Literature Review Project Plan

for Master in AI and Automation Programs at University West

1 Title

Optimizing efficiency and accuracy in manufacturing of low volume products: A study on machine vision-based quality control system.

2 Students

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3 Course

PAI700 – Project Work in AI and Automation

4 Amendment record

Rev	Date	Purpose	Nature of change
1	26/04/2024	To supervisor	Initial version
2			
3			
4			

5 Background

Machine Vision (MV) techniques are continually gaining traction and importance in human daily applications. In the recent days, MV has been adopted to play pivotal role in the industries for various industrial use and application, ranging from process control and monitoring, and in specifics automated inspection of products either during production, after production, or final inspection just before products leaves the factory as part of quality control [1].

Quality control has become a major aspect of all industrial manufacturing, and it contains all processes and tasks organized to foresee that products maintain their consistency in functionality, reliability, and safety, and comply with all required standards and regulations as obtainable in different industry [2]. Moreso, for manufacturer to gain the highly demanding customer satisfaction, trust and ultimately loyalty for the brand, good quality control processes are required and for this process to be successful it need to be flexible, highly repeatable, and of course cost effective [3], [4].
Furthermore, in the era where manufacturing industries are faced with the challenge of ensuring full match of the final product with the functional prototype, and demands for high quality customized products, low-volume manufacturing techniques or approach has found expression in industries, to ensure utilization of resources efficiently, waste minimization and reduce environmental impact [5]. Low-volume manufacturing industries are also faced with the challenge of releasing new products within a limited time while ensuring quality, cost-effectiveness, innovation, coupled with the lack of training for personnel and final verification of production processes for new product [5], a highly dependable quality control system must be put in place for these industries to deliver effectively in order to benefit maximally from low-volume production.

In ensuring a state-of-the-art quality control system in low volume manufacturing and ensuring that market demands and requirement are being met sustainably, engineers have developed diverse MV techniques, including and not limited to, MV with Deep Learning based image processing [2], [6], MV with algorithmic analysis of image dimensions [3], MV with neural networks and transfer learning, to replace human errors emanating from stress and fatigue of performing monotonous tasks [7].

6 Purpose

The purpose of this work is to examine diverse application of Machine vision in low volume industrial quality control. It focuses on how it has been adopted and engineered to solve diverse quality control tasks, its performance, efficiency and sustainability, integration into production line and limitations in implementing machine vision systems for quality control.

7 Aim(s)

Main goals

- Research various applications of Machine Vision (MV) in low volume product quality control.
- Evaluate the benefits and possible challenges of imploring Machine vision for quality control in low volume products.

Sub goals.

- Study different use cases of Machine Vision in Quality control of low-volume product.

- Assessment of various successes achieved with Machine vision in quality control of low volume products.
- Study conclusion.

8 Theory/related research

Machine vision (MV) has proven to have the needed potential for industries to be able to meet up with the task of ensuring that a high-quality product that meets customer demands and satisfaction, standard and other safety regulations guiding such production by aiding in a timely, efficient, and repeatable quality control. As such eliminating human errors due to fatigue from repetitive task and other environmental factors [3]. Several implementations of Machine vision have been engineered, although there is no any organized, defined framework guiding the implementation of a quality control based Machine vision systems [2].

Attempts have been made in the recent to evaluate an approach for MV based quality control but does not necessarily generalize a wholistic design or method, it rather focuses more on the general components of such system, how individual components influence and relate with each other, and how it can be implemented to ensure less implementation time and ultimately less cost [2], [6].

MV with several other Machine Learning algorithms have been used in quality control [1] , [8], for instance; in inspecting empty glass bottles for abnormality in the bottle mouth, the used technique and algorithm had an accuracy score of 99.41%, also, Huang *et al*. uses Support Vector Machine (SVM) to study the detection of bottle mouth defects with an accuracy rate of 91.6% [8]. In another study, Huang *et al*. also use MV with connected domain search algorithm; an algorithm that works by tracking specific defined dimension of the bottle and comparing such with predefine base parameters and thereby calculating average error(s) to classify the bottle mouth [8]. Akundi & Reyna seems to have follow the same approach as above in their studies, by using MV with a dimensional analysis algorithm similar to the connected domain search algorithm [3].

In another study, real-time surface defect recognition of parts produced by a die-casting process using MV system was designed, Andriosopoulou *et al* leveraged comparatively on the power of R-CNN, a convolutional neural network base algorithm, and transfer learning, using YOLOv5 detection networks. A satisfactory detection of the surfaces was reported with mean average precision of 0.77 for R-CNN and 0.65 for YOLOv5 [7].

Generally, individual authors have adopted MV methods and algorithm that seems convenient to their specific problems. Depending on the nature of different industry's product line, nature of specific product, MV based quality control systems might be adaptable for use across multi-product inspection, the system developed in [3] could identify defect across products of diverse shape and minute defect up to millimetre sized defects. While in some cases it might not be adaptable. However, the advantage of MV based quality inspection cannot be overstated despite various limitations stated by various authors in their studies.

9 Investigative question(s)

- How do the characteristics of low-volume production environments impact the implementation and effectiveness of machine vision-based quality control systems?

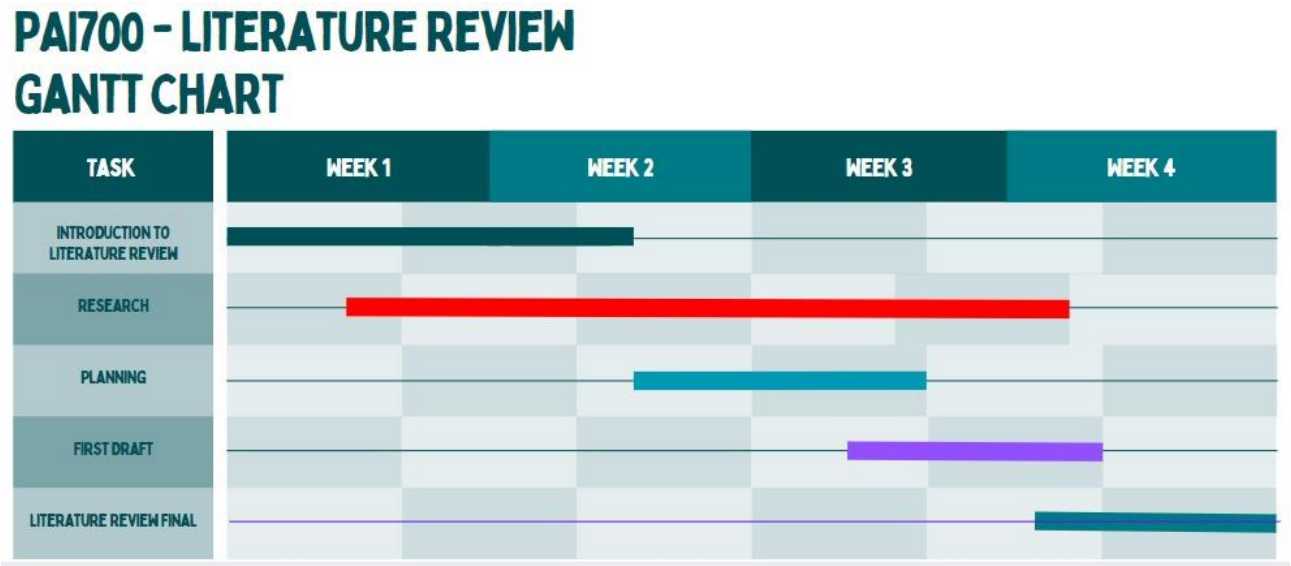
- What alternative or complementary approaches could be explored to address the limitations of machine vision systems in low-volume manufacturing contexts, particularly regarding efficiency and accuracy optimization?
- What strategies can be employed to mitigate the risks of over-reliance on machine vision systems in low-volume manufacturing, particularly in scenarios where manual inspection or intervention may still be necessary?

10 Limitations

- This study focuses on optimizing efficiency and accuracy in the manufacturing of low-volume products specifically, the conclusions drawn may not be directly applicable to settings with higher production volumes.
- The effectiveness of machine vision-based quality control systems may vary depending on the complexity of the manufacturing processes and the diversity of product types. Therefore, the study's applicability to other manufacturing contexts may be limited.

11 Schedule and activity plan

The following Gantt Chart has been crafted to illustrate the chronological order of activities, delineating their respective scopes and the specific weeks during which they are slated for execution.



12 References

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