MULTIPLE VISION INSPECTIONS FROM A SINGLE CONTROL SYSTEM USING VISION ASSISTANT SOFTWARE

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Abstract

The development of a Machine Vision system involved the selection of various components that will work together in order to solve a vision problem. The vision system was tasked with verifying reconfiguration and the position of devices within the assembly system, as well as inspecting the product for defects that infringe on its quality. The aim in this article is to discuss the control and setup of the multiple vision inspections that the vision system had to perform in order to solve the assembly systems verification and quality assurance problem.

Keywords: Illumination, Image Acquisition, Inspection, Machine Vision, Platform Reconfigurable, Reconfiguration

1. INTRODUCTION

A Machine Vision System is a combination of software and hardware devices that work together to complete a task. In order to develop a Machine Vision solution, an understanding of the problem is important and the tasks that needed to be completed by the system had to be laid out clearly; i.e. 'assembly-setup verification' and 'quality control' had to be understood in order to have a satisfactory output.

Assembly-setup verification has to do with verifying the arrangement of a system's different parts, meaning how the moving and non-moving parts are orientated with respect to each other. This process requires a visual verification and communication with the assembly system controller. Visual verification refers to image acquisition and processing, and the results from this can be communicated to the assembly system controller [1, 2].

The key was for the Machine Vision solution to incorporate the switching between three cameras, positioned at three locations on the assembly system, during inspection.

2. LITERATURE REVIEW

Manufacturing means to make by hand and is a practice almost as old as mankind itself dating back to the cottage industry- when products were manufactured by artisans from their homes, and extends into today's mass production for mass consumption, which is done in huge factories.

Throughout history skilled labourers have made what others needed; goods were custom made to meet the demand of others or built at home for the farm or household. This process lasted until the Industrial Revolution (1760 – 1850), which introduced Machine-based manufacturing, steam power and thus the production of items at a profit. Manufacturing was overhauled through improvements of the steam engine, several inventions and the production of interchangeable parts. Agriculture advanced to the point where fewer farms could feed more cities, and transportation was enhanced by a network of canals and railroads [3].

Modern manufacturing includes all the intermediate processes required for the production and integration of product components. Semiconductor and steel manufacturers use the term fabrication instead. The manufacturing industry is closely connected with engineering and industrial design [4]. Manufacturing industries represent a wealth-producing sector of an economy. These industries use various technologies and methods widely known as manufacturing process management. Manufacturing industries are categorized into engineering, construction, electronics, chemical, energy, textile, food and beverage, metalworking, plastic, transport and telecommunications industries. A huge share of the labour force is employed by these industries, and they produce materials required by sectors of strategic importance, such as national infrastructure and defence. The world manufacturing industry has geared up and incorporated several technologies within its scope, and so generates employment, introduces new techniques and presents the economy with real earnings from shipments [5].

The manufacturing industry is a global interest and countries such as the Republic of South Africa and other developing African countries are interested in growing their manufacturing scope. South Africa has developed an established, diversified manufacturing base and has shown its resilience and potential to compete globally. Manufacturing in South Africa is dominated by the agricultural-processing, automotive, chemical, ICT and electronics, metals, textiles, clothing and footwear industries [6].

Changes in manufacturing has resulted in several key developments in the techniques employed to produce a finished product, and one such development is the assembly line, a manufacturing process in which parts are added to a product in a sequential manner to create a finished product, which increased the speed of manufacturing and over the years has been adopted by many manufacturing companies and also improved upon [7]. This has led to modern day mechanised processes of assembly; assembly systems, and production in varying sizes of factories and workshops.

Assembly systems are made up of various components that contribute to the function or purpose of the system. Whether the system is meant to assemble an automobile or something as small as a padlock, the performance of the system depends on the design used - which determines the order of the actions to be taken in the process. The design is often supported by simulation software which allows a user to construct the system virtually and simulate the actions until an acceptable design and assembly process are reached and then physically implemented. This physical implementation results in a design that is fixed, meaning the assembly system can only manufacture/assemble what it was setup for initially. This presents a problem in the current rapidly changing and competitive manufacturing industry. Reconfiguration comes forth as a solution to this, and that is where Reconfigurable Manufacturing Systems (RMS) and Reconfigurable Assembly Systems (RAS) feature in modern manufacturing.

An RAS is said to be a component of RMS which is not only a system that can adapt to product change and regulation changes, but is also meant to be cost-effective. A Reconfigurable Assembly System, on the other hand, is an assembly system which consists of sub-systems that can change or reconfigure on demand in order to perform another function or action (e.g. from drilling to welding to pick-and-place).

Reconfiguration of the sub-systems needs to be verified and the quality of the product that comes from the system must also be checked at all stages of the process in order to prevent defective products. The performance of the system after reconfiguration is dependent on the correct behaviour of the sub-systems and the number of non-defective products.

2.1 Problem Statement

Since the performance of a Reconfigurable Assembly System (RAS) depends entirely on the correct configuration (or reconfiguration in this case), of the assembly-stations within the system, and the quality of the product that comes out of the system, the problem thus lies in checking whether the assembled products are of an acceptable quality and changes in the assembly system configuration that needed to take place, have done so correctly.

Machine Vision Systems should be utilized to enhance and verify the correct operation of reconfigurable assembly systems.

2.2 Methodology

Machine Vision is the application of computer vision to industry and manufacturing. Vision systems do not just identify faulty products; they control and monitor processes and play an important part in the manufacturing process. The design of a vision system depends on the requirements of the system (assembly or automation) it will be part of.

The Machine Vision System in development will work in unison with the assembly system, which will communicate the need for reconfiguration. The vision system, utilizing cameras and vision software packages, will monitor the changes and movements of the different components and, hence, the reconfiguration of the assembly system. Proximity sensors will be in place to alert the system if any component is in an appropriate position for quality control to be administered by the camera allocated to the specific task.

3. THE ASSEMBLY SYSTEM AND THE PRODUCT

The first step towards explaining the implementation of the vision system as well as the integration of it into the assembly system is to consider the assembly system, identify the areas that the vision system will be working in; i.e. looking at where the inspection areas are, and the position of all the components that make up the assembly system; i.e. conveyors, sensors, gantry systems and robotic arms. Figure 1 below illustrates the layout of the assembly system under discussion and the components that make up the system.

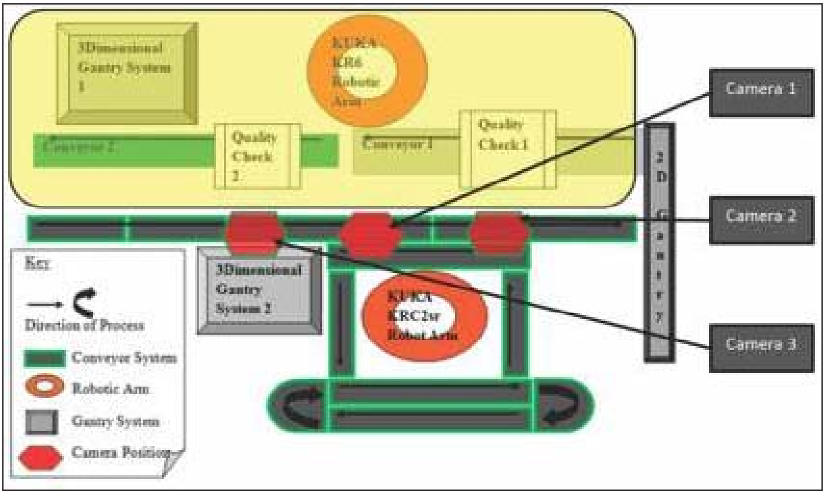

Figure 1: The Layout of the Assembly System

The areas of inspection are located below the camera positions, and the cameras are numbered according to which one was mounted and worked with first, instead of the order that they are placed in; from left to right. Conveyors are responsible for transporting the product as it goes through the assembly process; making assembly possible. The product shown in Figure 2 is a rectangular tray. The tray will be referred to as the pallet herein.

Figure 2: Gray Pallet Filled with Gray Parts

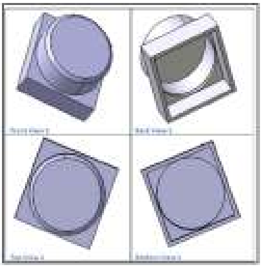

Figure 3: The Part to fit into Pallet

The quality of the final product assembled by the system is determined by the arrangement of gray or white parts, as seen in Figure 3, inside the pallet in a specific pattern. The white parts are placed in the shape of the letter 'A' (uppercase) or alternatively the letter 'b' (lowercase) in a grey pallet. The decision taken was that these arrangements in the gray and white pallet would constitute the number of products that the vision system has to identify and check for quality; i.e. four products: white pallet with gray letter 'A', white pallet with gray letter 'b', gray pallet with white letter 'A', and gray pallet with white letter 'b'.

The remaining (empty spaces) in the pallet should be filled with blocks of the same colour as the pallet itself. A representation of this is given in Figure 4; pattern A, on the left, and b, on the right, are shown in a gray pallet.

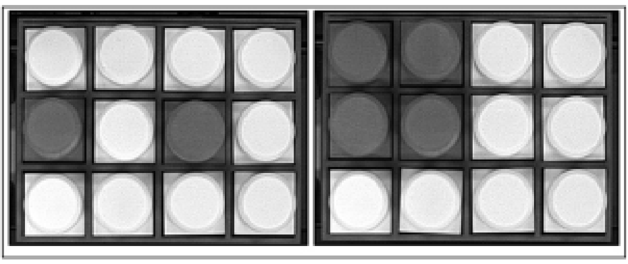

Figure 4: Two Products that are assembled by the System (Patterns A and b on a Gray Pallet)

4. SOFTWARE PACKAGE

National Instruments Vision Builder for Automated Inspection (NI VBAI was compared with two other Machine Vision Software packages MVTec HALCON and Microscan Visionscape®. NI VBAI was chosen based on the fact that it delivers complete vision solutions, and local support was available in case of any problems that might have come up. Another reason is the number of tools that are available in the software package and the researcher's familiarity with using National Instruments software products (e.g. LabVIEW). These tools enable a user to not only acquire an image, but also save and manipulate the image. Manipulate refers to handling an image and using the tools, in the software package, to enhance the image and extract details necessary for quality control. A tool that also presents itself as being very useful is the calculator tool, which computes numerical, Boolean, or string results from existing measurements [8].

5. MACHINE VISION SYSTEM

The Machine Vision System was made up of the following hardware devices: the Compact Vision System (CVS) from National Instruments; processing hardware, three cameras for image acquisition, the programming computer, and the display monitor that serves as an output for the inspection process taking place within the CVS. Figure 5 better explains the relationship between the different hardware devices.

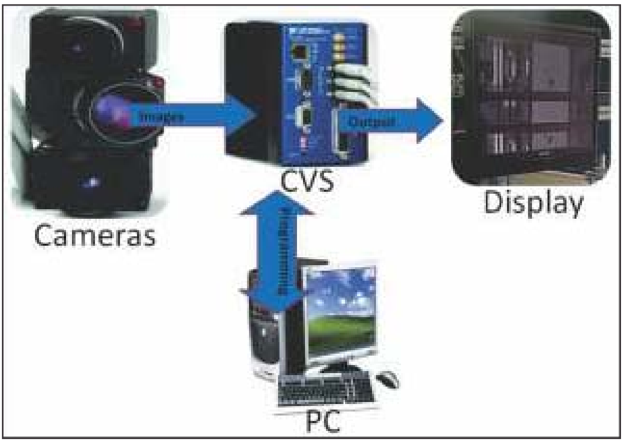

Figure 5: Vision System Component Relationship

The CVS acquires images through the cameras and then processes the images using the inspection program while showing this inspection process on the display. The PC has a bidirectional relationship with the CVS, meaning while programming, it can download to the CVS, initialise the program and act as a display so that the programmer can observe the inspection process.

The basic means of communication by the CVS is done through the digital input/output port situated on the front panel of the CVS device, which is in the form of a 44 pin DSUB terminal which consists of 2 Transistor-Transistor Logic (TTL) inputs, 10 TTL outputs, 13 isolated inputs and 4 isolated outputs. This port can be accessed and used to establish a digital communication link between the CVS and the controller of the assembly system [9].

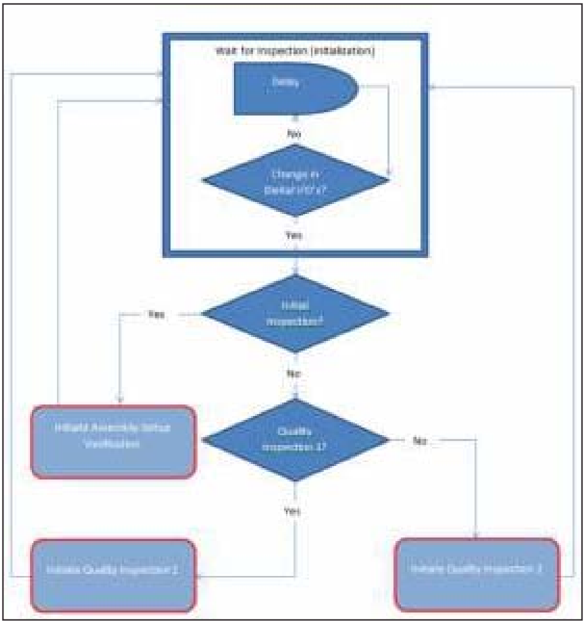

Figure 6: Inspection Program Structure

Figure 6 gives a basic outline of the procedure that the inspection program takes to fulfil the task of inspection.

Initial Inspection is triggered by the assembly system controller and then the controller waits for feedback from the vision system before it starts the assembly process; i.e. moving the pallet to the gantry for the first placement of parts. The verification process involves:

- The capturing of an image by Camera Three: the gantry system as viewed from the top
- Then the inspection of the image follows to determine where the mobile arm of the gantry system is located;
- Measurements are performed in the vision program to verify that the mobile arm is at the Home position or initialization position;
- An inspection result of 'Pass' is when the mobile arm is at this Home position, and a 'Fail' when it is not; and

- The assembly system is triggered to let it know what the inspection result is, through the outputs from the DSUB connector of the CVS.

The Quality Inspection of the product involves:

- A trigger from the assembly system controller when the pallet is in place; i.e. at Camera 1's inspection point;
- Image acquisition of the inspection area;
- Inspection of the image to identify if the correct pattern has been assembled, and to identify the XY coordinates of the empty spaces in the pallet; and
- If the pallet has the correct pattern then a feedback of 'Pass' is sent to the assembly system controller, if the pattern is incorrect then the feedback is a 'Fail'.

This routine holds true for both quality inspection programs.

The inspection process involved a number of tasks such as edge detection, object detection, pattern matching and distinguishing colour intensity, which then resulted in a 'Pass' or 'Fail'. A 'Pass', with regard to product verification, means that the current arrangement, under inspection, was a match to the desired arrangement of parts within the pallet. It is worth mentioning that the orientation of the arrangement can be 180 degrees either way. A 'Fail' on the other hand means that the current arrangement, under inspection, did not match the desired arrangement of parts within the pallet.

6. CONCLUSIONS

In order for the project to be cost effective there was a need to ensure that one vision system can complete the tasks of assembly verification and quality control, done separately and at three locations on the assembly system. The NIVBAI software package combined with the CVS made it possible to implement a solution that accomplishes this by making it possible to use three cameras; connected to the CVS, and to develop a program that can access these cameras and use the images captured through them in the diverging inspection processes.

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