Design and Implementation of Adaptive Conveyor Belt for Material Sorting and Handling Assisted With Image Processing Technology Control by Microcontroller

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Report submitted in partial fulfillment of the requirements
for the award of Bachelor of Mechatronics Engineering

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JUNE 2013

ABSTRACT

Laboratory users might find themselves going crazy looking for electronic parts commingled together. The hardest part is to locate the particular part that was thrown somewhere in the container with the commingled electronic components. There are certain limitations with machines which rely much on sensors to run operations such as processes and applications. This poses limitations not only to new product development for engineers, as well as evaluation and implementation of new products. It is time consuming for engineers to perform so after everything has been completed with the aid of machine vision technology. The project consists mainly of three subsystems namely the process flow control of components, component analysis and detection as well as material sorting and handling. For the process flow of components, conveyor belt system is being implemented and applied. As for material sorting and handling, it is done by making use of the Arduino Uno as the devices to control the movement of the elevator. Right after the analysis and recognition process is completed, the component will be allocated into its right drawer by a four axes elevator in a multi-drawer cabinet. The integration of computer control produces is a powerful tool for applications that require components recognising followed by specific allocations with the minimal level of programming involved. The innovation of this material sorting and handling machine involves the consideration of priorities in terms of reliability, cost, and ease of use and simplicity. It would be a magnificent achievement in implementing this system concept in order to create commercial gadgets and as an add-on to the advancement of our technologies.

ABSTRAK

Penggguna makmal mungkin mendapati diri mereka akan gila mencari bahagian-bahagian elektronik berbaur bersama-sama. Bahagian paling sukar adalah untuk mencari bahagian yang tertentu yang telah dibuang di suatu tempat di dalam bekas dengan berbaur komponen elektronik. Terdapat batasan tertentu dengan mesin yang bergantung banyak pada sensor untuk menjalankan operasi seperti proses dan aplikasi. Ini menimbulkan had bukan sahaja untuk pembangunan produk baru untuk jurutera, serta penilaian dan pelaksanaan produk baru. Ia mengambil masa yang lama untuk jurutera untuk melakukan demikian selepas segala-galanya telah selesai dengan bantuan teknologi penglihatan mesin. Projek ini terdiri terutamanya daripada tiga subsistem iaitu kawalan aliran proses komponen, analisis komponen dan pengesanan serta bahan menyusun dan pengendalian. Bagi aliran proses komponen, sistem tali sawat sedang dilaksanakan dan digunakan. Sebagai bahan menyusun dan mengendalikan, ia dilakukan dengan menggunakan Arduino Uno sebagai alat untuk mengawal pergerakan lif. Sejurus selepas proses analisis dan pengiktirafan selesai, komponen akan diperuntukkan ke dalam laci haknya oleh paksi lif empat dalam kabinet pelbagai laci. Integrasi kawalan komputer menghasilkan adalah alat yang berkuasa untuk aplikasi yang memerlukan komponen mengiktiraf diikuti oleh peruntukan tertentu dengan tahap minimum pengaturcaraan yang terlibat. Inovasi bahan ini menyusun dan mengendalikan mesin melibatkan pertimbangan keutamaan dari segi kebolehpercayaan, kos, dan kemudahan penggunaan dan kesederhanaan. Ia akan menjadi satu pencapaian yang hebat dalam melaksanakan konsep sistem ini untuk mencipta alat komersial dan sebagai tambahan kepada kemajuan teknologi kita

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LIST OF ABBREVIATIONS

PC	Personal Computer
DC	Direct Current
AC	Alternating Current
USB	Universal Serial Bus
3D	Three dimensional
RGB	Red, Green and Blue
COD	Center of Gravity
IDE	Integrated Development Environment
MV	Machine Vision

CHAPTER 1

INTRODUCTION

1.1 Introduction

Design and implementation of Adaptive conveyor belt for material sorting and handling assisted with image processing technology control by microcontroller is a project that intends to help human work effectively. This machine sorts out items according to category continuously without the assistance or monitoring of human. USB camera (webcam) is the main component in this whole project. The function of this camera is to capture images of objects delivered by loader and send them to PC via USB cable. RoboRealm is then used to analyze those images. A proper algorithm was designed in Arduino Uno and to perform the operation or analysis and generate output control signals to the respective hardware. Finally, a drawer which was installed on the elevator to collect items delivered by the conveyor then allocated into a multi-drawer cabinet as final storage. This project intends to convey the general idea of machine vision systems. Besides that, new component information update with notification enabled enhances the versatility of the entire system.

The idea of machine vision systems is that it can be widely accepted and can fit into any laboratory or factory. This concept can be implemented in a machine upgrade or to improve the current process. The whole idea is to make the world more fun with science and technology we have now.

Technology is an important term in human life. Technology has been applied in sectors like manufacturing, food, biological, agriculture and many more. Technology in the development of the manufacturing industry, human life is more flexible, easier, faster and simpler.

Human Vision is the most important sensing facility for the manufacturing industry (Cippola and Pentland, 1998). Vision is inherently clean, safe and hygienic, since it does not rely on physical contact between the observer/inspector and the object under examination. Vision is also very versatile; human beings are able to detect subtle changes of shape, texture, shade and colour (Cippola and Pentland, 1998). A human inspector can resolve highly complex and ambiguous scenes and can almost always make appropriate decisions in previously unseen situations. While HV remains dominant in the manufacturing industry, there is a strong research effort aimed at automating inspection, assembly, manufacture and other tasks using machines that can sense their environment optically (Watson, 1993). Commercial companies are also taking this forward and now offer a range of products and services, covering a wide variety of industries, including aerospace, automobile, electronics, domestic goods, food and pharmaceuticals.

Machines can be provided with visual sensing, thereby enabling them to perform a wide variety of tasks for the manufacturing industry namely: inspecting, counting, grading, sorting, matching, locating, guiding, recognizing, identifying, reading, classifying, verifying, measuring, controlling calibrating and monitoring. Machine Vision systems can be used to examine raw materials, feed-stock, tools, manufacturing processes, partially machined and finished products, coatings, labels, packaging, transport systems, waste materials and effluent (Jähne et al., 1999). Based on these advantages, it will be beneficial to manufacturing if intelligent robots are designed to substitute humans to perform those tasks.

In industrial applications, machine vision is the most commonly used method for sorting operations. For example, shipping firms are using machine vision to sort out products to see where they must be delivered. Also machine vision is used for in-vivo fish sorting applications (Zion, Shklyar & Karplus 2000).

1.2 Problem Statements

Nowadays, there are a lot of product has been invented for the human for more user friendly and also helping human more applicable at any activity. Thus, these have cause a lot of competition in between the manufacturing industrial sector where they need their product being produced as the fastest, most accurate, good quality, fewer defects; cost less, which is the most valuable toward the consumer by compare with other manufacturer. Thus, the application of robotic in the industry has rising where it can provide more benefit, which like less cost demand, high accuracy of working efficiency and restless.

The problems which often occurred in the industrial that can be solved by this project are:

i. The speed of manual sorting process is low. This is due to the limitation of response time for a human. In this project, a microcontroller is used to increase the speed of materials sorting and handling as well as decrease the human mistakes.

ii. The accuracy of manual sorting process is very slow. This is because an operator will need to handle hundred or thousand of object each day, they will feel boring and their eyes are tired after a long day working. In this project, a microcontroller was used to substitute the operator and thus increase the accuracy of sorting process.

iii. The implementation cost for a manual sorting is very high. This is because the work load for an operator is very low. In this project, an automated sorting and handling system was designed so that to increase the process time, and cut-down the cost of

process of manual sorting. Then minimizing the cost of the company by minimizing the workers.

1.3 Objectives

This project is developed with the purposed to optimizing the productivity, minimizing the cost of the project and make no human mistakes. The main thing of this project is to study how to use the programming language to communicate with the microcontroller. After determining the colour of the object, the machine will make its own decision to the station that been programmed. The objective can be summarized as below:

i. To design and implement an adaptive material sorting and handling system using microcontroller.
ii. To tracking or detecting a component by using image processing in RoboRealm To build a four-axes elevator to carry components from conveyor to multi-drawer cabinet as storage.
iii. To make the elevator stop at the desire location accurately and has the function of pick and place.

The idea of Design and implementation of Adaptive conveyor belt for material sorting and handling assisted with image processing technology control by microcontroller as my PSM topic which can be used to handle the situation above. Processes such as transferring, image processing and storage are part of the machine. Human operation could be replaced with higher reliability. The result clearly shows that it could reduce the time consumed, cost, increase the safety and cleanliness.

1.4 Scope of Research work

This project requires a USB webcam, RoboRealm, Arduino Uno, and a PC. Each of the element mentioned above are essential components to build the system. The costing and budget allocation is focused to hardware parts.

Arduino Uno interfacing with RoboRealm requires a serial connection and also knowledge on programming. I am required to understand the principle of writing a program with arithmetic feature.

In this project, the scope is based on two main parts. The first scope for this project starts with conducting research on information about materials handling and sorting, to get the basic idea to design the machine. The second scope is, after find the best structure design for this project.

Scope of project should be identified and planned to achieve the objective of the project successfully on the time. Among the scopes that been fixed for this project are as:-

i. Sorting and handling of used and commingled electronic components by Elevator and Conveyor belt
ii. Arduino Uno programming language
iii. Image capturing by USB camera and analysis of images by RoboRealm

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

According to Chan, Ip & Lau (1999), a key factor in material handling system design process is the selection and configuration of equipment for material transportation. So the design or selection of the correct system is one of the most important decisions that the designers must make, because it will influence the rest of the production or manufacturing plant. It will affect the material flow and plant layout. In addition to the initial investment cost for the new system, the consequences of any miscarriage of justice in the material handling will have a significant and long-term business impact. In recent years, computer-based simulation tools have been developed a simulation of the material handling system and their effects on the manufacturing process.

Ballou (1993) states that the storage and handling of goods are essential among the set of logistics activities, and their costs can absorb 12% to 40% of its costs. In addition, the The Materials Handling Industry of America, MHIA estimates that 20% to 25% of manufacturing costs are associated to handling (Groover, 2001, p. 281). According to Sule (1994) apud Sujono & Lashkari (2006), material handling (MH) accounts for 30–75% of the total cost of a product, and efficient material handling can be responsible for reducing the manufacturing system operations cost by 15–30%. These figures stressed that the importance of material handling costs as an element in improving the cost structure of a

product. The determination of a material handling system involves both the selection of appropriate material handling equipment and the assignment of material handling operations to each individual device components (Sujono & Lashkari, 2006). Hence, according to Sujono & Lashkari (2006) material handling system selection can be defined as the selection of material handling equipment to perform material handling operations within a working area considering all aspects of the products to be handled. Therefore the material handling system (MHS) plays a vital role in industries.

Materials handling study requires that several elements are considered. The first is a handling system project, which covers activities of sequencing, velocity, layout and routing (Groover, 2001). In order to complete the analysis, Groover (2001) recommends analyzing the material itself (or object) to be transported. Therefore, it suggests the classification of Muther and Hagan (apud Groover, 2001), which considers: (i) physical state (solid, liquid, gas); (ii) size (volume, length, width, height); (iii) weight; (iv) condition (hot, cold, dry, dirty, sticky, adhesive); (v) risk of damage (weak or strong); and (vi) safety hazards (explosive, flammable, toxic, corrosive, etc.).

The literature review of this project is the review of the all kind of sorting machine that available or existed in the market. The reviews are done by referring to the technical journal, reference books and internet searches. Beside that this chapter also covers the basis explanation of RoboRealm Machine Vision Systems and Microcontroller Arduino interfacing will be further discussed in this chapter as well.

2.2 Example of Existing Sorting Machine

2.2.1 The Compac System

Compac use a unique carrier system, advanced software electronics and precise measurement systems to sort produce by weight, size, color, shape, density, blemish or

defects, taste, internal characteristics and more. The automation system used is Invasion 5000 system. InVision5000 system uses high definition camera to snap multiple images of each fruit as it rotate under the camera. Dedicated computers and software captured and analyzed images from the camera. The operator then sorts fruit into different operator defined classifications base on the fruit's surface color, diameter, etc.

2.2.2 Automatic Bottle Sorting

Automatic sorting equipment has been developed to sort plastic bottles by polymer and colour in Materials Recovery Facilities (MRFs) or reprocessor environments. Autosort equipment offers several potential advantages over manual sorting; higher throughput, lower sort costs, better utilisation of space, improved operator environment, some sorts are easier and improved sort quality. Autosort equipment is best suited to relatively large MRFs and reprocessors where high bottle throughputs off-set the cost. Most UK MRFs and reprocessors rely on people for sorting recovered post consumer plastic bottles. Trained staffs are able to sort bottles by polymer and colour from a mixed bottle input at a rate of 60-100 kg per person per hour.

2.2.3 Led Sorting Machine

The high speed sorting machine for SMD & LAMP LEDs is provided by SUNWAVE OPTO. LT-643 LED SPECTRUM TESTER combines with the sorting machine. And LED TESTER tests the brightness, tone of color, and electric characteristics of LEDs supplied by the sorting machine. After the process, sorting machine sorts the devices into the bulk bins according to the test results. Cycle time is up-graded up to 0.3sec

per pc (test time 0.1sec per pc or less). Adopting touch panel input system, sorting programs can be programs can be input freely.

2.2.4 TC 100 Eggs Sorter

The egg sorter precisely selects eggs to prevent death from disease contagion. Useful on hatcheries & farms that handle large quantities of eggs .Built with the greatest care, this equipment can sort eggs of all species.TC 100 is delivered with 4 perforated discs from Ø 5 to Ø 8 mm. Eggs are pushed under pressure (2 bars) behind a photo sensor. Whenever dead eggs are passing over, the sensor sends a signal to the electronic unit. They are ejected and separated from the good eggs to prevent disease contagion.

2.2.5 Wafer Sorter

Wafer Sorting is a process of moving wafers between cassettes based on a number of different Wafer Slot per ID criteria. A substandard wafer sorter can have a huge financial impact on a company's running costs by introducing unnecessary complex and time consuming handling procedures into the manufacturing process.

C&D's smart Sort Product Family provides an environment to sort your wafers which is high in safety, reliability, flexibility and throughput while low in downtime, cost of ownership, complexity and price. C&D's Wafer Sorters are all recipe driven. A typical recipe will take less than 10 seconds for an engineer to create and execution by operators is then done through a single click "Hot Button".

C&D's smart Sort S4000 Wafer Sorter uses reliable, high speed and well proven hardware. Cassettes are placed onto the elevators in an ergonomic load position. Cassettes are then automatically moved into the working position for transfer. On completion of the

Sort operation, cassettes are returned to the ergonomic position for unloading by an operator. Prior to wafer sorting the cassettes are automatically mapped to determine occupied and empty slots as well as cross slot wafers.

After cassette mapping the sorter transfers the wafer based upon the criteria within the recipe. Sorting can be conducted using wafer slot position or Wafer ID as the critical move factor. The Wafer Sorter uses state of the art OCR technology for reading the ID mark on a wafer. The OCR system is capable of reading alphanumeric laser scribe, T7 dot matrix or barcodes all without any hardware changeover or recipe modifications. Read rate is typically greater >99%. It is also possible to include multiple cameras on a wafer sorter should a customer require reading of scribes on the topside and bottom side of the wafer.

2.2.6 Automatic Inspection and Sorting Of Tablets & Capsules

Sensum SPINE automatically inspects the entire surface of tablets and capsules at the speed of up to 360.000 products per hour. The products are held in reproducible position by a vacuum system, illuminated by special controllable LED illumination units and inspected by six colour cameras. The machine is controlled via a user-friendly graphical interface, providing simple operation and training for the inspection of new products. The active sorting system with sorting verification for both good and defective products ensures fail-safe and reliable operation. Ergonomic design with a small number of for-mat parts simplifies changeover, cleaning and maintenance.

2.2.7 Colour Sorting Machine for Coffee Beans and Other Products

The highly efficient colour sorter is equipped with an extremely powerful, high-precision imaging system of the Fraunhofer Institute IOSB, which is used for detection and

separation of broken, foreign particles, and rejects from numerous granulates, such as: coffee & cocoa, rice & nuts, grains & seeds, beans & pulses.

i. The line length of the image is 2,096 pixels with three colour sensors per pixel. Each pixel can be assigned to one of 16 million colours.
ii. The automatic colour calibration ensures consistent measurement of each individual pixel. Signal differences are detected over the entire line width and compensated. Optimum sorting is achieved by actuators which are arranged without gaps and are switched by high-precision fast-switching valves. By means of an optional reject return system the sorting result can even be further improved at high performance.
iii. The integrated system for contour detection ensures a reliable recognition of broken. By examining colour and shape, foreign particles are clearly recognised and sorted out. The simultaneous detection of shape, colour, and contour as well as the comparison with colour classes permit optimum sorting results despite product specific colour variations, such as grooves in coffee beans.
iv. The complete system is highly user-friendly. Operation is very quickly understood. Camera and valve block are synchronized by simple-to-use software.
v.

2.2.8 BEUMER Belt Tray Sorter

The BEUMER Belt Tray Sorter with con-tactless energy supply and linear induction motor drive is the high-capacity system for sorting a variety of products, including:

i. Letter trays, packets and small envelopes in the postal and courier industry
ii. Shoeboxes and apparel in the foot wear and clothing industry
iii. Plastic film wrapped products with high-friction (sticky) surfaces as in mail-order companies and the news paper distribution industry
iv. Unstable and sensitive products, such as frozen foods, cakes and dairy products

v. Other industries with extreme variation in product types, shapes and frictional behaviour such as bag gage handling for airports or freight center

The BEUMER Belt Tray Sorter with contactless energy supply sorts items safely and gently to the right destination, irrespective of size, shape or surface characteristics of the product handled.

2.2.9 TITECH Innovative Global Recycling Sorting Machine

TiTech's sorting technology enables fully automated separation of recyclable materials. The input material is transported through the sensor area on a conveyor belt. The sensors identify properties such as shape, structure, colour, density and spectral behavior, as required, to determine the material. The predefined target materials are pneumatically sorted out at the end of the conveyor belt by means of a nozzle system.

i. POLYSORT
    a. TiTech PolySort is a simple to use and easy to install sorting system that answers your requirements to sort objects by material type. It is designed to specifically sort polymers or mixed plastics by material properties. With its NIR (near infrared) sensor, TiTech PolySort efficiently detects the characteristic infrared wavelength of light reflected by illuminated objects. Thus you obtain a fingerprint of light – unique for every different type of material.
    b. Sorts objects by material types (PET, PE, PVC etc.)

ii. COLOURSORT
    a. If PET and PE needed to be sort by colour than TiTech ColourSort systems can be useful. TiTech VIS technique (visual spectrometry) enables you to precisely define the colour of the objects that you wish to sort. Being a flexible system, TiTech ColourSort is able to define the boundaries between

colours in line with your specific needs. TiTech ColourSort detects all colours within the visible light spectrum, both of transparent and opaque objects. Moreover, TiTech ColourSort provides simplified material detection.

b. Sorts objects by colour (transparent, light blue, natural colour etc.); also recognizes material types

iii. PAPERSORT

a. TiTech PaperSort systems offer precision sorting of different types of paper. In addition to an NIR sensor, TiTech PaperSort also uses a VIS sensor to detect colours printed with CMYK technology. This technique enables TiTech PaperSort to sort printed paper from printed carton of similar colour. Moreover, the system can sort deinking-capable material with a high purity grade.

b. Sorts different grades of paper (brown carton, printed carton and paper etc.)

iv. AUTOSORT

a. With TiTech AutoSort, you are choosing the most flexible sorting system from our range of offerings. TiTech AutoSort combines NIR and VIS sensors into a universal sorting system that meets a wide variety of needs as well as highly specialized ones. The VIS sensor, for example, can be used to recognize print media by CMYK spectral analysis. TiTech AutoSort sorts a wide variety of materials, everything from paper and carton (printed, coated or untreated), too many types of plastic. You get reliable fractions at top purity grade.

b. Flexible system that is prepared for all above-mentioned tasks

v. FINDER

a. TiTech Finder ensures the recovery of valuable metals in the recycling process and increases the added value of metal fractions. TiTech Finder guarantees high accessibility and product quality as well as flexibility for every customer. It is tailor-made to the specific wishes of the recycling market and secures the highest degree of recovery.

b. Sorts objects by metal properties (e.g. stainless steel from mixed metals)

vi. COMBISENSE

a. TiTech CombiSense is a sorting device designed to identify colours, shapes and metals from bulk solids. The metal sensor in TiTech Finder is combined with a colour camera. The high spatial resolution in conjunction with precise colour measurement enables sorting complex material streams of used electrical devices and the recovery of nonferrous metals with a high purity.

b. Sorts objects by colour, shape and size as well as by metal properties (e.g. separating aluminium, copper and high grade steel; numerous other application areas).

vii. X-TRACT

a. Innovation and progress in one. Based on high-resolution x-ray transmission image processing, the sorting machine uses dry-mechanic techniques to separate materials and waste streams based on specific atomic density. This innovation opens new frontiers in efficient processing of recovered valuable materials.

b. Sorts objects by their specific atomic density (e.g. CRT glass).

2.2.10 Currency Sorter (Uw-500/600)

The State-Of-The-Art GLORY UW-500/600 were developed based on an in-depth analysis of banknote handling processes in order to lower the operator's burden and further reduce overall processing time. They are equipped with a variety of NEW features, such as a multi-stacker system that improves sorting and separating performance, a twin reject stacker system that can hold more rejected notes and large capacity hopper with an Assisted Feeding Mechanism.

The UW-500/600 also offers outstanding cost performance features at outstanding reasonable prices. They are GLORY's latest answer to the need for smoother, more efficient, continuous processing of large amounts of banknotes. The UW-500/600 will optimize the work process and dramatically reduce the processing expenses.

i. High tech recognition capability with superb authentication.
    a. Banknote handling machines must deliver both high efficiency and a combination of speed and accuracy. GLORY's UW-500/600 offer high tech fitness sorting sensors and superb authentication sensors while processing at a remarkably high rate speed 720 notes per minute
ii. Multi stacker configuration for diverse sorting patterns with fewer re-sorting steps
    a. The multi stacker allows the diverse to sort and arrangement patterns for each banknote setting operation and reduce the number of re-sorting steps required by machines with fewer stackers.
iii. Larger stackers allow high capacity, higher efficiency for continuous and large volume processing
    a. Each of the UW-500/600 stackers hold up to 500 banknotes. This significantly increases efficiency and speed while continuously processing a large volume of banknote, reducing the frequency of stopping and starting.
iv. Large capacity hopper with an assisted feeding mechanism for a lower incidence of feeding issued of due to poor quality banknotes
    a. The Large capacity hopper holds 1000 banknotes. Thanks to assisted feeding mechanism the hopper reliably feeding one note at a time to prevent jamming or high rejects due to double feeding. The open type hopper let the user to keep an eye on the banknote feeding process so the user can add more notes in continuous large volume deposits.
v. Twin reject stacker system-work less for sorting rejected banknotes
    a. Two reject stackers with 150 banknote holding capacity. This also reduces frequent stopping and starting. Two enlarged reject stacker have greatly improved the UW's "Non Stop Operation" and allow banknotes to be

rejected individually by recognition effect. This reduces the amount of work normally required for sorting rejected banknotes.

vi. Double LCD display with illustrated operation guidance for ease of use and operation

   a. The display section features two side by side LCDs, one for displaying data and message and the other for use as an illustrated system guide. Wide display screens substantially improve visibility.

vii. Easier maintenance – quick trouble recovery reduces processing interruption

The system features a completely opening top that allows easy maintenance of the banknote transport section. Should banknotes jam or foreign object in the counting or transport section, the wide opening upper section of the main unit makes it easy to find and remove the jammed notes of foreign object. A duct tray is also provided for easy removal of accumulated dust.

2.2.11 X-RAY Material Sorting Machine

PVC or PET plastic bottle pass through the X-ray detector, the greater of its density and atomic number leads to the bigger absorption rate, thus the sensor capture the signal from the difference of color. The components inside the article are the mixed material combinedby aluminum, copper, zinc and lead, the absorption ratio is different from the Plastic bottle. This X-ray detector use collect master control system real-time data processing, and precise control actuator, achieving high density of material eliminate purpose, at thesame time, the product loss to the minimum.

Main Features

i. Adopt the high-performance linear array CCD and unique picture processing technology, which ensure the reliability and stability of the equipment.