AUTOMATIC ASSEMBLY FAULT DETECTION SYSTEM USING MACHINE VISION METHOD AND TRANSFER LEARNING

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A project report submitted
in fulfillment of the requirements for the degree of
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2022

DECLARATION

I declare that this project entitled Manufacture Assembly Fault Detection using Machine Vision Method and Transfer Learning” is the result of my own research except as cited in the references. The project report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature :

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Date : 18/01/2022

APPROVAL

I hereby declare that I have checked this thesis and in my opinion, this thesis is adequate in terms of scope and quality for the award of the Bachelor of Manufacturing Engineering Technology with Honours.

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Supervisor Name : Dr. Hadyan Hafizh

Date : 18/01/2022

DEDICATION

This research is lovingly dedicated to all my valuable treasures

For my beloved parents:

Abd. Halim bin Johar and Hasnah binti Musa

who have been my constant source of inspiration.

They have given me the drive and disipline to tackle

an task with enhusiast and determination.

Without their love and support

this project would not have

been made possible.

Not forgetting also to my supportive siblings:

Muhammad Fikri bin Abd. Halim, Nor Fadilah binti Abd. Halim

Raihanah binti Abd. Halim, Nurul Wahida binti Abd. Halim

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For my kindly and respected supervisor

Dr. Hadyan Hafizh

ABSTRACT

Defects and abnormalities in parts that affect the part's quality are a particular issue in additive manufacturing (AM) techniques such as at assembly line. At the moment, destructive and non-destructive testing methods are mostly employed to ensure the quality of additive manufacturing components after production. Machine learning (ML) techniques are increasingly being utilised in this area to allow computer-aided fault detection by automatically classifying production data. Convolutional neural networks (CNNs) based on machine learning techniques are often employed to accomplish this job. In this work, a transfer learning (TL) techniques for automatically classifying the defect in assembly process using relatively little datasets is proposed. The suggested techniques identify excellent faulty picture data and are able to classifiy the parts collected during component production using the CNN models with pretrained weights from the MobileNet dataset as initialization and a modified classifier. These findings demonstrate the efficacy of CNN-based part classification and provide a non-destructive quality assurance and production documentation approach for additively produced components.

ABSTRAK

Kecacatan dan kelainan pada bahagian yang menjejaskan kualiti bahagian adalah isu tertentu dalam teknik pembuatan aditif (AM) seperti di barisan pemasangan. Pada masa ini, kaedah ujian yang merosakkan dan tidak merosakkan kebanyakannya digunakan untuk memastikan kualiti komponen pembuatan aditif selepas pengeluaran. Teknik pembelajaran mesin (ML) semakin digunakan dalam bidang ini untuk membolehkan pengesanan kerosakan bantuan komputer dengan mengklasifikasikan data pengeluaran secara automatik. Rangkaian saraf konvolusi (CNN) berdasarkan teknik pembelajaran mesin sering digunakan untuk menyelesaikan tugas ini. Dalam kerja ini, teknik pembelajaran pemindahan (TL) untuk mengklasifikasikan kecacatan dalam proses pemasangan secara automatik menggunakan set data yang agak sedikit dicadangkan. Teknik yang dicadangkan mengenal pasti data gambar yang rosak yang sangat baik dan dapat mengelaskan bahagian yang dikumpul semasa pengeluaran komponen menggunakan model CNN dengan pemberat terlatih daripada set data MobileNet sebagai permulaan dan pengelas yang diubah suai. Penemuan ini menunjukkan keberkesanan klasifikasi bahagian berasaskan CNN dan menyediakan pendekatan jaminan kualiti dan dokumentasi pengeluaran yang tidak merosakkan untuk komponen yang dihasilkan secara tambahan.

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CHAPTER 1

INTRODUCTION

1.1 Background

With today's growing automation in production, automated part quality checking with little human interaction is also required. The trend in quality inspection automation is to achieve human-level accuracy or greater. To maintain their competitive edge, contemporary industrial businesses aim to automate both quantity and quality without sacrificing either. This article walks the reader through an application of artificial intelligence technology and demonstrates the importance of optimising the entire stack (algorithms, inference framework, and hardware accelerators) for best performance.

The internet of things is critical in transforming any system into an intelligent one. To satisfy the requirements of contemporary systems, modern operating systems are employed. Numerous platforms for the Internet of Things have been created. However, the Internet of Things is rapidly growing in popularity and is playing a significant role in improving living quality. The term "Internet of Things" refers to a broad concept of items, particularly ordinary objects, that are readable, identifiable, locatable, accessible through information sensing devices, and/or controlled over the Internet, regardless of the communication medium used (whether via RFID, wireless LAN, wide area networks, or other means). (KK Patel, SM Patel, 2016) Not only can everyday objects contain electronic gadgets and products of greater technical development such as cars and equipment, but also items that we do not normally consider to be electronic at all - Massive current breakthroughs and development are the primary drivers of Internet of things developments. The device's continuous adaptability requires the utilisation of widely available, low-cost hardware. The way forward is to develop Internet of Things operating systems that can handle freshly developed hardware while adhering to established communication protocols and standards at all levels. (Al Turjman, F., 2019). The Internet of Objects (IoT) is more sophisticated and diverse than the Internet, as it necessitates a massive amount of interaction between things and humans. According to IDC's Worldwide IoT Taxonomy (2015), the IoT market is expected to be worth 1.7 trillion US Dollars, with hardware accounting for the lion's share (35%), followed by services (27%), connectivity (22%), and software (12%). (16 percent).

As defined by Minsky and McCarthy (the "fathers of AI"), AI is any job performed by a programme or computer that would need a person to utilise intelligence to complete if undertaken by a human. AI is currently widely employed in a wide variety of applications in the modern information society. Artificial intelligence and the fourth industrial revolution have made significant strides in recent years. As you will see in subsequent blogs, the majority of this current development that is useable has been created for industrial and corporate objectives. Research institutions and specialised firms are advancing the ultimate objective of AI (cracking artificial general intelligence), establishing open platforms and examining the ethical implications. There are also a number of firms developing AI solutions aimed at consumers, which is how we'll begin this series of posts: "Artificial intelligence is similar to climbing a tree in order to reach the moon; one may report continuous progress all the way to the summit of the tree". (Liam Hanel, 2017)

Machine vision (MV) is a term that refers to the technologies and techniques used in industry to perform imaging-based automated inspection and analysis for a variety of applications including automatic inspection, process control, and robot guiding. Machine vision is a broad category of technology that includes software and hardware, integrated structures, action, processes, and experience. Machine vision is distinct from computer vision, which is a subfield of computer science. It aims to innovate by combining current technologies and applying them to real-world issues. While the term "machine vision" is defined differently by different people, it refers to the technology and methods used to extract information from images automatically, as opposed to image processing, which results in another image. The retrieved data may be as basic as a signal indicating which parts are acceptable and which are poor, or as complicated as the identity, position, and orientation of each item in a picture. The data may be utilised in a variety of industrial applications, including automated inspection and guiding for robots and processes, as well as security monitoring and vehicle guidance (Steger & Carsten, 2018). This area includes a diverse range of technologies, software and hardware products, integrated systems, processes, and expertise (Mark & Bruce, 2005). Machine vision is almost exclusively used to refer to these capabilities in industrial automation applications; the phrase is less used in other contexts, such as security and vehicle guiding. Machine vision as a field of systems engineering is different from computer vision as a subset of fundamental computer science. Machine vision seeks to expand the capabilities of current technologies and apply them to real-world problems in ways that satisfy the requirements of industrial automation and other relevant application fields (Alex, 2016).

Machine vision systems are a collection of connected components that are intended to automatically direct manufacturing and production activities such as go/no testing and quality control processes by using information collected from digital pictures. These systems may also assist in automated assembly verification and inspection activities by guiding component handling equipment to the proper location for a particular procedure. They are useful in a variety of sectors and may be used to automate any boring, repetitive activities that would become tiresome for a human inspection or operator. Machine vision systems provide 100 percent inspection of products or components throughout a process, resulting in higher yields, decreased defect rates, increased quality, reduced costs, and more process consistency.

Machine vision is defined by the Automated Imaging Association (AIA) as "all industrial and non-industrial applications in which a combination of hardware and software assists devices in performing their functions via the gathering and processing of images." While industrial computer vision applications make use of many of the same concepts and approaches as academic/educational and governmental/military computer vision applications, they have unique constraints.

Industrial vision systems need higher levels of robustness, dependability, and stability than academic/educational vision systems and are usually considerably less expensive than those employed in governmental/military applications. Thus, industrial machine vision is associated with low cost, acceptable accuracy, high robustness, high reliability, and superior mechanical and thermal stability. Machine vision systems collect images using digital sensors embedded in industrial cameras equipped with specialised optics, which are then processed, analysed, and evaluated by computer hardware and software to aid in decision making.

The following illustration illustrates the many critical components of a machine vision system, which include the lighting system, lenses, vision sensor, image processing, vision processing, and communications.

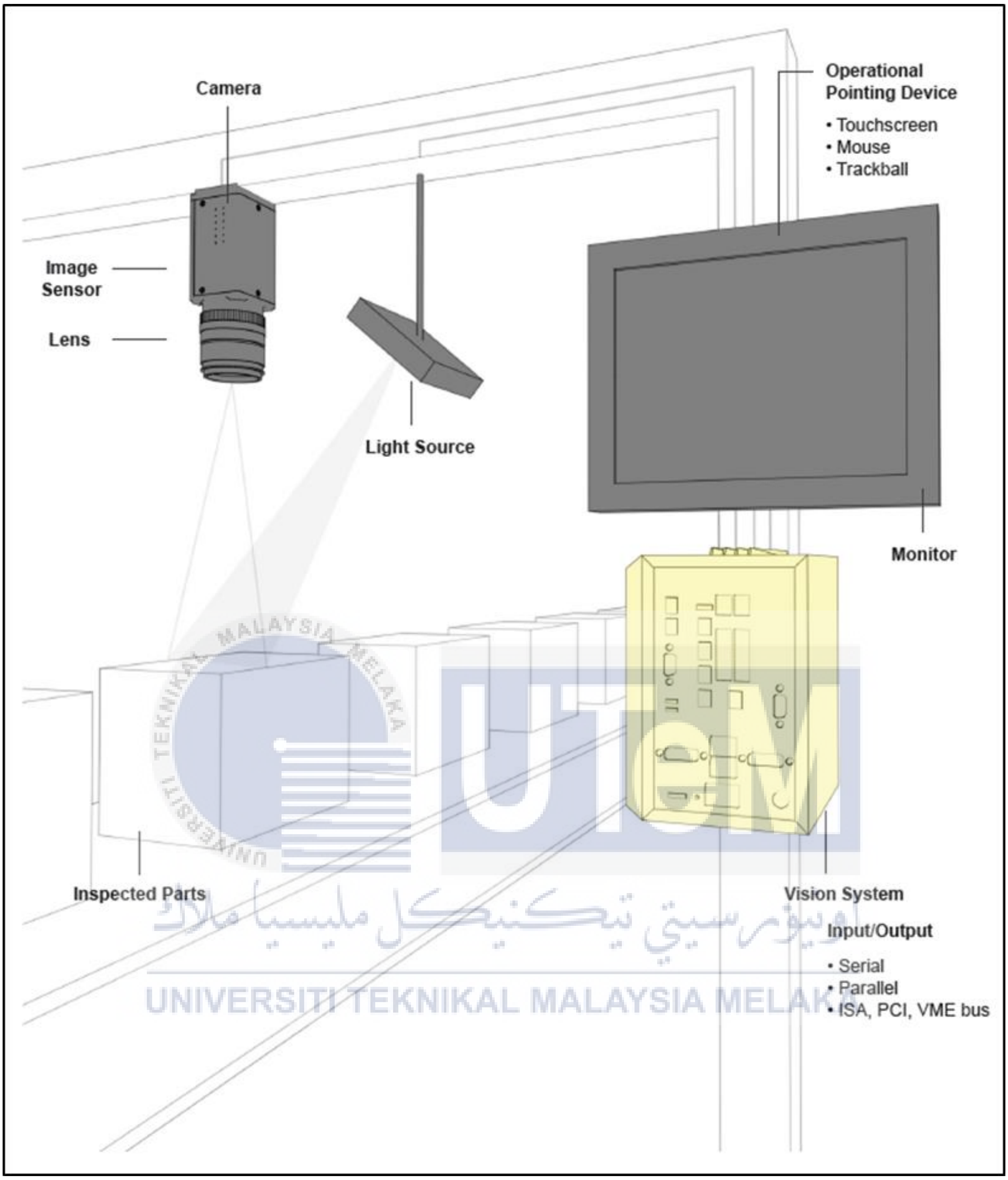

Figure 1.1 Main components of a machine vision system.

Transfer learning has emerged as a promising area of machine learning due to the breadth of its application possibilities. Due to its use, it has generated a plethora of methods and activities. Transfer learning is the process of improving target learners' output in a target domain by transferring knowledge from dissimilar but related source domains. In other words, we may train a model with better generalisation using data from different domains or tasks. Transfer learning will alleviate the need for massive quantities of target-domain data, enabling the creation of target learners. Transfer learning has developed lately in the areas of computer vision (CV) and natural language processing (NLP), significantly increasing the performance of the most advanced technologies across a broad range of CV and NLP applications.

Rotating equipment is extensively utilised in contemporary industries. Critical components of these machines are prone to failure due to the harsh working environment in which they operate. The most often occurring faults in rotating machines are imbalance, misalignment, rub, and bearing and gear damage. These flaws may result in further damage to the equipment if not detected in a timely manner, resulting in catastrophic casualties and huge loss. Health management through decision-making methods is gaining popularity in today's environment and is often used to monitor different parts of rotating equipment. A sufficient number of samples from the source domain is used to train the updated CNN. Following that, the model is fine-tuned using tiny data samples from the target domain for the purpose of identifying flaws. The proposed deep learning model is evaluated on two kinds of data sets: gear and rotor. The planned work's concluding findings have been compared to the existing state-of-the-art. The comparative study demonstrates the suggested methodology's superiority over current techniques.

1.2 Problem Statement

The problem statement are formulated based on the background and motivation. Since the quality control is a fundamental component of many manufacturing processes, especially in assembly line jobs, there are some problems to solve:

- How to design an automatic part recognition system based on artificial intelligence framework?
- How to integrate the machine vision technique and AI-based transfer learning models in a lightweight technology stack?
- What is the practical and industrial applicability of the AI-based part recognition system?

1.3 Research Objective

Research objectives must be aligned with the research question. Each objective must answer each research question. Therefore, the formulated objectives can be listed as follow:

- To design an automatic assembly part detection system for autonomous part recognition
- To integrate machine vision technique and AI-based transfer learning models in a lightweight technology stack.
- To test the applicability of the developed system using industrial case study.

1.4 Scope of Research

Scope of the current research work can be summarized as follows:

- The project is develop based on Processing Software with Java Script language and Raspberry Pi Microcomputer. Also using a camera and -localhost for the platform.
- The data are captured in form of image from the camera to be used as input for the recognition task performed by CNN model.
- This project is limited only to performed recognition task of similar machining parts.

1.5 Research General Planning

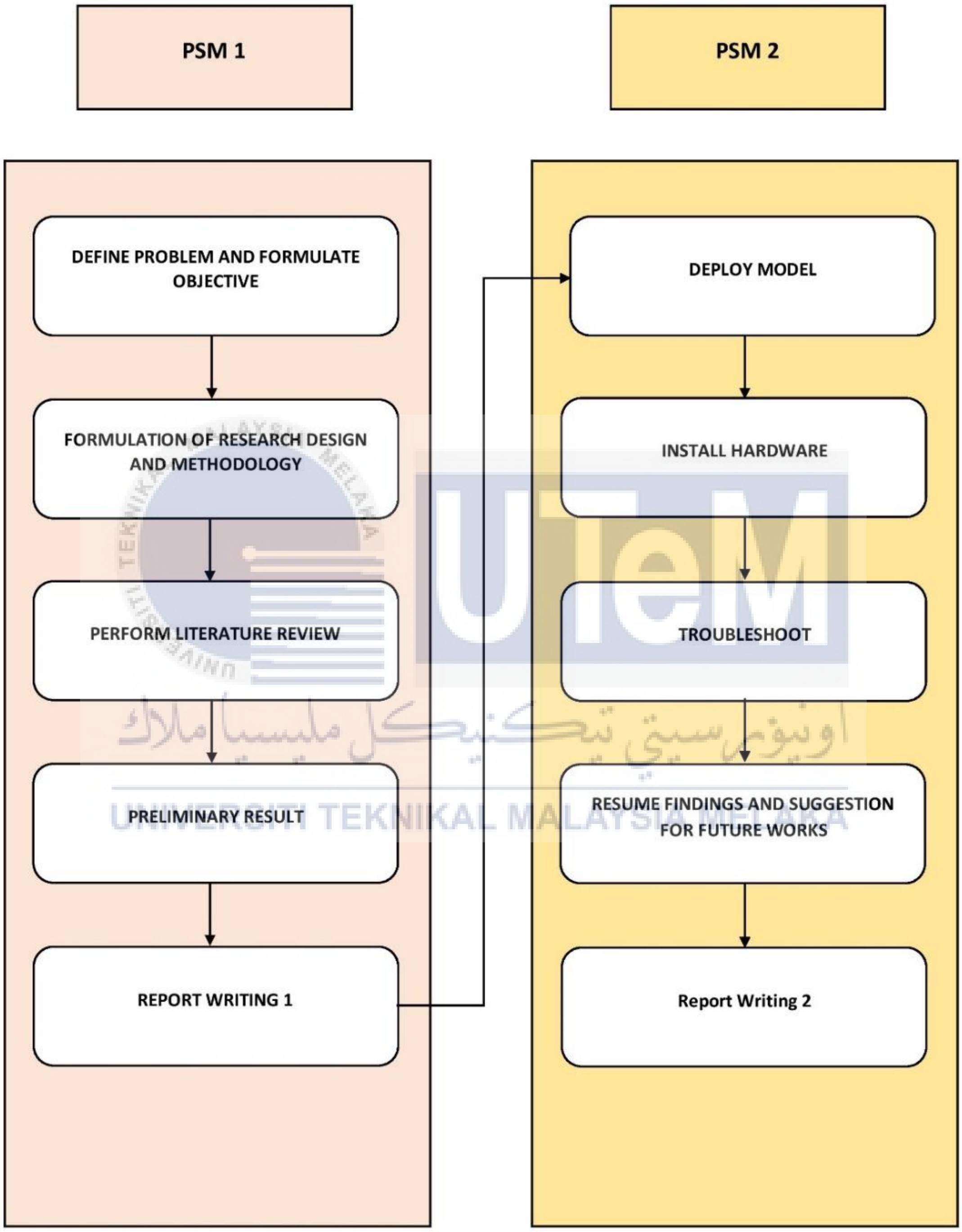

Figure 1.2 Flow Chart of the General Planning