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Project Title: Can machine vision be used to improve efficiency in manufacturing?

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Can machine vision improve efficiency in manufacturing?

1. Introduction and Aims

The demand for mass-produced goods is rapidly increasing as the Earth's population, and their disposable income, rises. This is likely to lead to an increase in the number of factories in operation, as more are built to keep up with the ever-increasing demand. In an effort to make factories more efficient by reducing operating costs, research is being conducted into using machine vision along the manufacturing lines as both a position validation and error checking system.

The aim of this project is to produce a machine vision system capable of detecting faults at strategic locations within the FischerTechnik model factory, that will be used to determine if the use of machine vision is a viable method to improve performance on factory production lines.

In order to make sure that the project is running on schedule progress will be regularly reviewed against the Gantt chart and adjustments to variables such as time allocations for tasks, will be adjusted accordingly.

2. Objectives

This project has potential benefits to society, as reducing operating costs and increasing factory performance and output could lead to cheaper products for the consumer. Additionally, the need for humans to perform monotonous or dangerous tasks could be eliminated, thereby reducing errors and injuries.

The project does not have any direct ethical issues because it does not make use of human or animal tissue. However, there are some potential long-term ethical ramifications in that the utilisation of such technology could result in the loss of available jobs in manufacturing plants, though other jobs would be created as a result, such as additional maintenance workers or technicians. There is also the potential issue of an increased carbon footprint due to additional factories being built, but on the other hand making factories more efficient could also reduce their number as less would in effect produce more goods.

In addition, there could be further ethical implications if this technology was being employed in the manufacture of weapons or toxic substances which could be used to harm people or the environment.

3. Scope

This project is relevant to the degree 'BEng Robotics' because it will show that machine vision potentially has multiple applications in the field of robotics and within manufacturing as a whole, both pertinent to this degree. For instance, machine vision could be used for position verification as it will be in this project, or used to examine products off a manufacturing line as a means of quality control in factories.

If this project were to be continued into a master's programme there are a few possible extensions to be considered:

Utilising colour cameras could enhance product differentiation and error finding.

Multiple cameras could be pointed at different locations within the model factory, such as the crane and the storage rack, with camera data then being automatically analysed to control the system; for instance, if camera 'A' overlooking the storage rack reported an error then the crane could be stopped, and camera 'B' observing the crane could provide verification on how the error happened. Or perhaps the cameras could be used more in tandem to control the speed of the crane rather that completely stopping it, in order to regulate any disturbances in the flow.

Additionally, a rotatable camera could be positioned on a track, allowing it to move around the factory. This would give a supervisory view of the whole model factory, allowing the system to identify any bottlenecks or other potential issues and react accordingly.

4. Proposed research questions

- What different techniques are there for identifying shapes within the field of machine vision?

This is a key question for using machine vision as without ways to recognise standardised geometric shapes, objects will never be found with any degree of reliability.

- What is and how effective is the Hough circle transform for finding circles within an image?

The Hough circle transform is a method used to find circles within images and seems to be the most widely used technique for doing so. This question is particularly important to this project because the cargo used in the model factory are circular.

- What methods can be used to detect when a certain object enters the frame?

This knowledge will be necessary so that the location verification programme only runs when the cargo is within the frame, thus saving computational power and reducing energy consumption.

5. Initial research and literature review

(Edinbarough, et al., 2005) talks about using a single layer neural network vision system connected to a robot to detect and report defects of integrated circuits on a PCB. Although the project will not be using a neural network it is still interesting to consider the possibility and could be an area for further research. The paper also talks about using grey scale images, specifically how it seems to be converted into an array of numbers which store the row and column of the pixel value, as well as using MATLAB's image processing library which will be utilised for the project.

(Kita, et al., 2017) details some applications of machine vision which, due to progress in computer vision theories and the massive advancement of computational power, mean that the range of solvable problems has widened immensely. The paper talks about how problematic lighting can be, specifically referring to parts/system inspection, but is probably

applicable to most machine vision tasks. This could be a major issue moving forward and will need to be looked at in more detail. The solution concluded in the paper is to use a modified local binary pattern which is a method of texture classification; in short, it allows the system to differentiate where one material ends and another begins. Implementing this should reduce the impact of lighting changes.

(Mahapatra, et al., 2015) features the use of a machine vision-based tool positioning and verification system for use with milling and lathe machines. This system is much more accurate than the one for my project will be, as it states a maximum error of ±206 μm for 14.99999 mm movement. This system makes use of a new biologically inspired technique for image thresholding called negative selection algorithm, which essentially removes the 'bad' population, in this case the positions which give a greater error. The conclusion of this paper is that the system was just as robust as more conventional systems such as sensor-based ones.

(McAndrew, 2004) details the use of the MATLAB image processing library which will make designing the machine vision system much easier, as it contains lots of pre-built functions to do things such as convert from RBG to greyscale or resize the image by a given scale factor. It is likely that McAndrew's work will have the most relevance to this project.

(Montironi, et al., 2014) discusses using an FFT (Fast Fourier Transform) algorithm on the image to locate obstacles between the camera and the object to be tracked, the camera can then be moved such that its view of the target object is no longer obstructed. While this will probably not be used for this project it shows that the system could be adapted to work in situations where obstacles could present an issue.

(Mukhopadhyay & Chaudhuri, 2015) examines in great depth both the mathematics behind and the applications of the Hough circle transform. The Hough circle transform is something that will be used within the project, as it seems to be the most prominent method of finding circles in digital images.

6. Methodology

1) Initial research
   a) Decide on aims of the project
   b) Acquire knowledge on general machine vision techniques, specifically involving MATLAB
2) Begin technical work
   a) Get the control code for the factory working
   b) Take some still photos of the cargo to be used in testing algorithms
   c) Take some short (black and white) videos of the cargo being put into the racks
   d) Create short MATLAB files to test things such as the Hough circle transform on the still images
3) Begin actual machine vision system
   a) Write machine vision system in MATLAB
   b) Test with multiple videos
4) Complete machine vision system
   a) Ensure that it works correctly

b) Fix any bugs found and retest

The bulk of the data collection within this project will take the form of photos and videos taken (probably using a phone). These photos and videos will, at least to start, be taken from above the storage rack in the model factory as this would be one of the more useful places to demonstrate the concept, and potentially from different locations later.

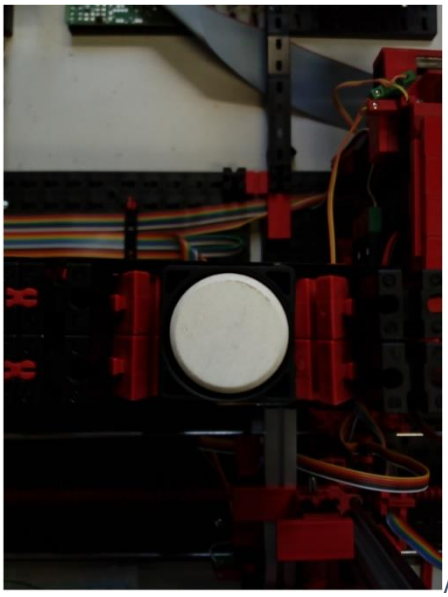

Figure 1 - Showing a bird's eye view of the cargo

A large foreseeable problem with these videos will be that the lighting may change, which could mean that the machine vision will work for one video but not for another. To endeavour to solve the modified local binary pattern as mentioned in (Kita, et al., 2017) will be used.

The project will consist of both qualitative and quantitative tasks, with an emphasis on the former as a lot of work will be required to make sure the machine vision system works correctly.

The Gantt chart shows estimated timescales for all the activities necessary for the project to run to completion as well as showing dependencies between a task finishing and another starting. In addition, the critical path tasks on the Gantt chart are shown as red diamonds (the interim report and the dissertation).

The resource requirements form shows that access to the dynamics lab in N-block will be necessary because that is where the model factory is located.

The risk assessment attached shows that while the risk is not non-existent as some non-standard pieces of kit will be used (i.e. the model factory), it is fairly minimal as long as general awareness and safety procedures are observed.

7. Progress to date

During the course of the project so far, the following tasks have been completed:

- Aims have been decided
- Gained familiarity with the MATLAB machine vision library

- Acquired knowledge of machine vision and techniques used so that the bulk of the technical work can begin
- Images and videos from the model factory have been taken
- Some preliminary test files have been created in order to test basic steps such as converting the image from colour to black and white

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