German International University
Informatics and Computer Science

Automating Quality Control in Industry 4.0 Using Machine Learning

Bachelor Thesis

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Supervisors: Dr Nada Sharaf
Submission Date: 20/11/2022

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This is to certify that:

(i) the thesis comprises only my original work toward the Bachelor Degree

(ii) due acknowledgement has been made in the text to all other material used

Author
XX July, 20XX

Acknowledgments

Text

Abstract

Abstact

Contents

Acknowledgments **III**

1 Introduction **1**
1.1 Section Name . . . 1
1.2 Another Section . . . 1

2 Background **3**
2.1 Machine Learning . . . 3
2.1.1 Overview of Machine Learning . . . 3
2.1.2 Supervised Machine Leaning . . . 3
2.1.3 Unsupervised Machine Leaning . . . 4
2.2 Deep Learning . . . 4
2.2.1 Overview of Deep Learning . . . 4
2.2.2 Deep Learning Applications . . . 4
2.2.3 Deep Learning Algorithms . . . 5
2.3 Neural Networks . . . 6
2.3.1 Overview of Neural Networks . . . 6
2.3.2 Types of Neural Networks . . . 6
2.3.3 Application of Neural Networks . . . 7
2.4 NLP - Natural Language Processing . . . 8
2.5 Transformers . . . 8
2.6 Speech to Text APIs . . . 8

3 Methodology **9**

4 Literature Review **11**
4.1 Image Acquisition . . . 11
4.2 Image pre-processing . . . 11
4.3 Image Segmentation . . . 11
4.4 Feature Extraction . . . 12
4.5 Classification . . . 12

5 Conclusion **13**

Appendix **14**

A Lists **15**
List of Abbreviations 15
List of Figures 16

References **17**

Chapter 1

Introduction

1.1 Section Name

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1.2 Another Section

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Chapter 2

Background

2.1 Machine Learning

2.1.1 Overview of Machine Learning

Machine learning (ML) is a field of inquiry devoted to understanding and building methods that 'learn', that is, methods that leverage data to improve performance on some set of tasks. It is seen as a part of artificial intelligence. Machine learning algorithms build a model based on sample data, known as training data, in order to make predictions or decisions without being explicitly programmed to do so. Machine learning algorithms are used in a wide variety of applications, such as in medicine, email filtering, speech recognition, agriculture, and computer vision, and many other applications . Machine learning tasks can be classified into two categories: Supervised Learning and Unsupervised Learning

2.1.2 Supervised Machine Leaning

Supervised learning, also known as supervised machine learning, is a subcategory of machine learning and artificial intelligence. It is defined by its use of labeled data sets to train algorithms that to classify data or predict outcomes accurately. As input data is fed into the model, it adjusts its weights until the model has been fitted appropriately, which occurs as part of the cross validation process. Supervised learning helps organizations solve for a variety of real-world problems at scale. Supervised machine learning can be classified into two categories : Regression and Classification.

Some of the supervised machine learning algorithms are:

1. Linear Regression
2. Logistic Regression

3. Support Vector Machine (SVM)
4. Naive Bayes

2.1.3 Unsupervised Machine Leaning

Unsupervised Learning is a machine learning technique in which the users do not need to supervise the model. Instead, it allows the model to work on its own to discover patterns and information that was previously undetected. It mainly deals with the unlabelled data.Unsupervised Learning Algorithms allow users to perform more complex processing tasks compared to supervised learning. Although, unsupervised learning can be more unpredictable compared with other natural learning methods. Unsupervised learning algorithms include clustering, anomaly detection, neural networks, etc.
Unsupervised machine learning can be classified into two categories: Clustering and Association

Some of the supervised machine learning algorithms are:

1. K-means clustering
2. K-NN (k nearest neighbors)

2.2 Deep Learning

2.2.1 Overview of Deep Learning

Deep learning, also called deep neural networks, is originated from modelling biological vision and brain information processing. Deep learning is one part of the contents of machine learning or machine intelligence. Deep learning is closely related to mathematics, especially optimization, graphical theory, numerical analysis, functional analysis, probability theory, mathematical statistics, information theory, etc. These subjects could provide the analysis for a neural network model. Usually, when we measure a neural network or evaluate an algorithm

2.2.2 Deep Learning Applications

Deep Learning is a part of Machine Learning used to solve complex problems and build intelligent solutions. The core concept of Deep Learning has been derived from the structure and function of the human brain. Deep Learning uses artificial neural networks to analyze data and make predictions. It has found its application in almost every sector of business. And here are some applications

1. **Virtual Assistants**

   Virtual Assistants are cloud-based applications that understand natural language voice commands and complete tasks for the user. Amazon Alexa, Cortana, Siri, and Google Assistant are typical examples of virtual assistants. They need internet-connected devices to work with their full capabilities. Each time a command is fed to the assistant, they tend to provide a better user experience based on past experiences using Deep Learning algorithms.

2. **Language Translations**

   Machine translation is receiving a lot of attention from technology businesses. This investment, along with recent advances in deep learning, has resulted in significant increases in translation quality. According to Google, transitioning to deep learning resulted in a 60% boost in translation accuracy over the prior phrase-based strategy employed in Google Translate. Google and Microsoft can now translate over 100 different languages with near-human accuracy in several of them.

3. **Healthcare**

   Deep Learning has found its application in the Healthcare sector. Computer-aided disease detection and computer-aided diagnosis have been possible using Deep Learning. It is widely used for medical research, drug discovery, and diagnosis of life-threatening diseases such as cancer and diabetic retinopathy through the process of medical imaging.

4. **Virtual Assistants**

   Speech recognition, also known as automatic speech recognition (ASR), computer speech recognition, or speech-to-text conversion, is a function that allows programs to process human speech in a written format. Although often confused with voice recognition, speech recognition focuses on converting speech from a spoken format to a text format, while voice recognition only attempts to recognize the voice of a single user. There are many speech recognition apps and devices available, but the most advanced solutions use machine learning. They integrate the grammar, syntax, structure and composition of speech and audio signals to understand and process human speech.

2.2.3 Deep Learning Algorithms

1. **Convolutional Neural Networks (CNNs)**

   Within Deep Learning, a Convolutional Neural Network or CNN is a type of artificial neural network, which is widely used for image/object recognition and classification. Deep Learning thus recognizes objects in an image by using a CNN.

CNNs are playing a major role in diverse tasks/functions like image processing problems, computer vision tasks like localization and segmentation, video analysis, to recognize obstacles in self-driving cars, as well as speech recognition in natural language processing. As CNNs are playing a significant role in these fast-growing and emerging areas, they are very popular in Deep Learning.

2. **Recurrent Neural Networks (RNNs)**

   Recurrent neural networks (RNNs) are the state of the art algorithm for sequential data and are used by Apple's Siri and Google's voice search. It is the first algorithm that remembers its input, due to an internal memory, which makes it perfectly suited for machine learning problems that involve sequential data. It is one of the algorithms behind the scenes of the amazing achievements seen in deep learning over the past few years.

3. **Long Short Term Memory Networks (LSTMs)**

   LSTMs are a type of Recurrent Neural Network (RNN) that can learn and memorize long-term dependencies. Recalling past information for long periods is the default behavior. LSTMs retain information over time. They are useful in time-series prediction because they remember previous inputs. LSTMs have a chain-like structure where four interacting layers communicate in a unique way. Besides time-series predictions, LSTMs are typically used for speech recognition, music composition, and pharmaceutical development.

2.3 Neural Networks

2.3.1 Overview of Neural Networks

A neural network is a series of algorithms that endeavours to recognize underlying relationships in a set of data through a process that mimics the way the human brain operates. In this sense, neural networks refer to systems of neurons, either organic or artificial in nature. Neural networks can adapt to changing input; so the network generates the best possible result without needing to redesign the output criteria. The concept of neural networks,

2.3.2 Types of Neural Networks

1. **Feed-Forward Neural Networks**

   One of the simpler varieties of neural networks is the feed-forward network. Through input nodes, it transmits information in a single direction, processing it in this manner until it reaches the output mode. Feed-forward neural networks may include

hidden layers for functioning. Most frequently employed for facial recognition technology

2. **Recurrent Neural Networks**

   Recurrent neural networks take the output of a processing node and feed it back into the network, making it a more complicated sort of neural network. This causes theoretical "learning" and network enhancement. Each node keeps a record of previous operations, which are later utilised while processing data. This is crucial for networks if the forecast is wrong since the system will try to figure out why the right thing happened and adjust. Applications for text-to-speech are frequently utilised using this kind of neural network.

3. **Convolutional Neural Networks**

   Convolutional neural networks, commonly known as ConvNets or CNNs, have a number of layers where categories of input are sorted into. A hidden plethora of convolutional layers are sandwiched between the input and output layers in these networks. The layers provide feature maps that catalogue regions of an image that are further subdivided until they produce useful outputs. These networks are very useful for applications involving image recognition because these layers can be combined or connected fully.

2.3.3 Application of Neural Networks

1. **Facial Recognition**

   Facial Recognition Systems are serving as robust systems of surveillance. Recognition Systems matches the human face and compares it with the digital images. They are used in offices for selective entries. The systems thus authenticate a human face and match it up with the list of IDs that are present in its database. Convolutional Neural Networks (CNN) are used for facial recognition and image processing. Large number of pictures are fed into the database for training a neural network. The collected images are further processed for training.

2. **Weather Forecasting**

   The forecasts done by the meteorological department were never accurate before artificial intelligence came into force. Weather Forecasting is primarily undertaken to anticipate the upcoming weather conditions beforehand. In the modern era, weather forecasts are even used to predict the possibilities of natural disasters. Multilayer Perceptron (MLP), Convolutional Neural Network (CNN) and Recurrent Neural Networks (RNN) are used for weather forecasting. Traditional ANN

multilayer models can also be used to predict climatic conditions 15 days in advance. A combination of different types of neural network architecture can be used to predict air temperatures.

3. **Healthcare**

   Modern day individuals are leveraging the advantages of technology in the healthcare sector. Convolutional Neural Networks are actively employed in the healthcare industry for X ray detection, CT Scan and ultrasound. As CNN is used in image processing, the medical imaging data retrieved from aforementioned tests is analyzed and assessed based on neural network models. Recurrent Neural Network (RNN) is also being employed for the development of voice recognition systems.

4. **Social Media**

   No matter how cliche it may sound, social media has altered the normal boring course of life. Artificial Neural Networks are used to study the behaviours of social media users. Data shared everyday via virtual conversations is tacked up and analyzed for competitive analysis. Neural networks duplicate the behaviours of social media users. Post analysis of individuals' behaviours via social media networks the data can be linked to people's spending habits. Multilayer Perceptron ANN is used to mine data from social media applications.

2.4 NLP - Natural Language Processing

2.5 Transformers

2.6 Speech to Text APIs

Chapter 3

Methodology

Methodology

Chapter 4

Literature Review

4.1 Image Acquisition

The acquisition of images is captured through various ways such as camera, Light Detection and Ranging (LiDAR), and sensors (both passive and active)[2]. Most of the captured images are in RGB (Red, Green And Blue) form, where the colour transformation structure of the RGB image is created [1]. However [2] stated that each sensor has some limitations, as RGB are highly sensitive to lighting conditions and background colours.Converts the RGB value to HSV colour space.

4.2 Image pre-processing

Raw images are generally unsuitable for the extraction of appropriate features for computer vision and image processing applications. To reduce the distortions and noise a significant pre-processing is essential [2]. Various techniques are used such as cropping the image (to cut out unintended information), smoothing filters, Image enhancements for contrasts, and creating histogram equalizations on grey images using colour conversions and their intensities [1]. Representation of three-dimensional objects in two-dimensional images cause geometric distortion which is subject to the relative position of the camera and the object in the case of still images and the speed, stability and angle of the camera for mobile robotic applications [2].

4.3 Image Segmentation

To extract the distinct section of an image as a Region of Interest (ROI) image segmentation is performed. Segmentation means partitioning of an image into various part of same features or having some similarity. A preliminary segmentation can be achieved by

detecting the edges and subtracting the unwanted objects or backgrounds from the image. Lower and upper threshold selection to find a discontinuity is crucial for the extraction of edge pixels in complex images and different edge detection techniques have a tendency to detect a false edge in pre-processed images. Hence, edge-based segmentation is less suitable for images with a similar background, occlusion and mixed edges . Pixel level threshold for generating regions in the images has been used for threshold segmentation. Greyscale techniques have been altered for RGB images by applying a threshold on three channels separately [2]. Or converting gray-level images into binary images by setting all pixels below the threshold to zero and all pixels above that threshold to one. Another technique used is K-means clustering where its object is based on a set of features in K number of classes. This classification of the object is done by minimizing the sum of the squares of the distance between the object and the corresponding cluster [1].

4.4 Feature Extraction

A piece of information related to some particular dynamic property of an object in a digital image with a higher level of perspective i.e. recognition, classification, retrieval and reconstruction is called a feature descriptor. Feature Extraction is used to validate the accuracy and efficiency of an image using features like colour, texture, shape and etc. There are various techniques to extract features from mages like Global Color Histogram, Color Coherence Vector, Local Binary Pattern and Complete Local Binary Pattern [2].

4.5 Classification

There are various technique for classification: Artificial Neural Network, Backbone Propagation Neural Network, Feed forward Back propagation Neural Network, Probabilistic Neural Network, Support Vector Machine [1]. Multiclass Support Vector Machine and etc. Linear and non-linear hyper-dimensional data can be classified with the SVM which is a non-linear mapping of data with the help of kernel functions. KNN is an instance based non-parametric similarity measure learning for data of infinite dimensions and a decision tree is a probability based graph for multi-class classification. SVM and KNN have been widely used for fruit and vegetable classification and a comparable classification effectiveness w.r.t. Multi-layer Perceptron (MLP) and Radial Bias Functions (RBF) has been reported [2].

Chapter 5

Conclusion

Conclusion

Appendix

Appendix A

Lists

AC	Acronym Without Citation
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List of Figures

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