN.

In terms of accuracy, YOLO is not yet on par with other cutting-edge detection methods. It can quickly recognise things in photos; but it has trouble correctly localising some items, particularly little ones.

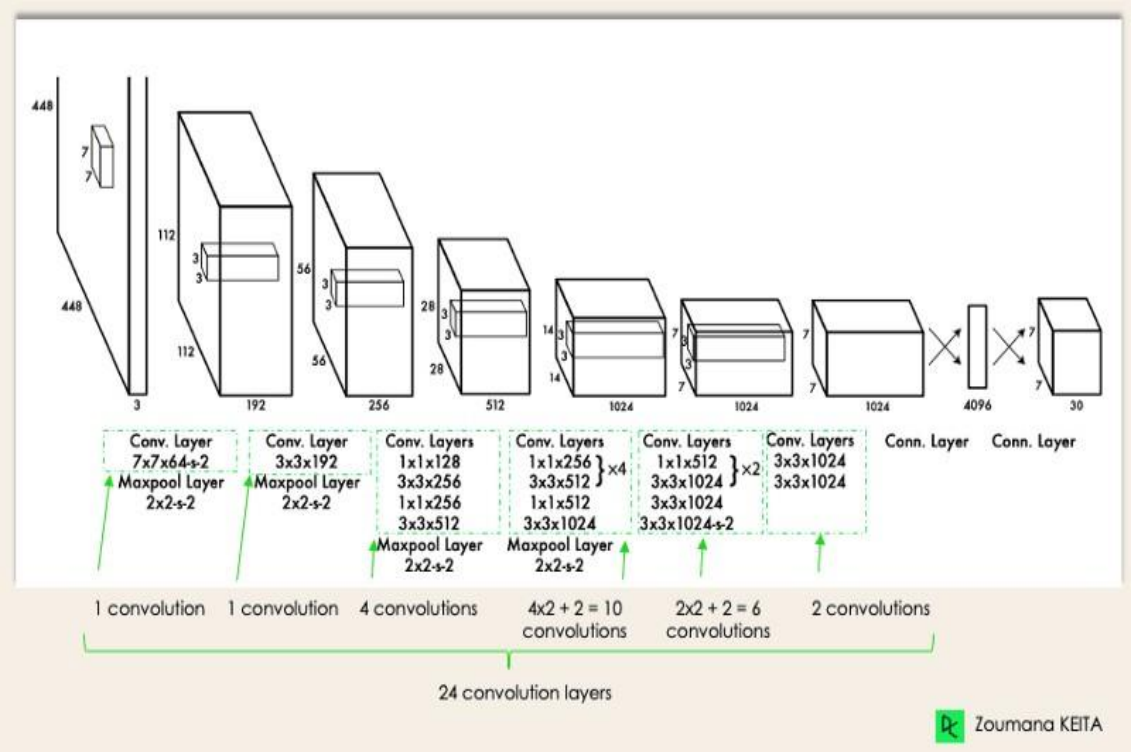

Figure 1.1 2 Yolo Architecture [2]

In 2015, Microsoft researchers created the ResNet-50 convolutional neural network design. The network has 50 hidden layers and was trained using the ImageNet database, which contains over a million photos. The ResNet-50 architecture is a subset of the original ResNet design, and it is well-known for its ability to train deeper neural networks without the vanishing gradients problem that plagues extremely deep networks. For this purpose, the "shortcut" or "skip" link is created between certain layers in the network in a "residual learning" procedure, facilitating the smoother transit of gradients across the network.[4]

ResNet-50 has been extensively used for a variety of computer vision applications, including image classification, object identification, and semantic segmentation. It has been shown to have excellent accuracy and strong generalisation capabilities, making it suited for large-scale image recognition applications.[4]

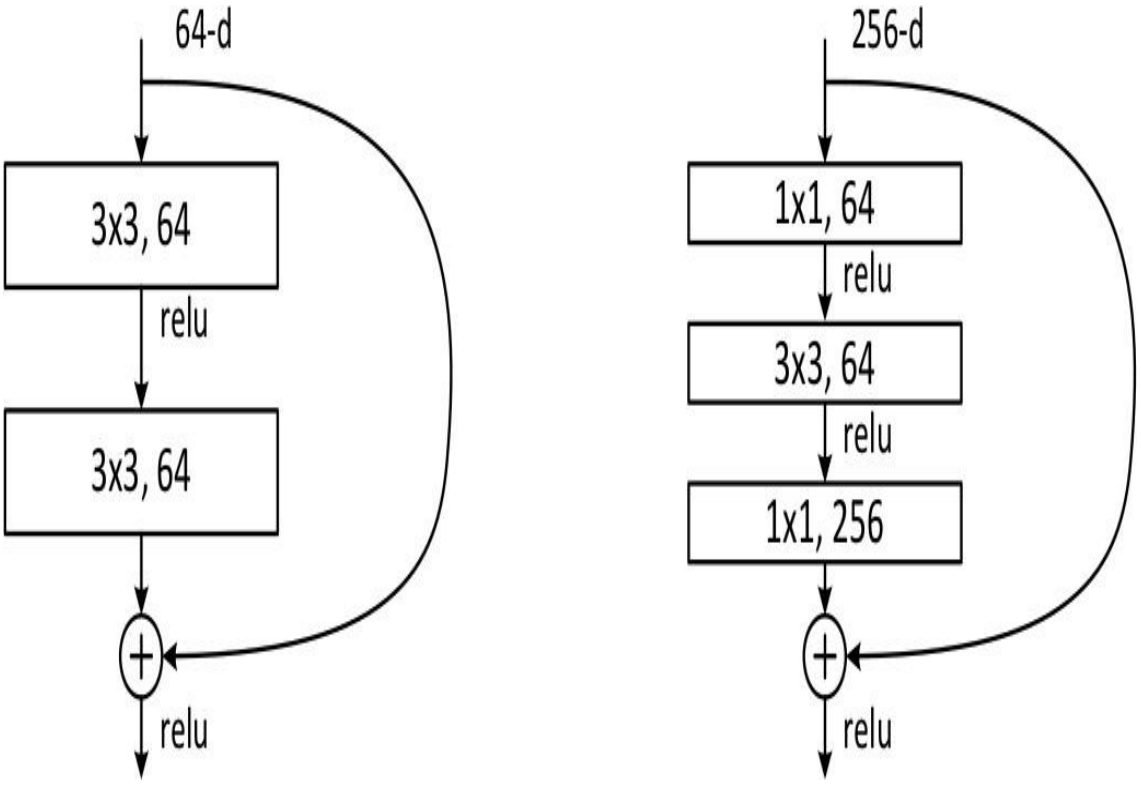

Figure 1.1 3 Resnet50 Architecture [4]

Spatial Pyramid Pooling (SPP) is a strategy for dealing with inputs of various sizes in convolutional neural networks (CNNs). SPP is based on the concept of dividing the input picture into a pyramid of sub-regions and then applying the max-pooling operation to each sub-region. This enables CNN to process variable-sized inputs by collecting data from several visual areas.

The SPP module may be incorporated into any CNN architecture, and it can be used to extract features from images of any size, which are then sent to a fully connected layer for classification. This makes CNN more robust to changes in the size of the image objects. SPP may also be used with other approaches, such as regional proposal networks (RPNs) and anchor boxes, to enhance the performance of object identification tasks [6].

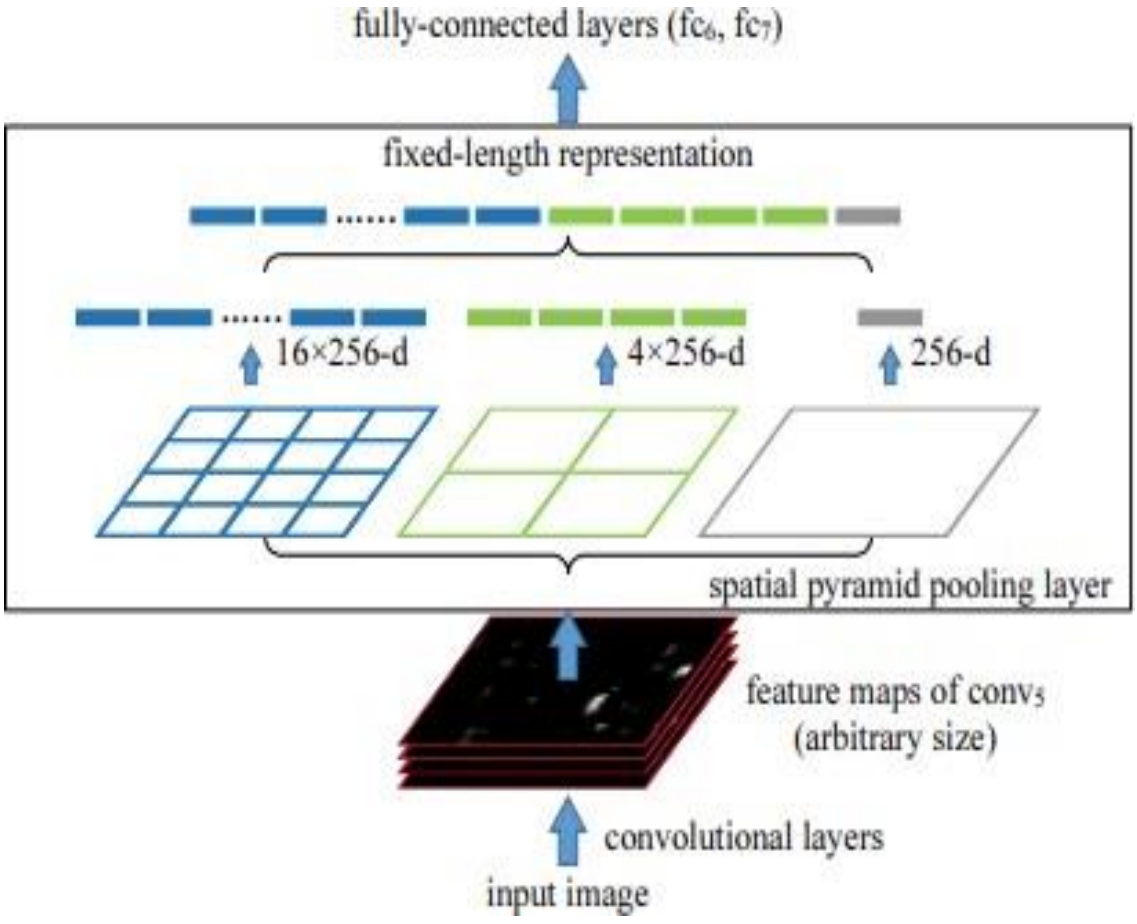

Figure 1.1 4 Spatial Pyramid Pooling Layer [6]

PANet (Path Aggregation Network) is an advanced object identification algorithm created in 2020 by Huawei engineers. It consists of a feature pyramid network (FPN) and a path aggregation network (PAN). The PANet employs an FPN-generated multi-scale feature pyramid to extract features from the input picture. In contrast, the PAN is used to aggregate the pyramid's characteristics and provide the final item detection results.[7]

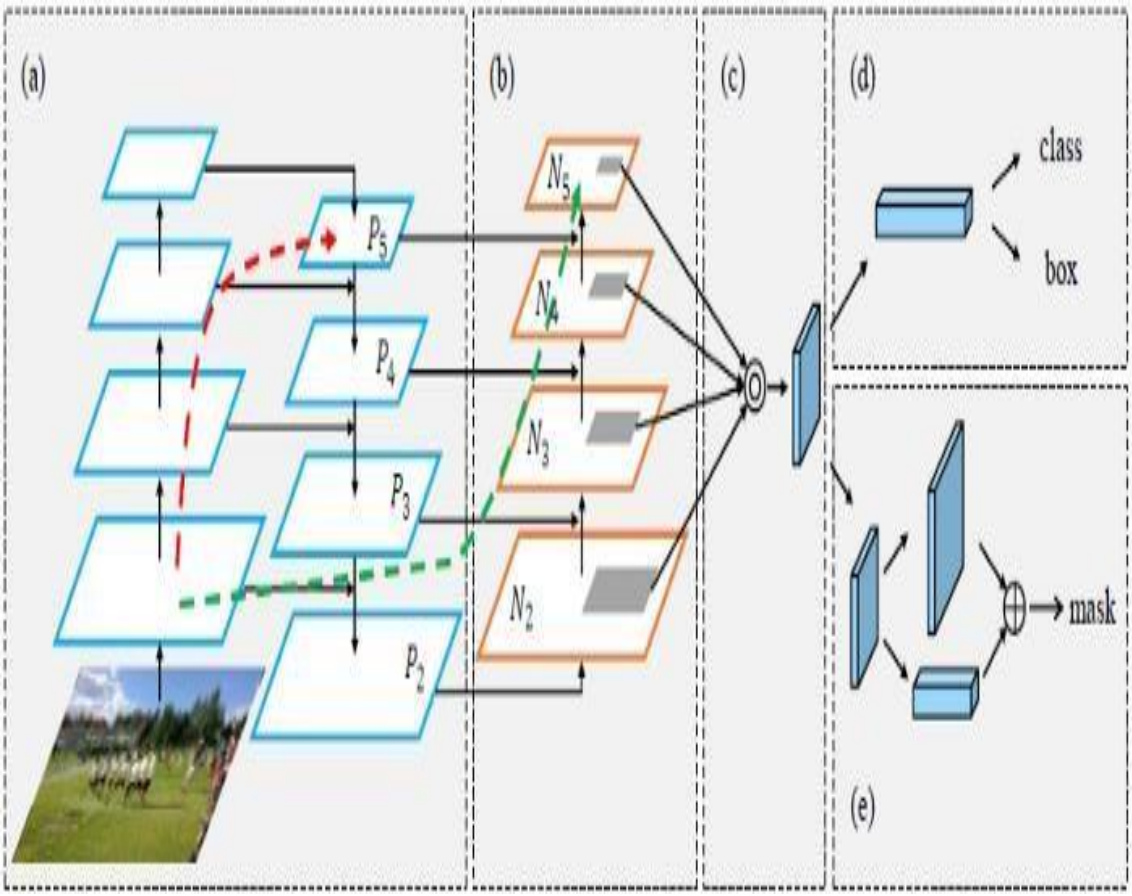

Figure 1.1 5 PANET Architecture [7]

PANet improves the FPN by incorporating an attention mechanism that enables the network to selectively concentrate on informative characteristics and suppress irrelevant or noisy data. In computer vision tasks, attention mechanisms have proven effective at capturing long-range dependencies and contextual information.

The PANet architecture combines characteristics from various levels of the feature pyramid and restores high-resolution data. Attention-guided representations are used to perform feature fusion, thereby enhancing the comprehensive feature representation.[18]

PANet has demonstrated enhanced performance in semantic segmentation tasks, particularly in capturing contextual information at various scales and improving the precision of object boundaries. It has been extensively adopted and is a potent instrument for computer vision research and applications.

All these CNN model types are essential components for creating a new model or enhancing an existing one by modifying its hyperparameters. A slight modification to each model yields a different result in terms of speed or accuracy of the model in detecting any variant of situation, based on the user's intent to conduct operations in any type of area in terms of detecting or evaluating a target.

1.2 Problem Statement

First problem statement discussed on the fault on the insulator at the power grid. Overhead transmission lines require insulators that are resistant to both mechanical and electrical forces. While mechanical stress comes from things like wind and conductor loads, electrical stress comes mostly from line voltage and can lead to the insulator failing. The electrical breakdown of the insulator might occur either through flash-over or piercing.

The goal is to develop an automated system that, given a dataset of photographs of insulators, can accurately detect problems in the insulators that are difficult to notice with the naked eye, such as minute cracks, punctures, or other sorts of damage. These flaws might not be noticeable to the human eye or by using standard visual examination methods. The system should work reliably regardless of the image's brightness, the insulator's position within the frame, or the faults' appearance. Generalization to novel insulator pictures not encountered during training is also a necessary capability.

If there is an arc between the line conductor and the insulator pin, the discharge will jump over the air gaps and take the quickest route. This is due to the insulator's dryness and good insulating characteristics on its surfaces. As a result, the arc can only happen in the air space between the pin and the conductor. Unless the insulator is destroyed by the intense heat generated by the arc, it will continue to function normally in the event of a flash-over.

When an insulator is punctured, an arc discharge travels from the conductor to the insulator pin through the insulator itself. As a result, the insulator has been irretrievably damaged by the extreme heat. A thick enough layer of porcelain is typically used in insulators to prevent line voltage from penetrating.

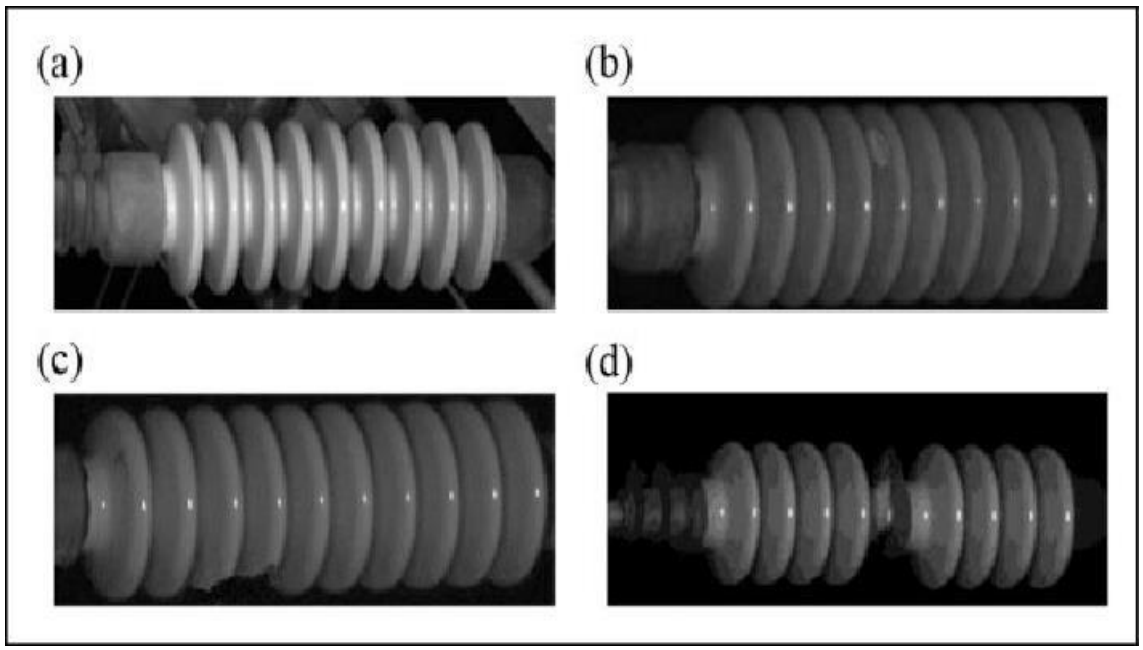

Figure 1.2 1 Example figure a) Good Insulator | b, c, d) Defect Insulator [1]

Another problem that came to the point that needed a solution is to detect the position of the fault insulator by using image processing by uploading a picture and able to detect which part the fault is. However, there has not been much images of faulty insulator using UAV and this bring to low dataset amount for the researchers to do their thesis. [25]

The precision of detection that are studied by a lot of researchers are lower for this detection by using any UAVs or image processing because of the error in detecting the image by mistaking any random object near the insulator itself.