Sameer Aryal

INTEGRATING CAMERA RECOGNITION AND RFID SYSTEM FOR ASSETS TRACKING AND WAREHOUSE MANAGEMENT

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ABSTRACT

Department	**Date**	**Author(s)**
Technology, Ylivieska	20 March 2012	Sameer Aryal

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Dr. Mika Luimula	37

Supervisor(s)
Mr. Jari Kaarela and Mr. Sakari Pieskä

This research project is focused on developing a solution for a warehouse management. The primary objective of the research project is to develop an assets tracking system deploying camera recognition and RFID technology.

RFID systems have been long used in various fields and its usage is growing each and every day. Furthermore, camera vision system has also been used for a long time in an industry mainly for quality control purpose and to increase efficiency. However in this project, these two different systems are integrated to track an assets inside an industry and to maintain a real time inventory minimizing the processing cost.

Key words
Machine Vision System, RFID System, Warehouse Management

FOREWORD

This final thesis has been prepared for the partial fulfillment of the requirements for Degree Program in Industrial Management in Central Ostrobothnia University of Applied Sciences. The primary target of the research project was to develop an efficient technique to track assets in a warehouse and to maintain real time inventory, subsequently minimizing the processing time and cost

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1 INTRODUCTION

Hundreds and thousands of products are manufactured each day around the world to meet the requirements of customers. These days, due to globalization, world has changed into a small village, and companies from around the world compete with each other to sell their product and make profit, thus there is a fierce competition within companies to sell their product at a comparatively cheap price without compromising in quality. If we consider any manufacturing industries, there are hundreds and thousands of raw materials used to manufacture a product. Similarly, industries need to produce thousands of different products and deliver to their clients on time. The success of any industry depends on smooth flow of materials within the supply chain. On the success of a company, a proper and efficient warehouse management system has a pivotal role.

In a company, an unwanted level of its stock means too much working capital. Thus every company tries to minimize stock level however, at the same time, attention should be given that continuous flow of materials could be ensured and there is no short supply of materials because any shortage of supplies adds unwanted overhead to the production. All this can be managed only by careful planning, designing and implementation of warehouse management system.

Since there are hundreds and thousands of different materials in huge quantity in a warehouse, managing all these products is not an easy task. Various techniques and methods are currently being used for their proper management, however; still the solution has not been very reliable. Due to various reasons like carelessness, work pressure, innocence etc., people working in a factory make mistakes and products get lost and once the product gets lost in a warehouse, it takes lot of extra effort, resources, time and money to relocate them and not to forget the client reliability factors.

As an example, if we consider any car manufacturing industry, there are thousands of different raw materials needed to manufacture a car. A small nut and bolt to big heavy engine parts are equally important to manufacture a car and it is very important that a smooth flow of these raw materials has to be ensured but at the same time maintaining small inventory level so as to minimize the cost of production. In these circumstances if

any product is lost and misplaced in a warehouse, it brings huge amount of extra cost to the production of the car and at in worst case scenario even the production has to be stopped because of unavailability of raw material. Thus industries need a very effective system to locate these products.

Thus realizing this problem which was going on in industries for a long time, a reliable solution would be attempted to be developed to overcome the problem. In this research project, a prototype will be developed in a laboratory by using a camera vision system and Radio Frequency Identification (RFID) system to track the products inside a warehouse and get their location in real time.

For this purpose, two sets of camera are used on the roof of the laboratory which continuously send the location of fork lift to the server. Furthermore, all the products are attached with Ultra High Frequency (UHF) RFID tags and fork lifts are installed with UHF RFID readers and a Wi-Fi to continuously send the information from RFID tags to the server. Thus when the forklift picks up any material inside a warehouse, the camera vision system gives the X axis and Y axis location to the server and based on the information stored on the RFID tags, no matter where the product is stored or kept, the location can be tracked immediately.

After a successful implementation of this technology, even if products are not stored in shelves and are kept in the corridors, they can still be tracked within no time thus saving considerable amount of time and money.

Thus, once this technology is implemented, the products will no longer get lost inside a warehouse.

2 RADIO FREQUENCY IDENTIFICATION

Radio Frequency Identification (RFID) is a hot topic these days in manufacturing and service sectors. Defining RFID in simple words, it is basically a chip and an antenna in which the chip is capable of carrying data. Since this is also used for identification, it is somehow similar to barcodes, however; one of the biggest advantages of RFID over barcode is that RFID is capable of storing much more data than the barcode and the data are rewritable in RFID. At present, RFID is mainly used in logistic handling, product identification and tracking, collecting road toll, security system etc.

2.1 History and development of RFID

Even though, RFID is drawing many peoples' attention these days, however if we track the history of RFID, it leads us back to the days of World War II. The primitive version of RFID evolved during the war time when British, Japanese, Americans and the Germans were all using radar technology to identify the allies and the enemies' air crafts. However, the radar technology could not distinguish between the own aircraft and the one belonged to the enemies'. To overcome this problem, the British developed the first active identity friend system. It is a system which enabled the military to distinguish between and enemies' aircraft and theirs' own by using a transmitter. They installed these transmitters to each British plane and these transmitters were sending signals to the ground station which helped to distinguish between the British and other planes. RFID system works in similar concept. The RFID tag which contains the data generates an electromagnetic signal which is read by the RFID reader which then passes the information for further processing. The tags mainly do not have their own power source; hence they draw energy from the reader and reflect the modulated signal back to the reader.

In the post war period, scientists realized the importance of this new technology and started to focus on further development of this technology. Their main focus initially was to identify objects remotely. In subsequent years, companies started to do further research on its uses in industrial production and in supply chain management.

It was during 1960's; RFID was first considered to be a good identification solution for the commercial world. Especially during the after the world war II, rapid industrialization took place around the world, as a result of which big volumes of cargo shipments and huge number of products were being transferred between different places and countries. However, for companies, it was difficult to handle and identify those big volume of shipments which eventually lead to a realization that RFID could be a good possible solution for product identification. Thus, with enormous research on the subject matter, finally on 23 January, Mario W. Cardullo received the first US patent for an active RFID tag with rewritable memory. In the same year, a Californian entrepreneur received a patent for a passive tag which was used to open a door without any key. The technology used a simple technique of RFID in which when the reader identified the valid code stored in the passive tag, the security enabled door opened without any use of a key.

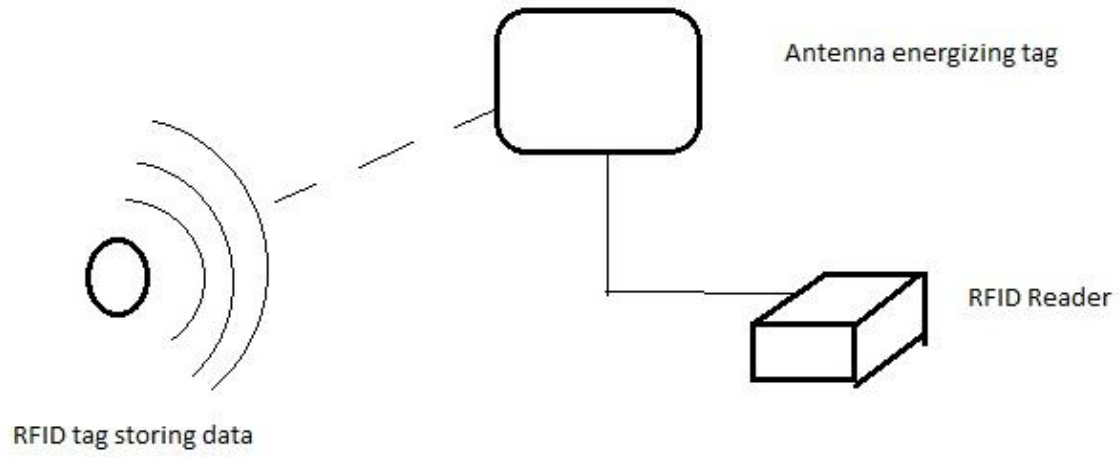
While all these technologies were being introduced into the market, US Government was also working on developing of RFID system and as a result in 1970, Los Alamos National Laboratory developed a system in which a transponder was installed in a vehicle and reader in different gates. The gate antenna transmitted an electromagnetic signal which induced the transponder and finally the data stored in the tag was transferred to the reader. Now a day, the same technology is being used to collect road toll in different countries.

In 1990's; International Business Machines (IBM) developed and patented and ultra-high frequency (UHF) transponders which was being operated at a frequency range of 300MHz-3GHz. This new technology developed by IBM and which works in UHF range has been applied by many companies in different fields. (RFID Journal LLC 2011.)

2.2 How RFID works

RFID in general is a system which transmits a data from a transpoder or a tag to its reader wirelessly using electromagnetic waves. In other words, RFID works in a simple system of radio frequency where communication occurs with the help of electromagnetic waves without any use of wires. In RFID system, in the tag or a transpoder, data can be stored and reprogrammed which when induced by the energy transmitted by the antenna, transmits the

data which is ultimately read by the RFID reader (Graph 1) and finally forwarded for further processing of information. (Chatterjee 2007.)



GRAPH 1. Working Mechanism of RFID

2.2.1 RFID Tags

Tags are one of the most important components of RFID system in which the specific information about a particular product is stored (Graph 2). Any specific information which is useful to track a specific product is stored in a memory chip of a tag which could be easily accessed by the RFID reader in a form of a radio signal. While accessing the information stored on a tag, the antennas sends a signal to the tag inducing the tag, which finally sends the information to the RFID reader. RFID tags contain two basic parts. First is an integrated circuit whose primary objective is to store and process various information as needed and to modulate and demodulate radio frequency signal. (Chatterjee et al. 2007.)

GRAPH 2. RFID Tag (Wired 2011.)

2.2.2 Antennas and Reader

RFID readers are those devices which convert electromagnetic waves coming from RFID tags into an information packages which could be easily read by middleware (Graph 3). The antennas inserted into a RFID reader transmit an electro-magnetic wave which acts as a power source for the tags which then transmits the information stored to it to the reader. The readers could be a handheld which are mobile in nature and carried with the operator or a wall mounted which are fixed and reads the tag which passes them. All these different types of readers could be used as the requirements in different situation.

GRAPH 3. Long range RFID reader (DIYSite 2011.)

2.2.3 Middleware

In simple words, middleware are kind of software which are used to manage the flow of information between the tag and the back end management system. Usually there are various information stored in a tag and not in each and every case those information are useful. Thus middleware software helps to filter information and send only the valuable information to the back end software at that particular stage. (The Institute of Internal Auditors 2010.)

2.3 Types of RFID tags

Generally RFID tags can be differentiated between a passive tag, a semi passive tag and an active tag. All of these three different tags have their own merits and demerits and they can be used in different situations depending on the requirements.

2.3.1 The passive tag

In general, passive tag are those kind of tags which doesn't have their own power source and thus depend on incoming radio frequency signal from the antennas (Graph 4). The incoming signal from the antennas supplies the tag with the power which is just sufficient to induce the internal circuit of the tag and thus transmits the data to the reader. In an RFID system where the passive tags has been used, the antennas has to be designed and fixed in such a way that it collects the incoming signal and transmits the outbound backscattered signal too. Since the tag doesn't have its own source of power thus the communication distance between the tag and the reader is very low. (Chatterjee et al. 2007.)

GRAPH 4. Passive RFID tag (EC21 Inc 2012.)

2.3.2 Semi passive tag

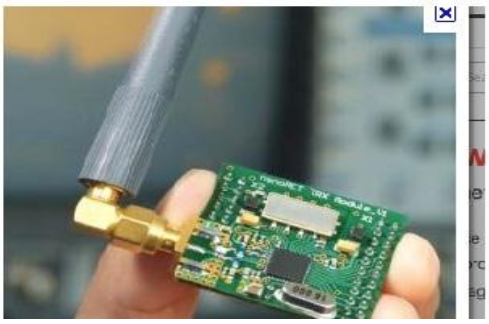
Semi passive tags are those kinds of tags which has its own internal power supply (Graph 5). A battery is implanted on a semi passive tag which continuously powers the integrated circuit which enables them to operate independently with the reader and provides with

longer reading distances. The semi passive tags are often used as communication interface between different sensors and devices and it's worth noticing that in semi passive tags, no power is transmitted and the tag simply reflects the power generated by the antenna. (Chatterjee et al. 2007.)

GRAPH 5. Semi-Passive tag (RFIP Solutions 2011.)

2.3.3 Active tag

Active tags are those kinds of RFID tags which are capable of generating its own power source with the help of a battery implanted on it (Graph 6). The battery implanted on the tag generated the power needed for its internal circuit which generates the outgoing signal. The battery installed in the active tag can last from at least a year to many years depending on the nature of a tag. These tags have very high reading distance and the data transfer rate between the tag and the reader is very high, however the drawbacks of these tags is they are very expensive compared to the passive tags. (Technovelgy LLC.)



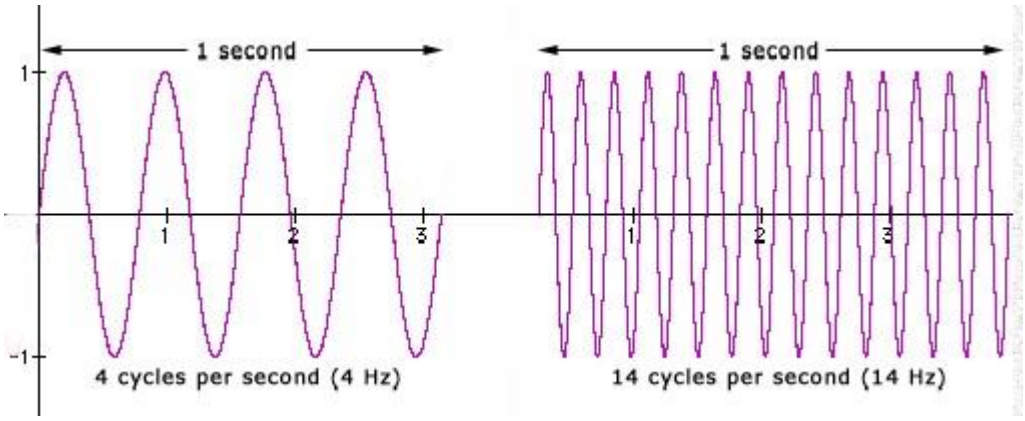
GRAPH6. Active RFID tag (Automattic 2011.)

TABLE 1. Difference between active and passive tags

ACTIVE TAG	PASSIVE TAG
Active tags generate their own power supply with the battery inserted on it	Passive tags depends on incoming radio signals for its power source
They transmits strong signal and have longer reading distance because of their own power source	They transmit weaker signal due to the lack of their own energy source and the reading distances are shorter too.
The prices of theses tags are usually expensive and thus it is only used in high value goods.	They are relatively cheap in comparison to active tags so could be used in mass products

2.4 Frequency in RFID

The number of cycle made in per unit time is known as frequency (GRAPH 7). The unit for frequency is cycles per seconds (CPS) or Hertz (Hz) (Hass 2003).



GRAPH 7. Frequency cycle made in a second (Hass, J. 2003.)

All the wireless communication devices like radios, mobile phones, aircraft communication devices etc. operate on their own specific frequencies and RFID is no exception. It is very important that all these devices function on their own particular frequency range and doesn't interfere with other devices signal. Thus to standardize the frequency range for all wireless communication devices, each countriy has allocated

specific frequencies range for all these devices and has to perform strictly on these ranges to avoid any chaos because of frequency interference.

Thus for RFID too, countries around the world have allocated specific frequencies to operate and it is very important to understand the strengths and limitations of these bands and careful attention has to be given while choosing the right frequency according to the application needs.

RFID works in Industrial, Scientific and Medical (ISM) bands which are open frequency bands and doesn't require any special license or permission from government authorities for operation. However, these open bands vary greatly according to countries and regions. For example the ISM band in The United States of America is in 902-928 MHz however the same ISM band for Europe is 868 MHz. The Wi-Fi, Bluetooth, RFID etc. operates in ISM bands.

In RFID, the tag mainly operates in 4 different frequency categories (TABLE 2) which are:

Low Frequency (LF): 125 – 134 KHz

High Frequency (HF): 13.56 MHz

Ultra High Frequency (UHF): 433 MHz and 860 - 956 MHz

Microwave Frequency: 2.45 – 5.8 GHz

Even though the RFID system works in all of these different frequency ranges, each frequency range has own benefits and limitations and which operational frequency to choose solely depends upon the area of application too.

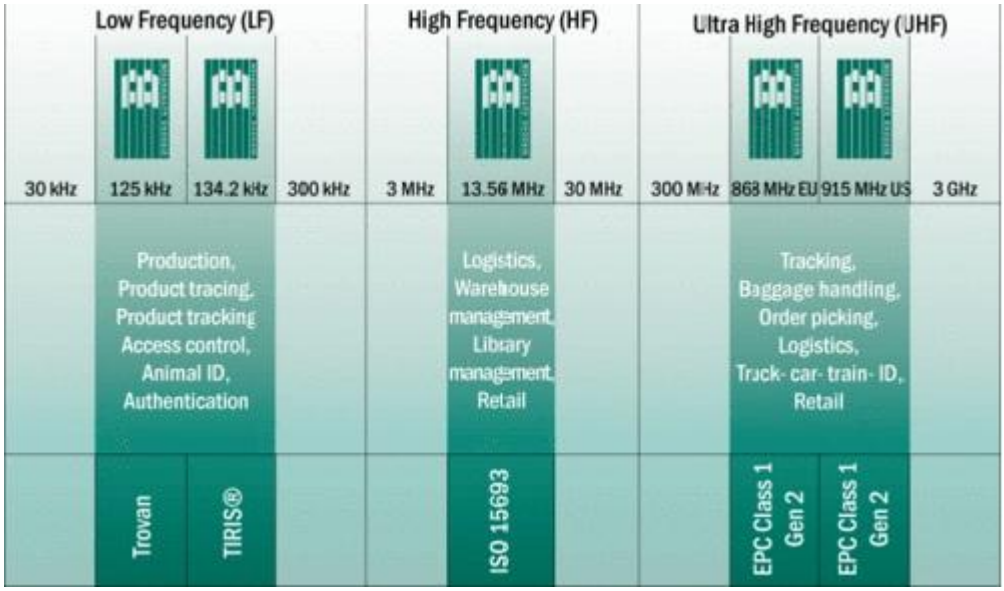
The LF in RFID requires very little energy to operate which means that only a small impulse is enough to induce the IC. However their reading distances are very low which can be only few centimeters to a maximum of half a meter. However, these tags are least effected by the presence of foreign bodies in the surroundings. LF tags are still capable of reading the signals despite the presence of foreign object like metals etc. and even water. Even though the LF has a low reading speed and it is widely used in applications of access control, animal identification, monitoring manufacturing processes etc.

Similarly, HF has longer reading distance compared to Lf which can range up to 2m however the range is not as far as UHF. The HF tags are cheaper in comparison to the LF. However they do not have a very good reading speed. The applications of HF tags are in library management system, luggage handling etc.

UHF has more energy which means the system can be used for reading and transmitting data for very long distance which can range from 10m operating in 860 - 956 MHz range up to 10's of meters operating in 433 MHz. However, the signals in UHF are easily interfered by the presence of foreign bodies which directly affects the performance of the system. The UHF is cheaper compared to LF and HF and has a very fast reading speed and is best used in logistic handling, toll collection etc.

Microwave frequencies can identify the object very fast especially because of its fast reading speed however, they do not operate efficiently in the presence of water and metals. The typical application of this is in luggage handling and in toll collection. (Wireless-Technology-Advisor 2011.)

TABLE 2. Application of RFID in different frequency level (A Brooks Automation 2011.)



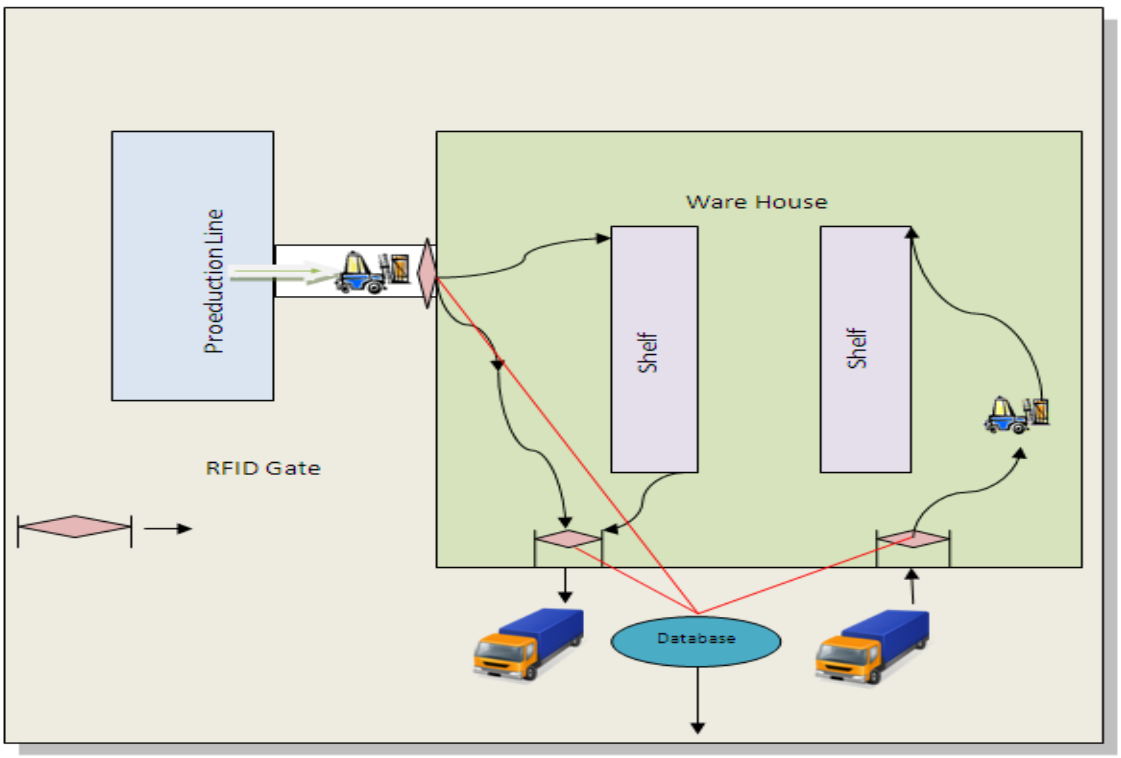
2.5 Areas of application of RFID in industrial environment

Even though vast areas of application of RFID have been identified and various researches is still on going to predict the future application of RFID, however, for our research purpose in industrial field, following few areas of application have been identified.

- Warehouse Management System with RFID
- Optical Vision System and RFID for product tracking
- RFID in Assembly Line with Access Control
- Integration of RFID and Barcodes

2.5.1 Warehouse management system with RFID

One of the biggest applications of RFID in manufacturing industries is maintaining real time inventory system in the warehouses. In general, warehouse gates needs to be constructed and RFID readers are installed in all the gates (Graph 8).



GRAPH 8. Warehouse layout using RFID ports

2.5.2 Current technology in use for warehouse management

A similar technology is being used by Transluz Casual Wear to manage their warehouse and inventory system. Transluz Casual Wear is a Spanish clothing company with over 30 franchise stores worldwide. The company has successfully implemented RFID system which tracks the clothes from the point of manufacturing up to the point of sales. All 30 Transluz stores are equipped with RFID system to record the movement of goods and maintain the real time inventory system of the store.

In this system, the use of RFID tags starts at the point of manufacturing. When the clothes are being manufactured, RFID tags are inserted into each and every label of the clothes and the necessary data are stored on the tags. These information are transferred to the central database with the help of handheld devices. After successfully inserting the information on the tags, the clothes are packed into boxes and then transferred to the central warehouse of the company where each and every boxes are passed through a conveyor belt installed with RFID reader and antennas. While the boxes are passed through the conveyor (Graph 9), it reads all the tags in the boxes and maintains necessary inventory of goods in the databases of all the products received in the central warehouse. After that, while the boxes of clothes are again ready to be shipped to the stores, they are passed through the same conveyor belts and software updates the dispatch of products to a specific store.

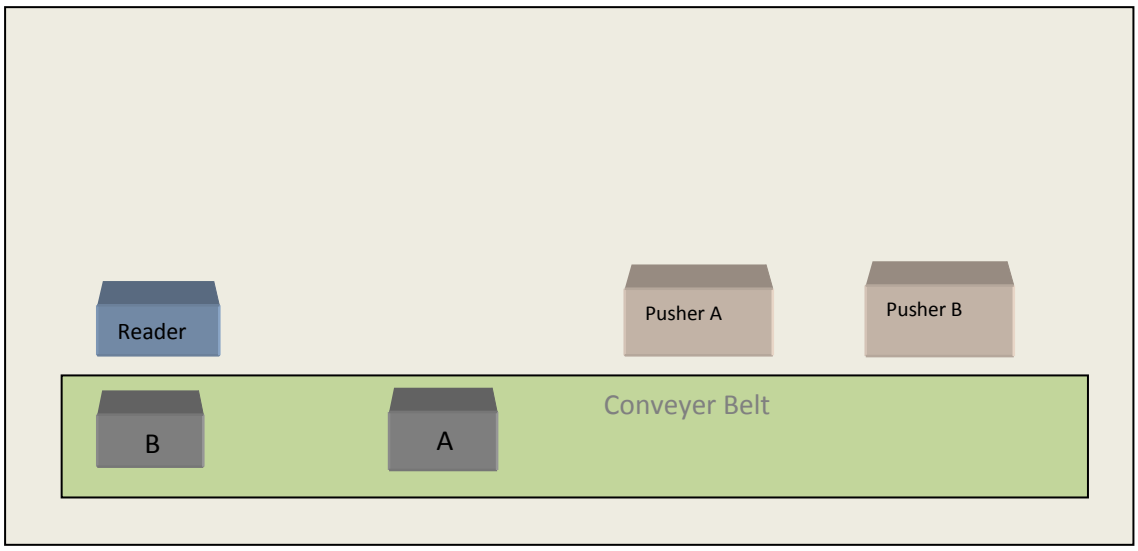
Similarly, once these boxes arrives at the final store, with the help of handheld RFID reader each tags are read which ultimately transfers the information regarding which product has arrived in to the store subsequently maintaining the database too. (RFID Journal LLC 2012.)

GRAPH 9. Tracking of RFID products (Adopted from: RFID Journal LLC 2012.)

2.5.3 RFID in assembly line

Another application field of RFID can be found in the assembly line. A system prototype can be developed in which a RFID reader will identify the product and with the help of conveyer belt, pusher and a manipulator, the product will be sent to its designated area. In the same demonstration, the feature of security and access control on RFID can be developed too. The biggest advantage of this system will be that the product parts can reach its designated place automatically at the time of requirement. This system will also help to reduce the process handling cost and processing time too.

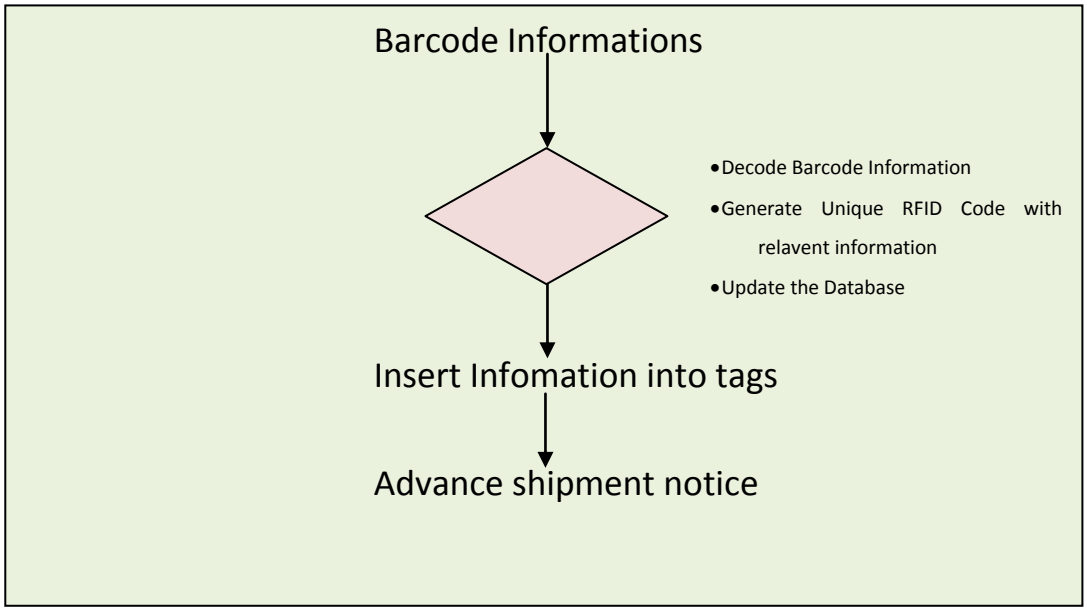
In this system, both product A and product B are attached with RFID tags (Graph 10), and when the RFID reader identifies the product, it sends the information to the pusher, so that when product A arrives in front; pusher A operates and when product B arrives in front; pusher B operates.



GRAPH 10. Concept to use RFID tags on assembly line

2.5.4 Integration of barcodes and RFID

The biggest advantage of RFID over Barcode is that the RFID tags can store much more data compared to barcodes (Graph 11). Furthermore, RFID tags do not need to be positioned precisely in front of a scanner thus minimizing the human involvement and errors too. However the cost involved in implementing on RFID technology is much higher than for the barcodes, which is one of the biggest reasons for RFID not being used fully on Supply Chain.



GRAPH 11. Flowchart for integration of bar code and RFID

Usually it involves a huge investment to switch from barcode to RFID technology and it cannot be done overnight. This makes small companies reluctant to implement RFID. Thus system can be developed where the information stored in a barcode could be converted from barcode to RFID tags easily by the use of handheld barcode scanner and RFID reader.

3 MACHINE VISION SYSTEM

In human beings, an image is formed when a light reflects from an object and enters to the viewer's eyes. In camera system however, an image is formed when the detector installed in a camera detects an emitted radiation that has interacted with the physical objects.

These days, the machine vision system has become a very common concept in the industrial sector. It is a term which is used to describe a vision system in an industrial environment resembling the automated processing, analysis and interpretation of various images. The history of machine vision system is not very long and its need was realized during the industrialization era when industries were focusing on big volumes of production.

During the 1960's, institutes like National Physical Laboratory, Edinburg University, Massachusetts University of Technology and others made successful research on vision systems and demonstrated an useful application in industrial inspection, robotic control and automated assembly. Since then the technology has made huge progress and has been effectively applied in various industries.

In general, a machine vision system is a mechanism in which non a contacting sensor installed in a camera receives the images, which then are analyzed by the processor and based on the result of analysis; a process is controlled in an industry. A machine vision system not only helps to improve the quality and safety of a product, it also improves the production efficiency and profit maximization. Machine vision system doesn't possess its own intelligence; however this feature is added with the installation of image processing software and computer coding.

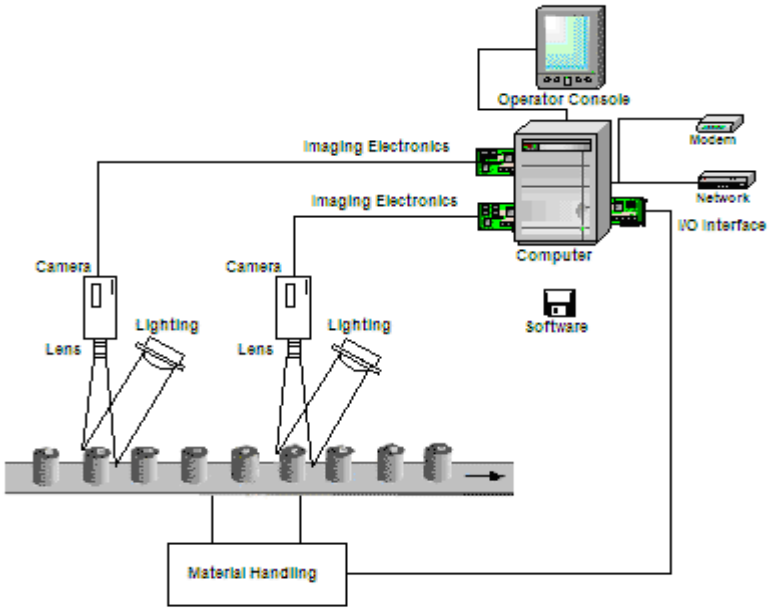
A complete set of machine vision includes the following components (Graph 12):

- Cameras
- Image processing software
- Mechanical Engineering
- Electronics
- Computer Architecture

Designing and effective installation of a machine vision system is not an easy task. It requires a very complex process before the target can be obtained and rather than an individual effort, it requires a concrete team effort. The first step of installing machine vision requires problem identification. In this step, the technician needs to identify what is the real problem inside an industry and why there is a need of machine vision system? Once the problem is properly identified, it is much easier to develop the solution to the problem. Apart from problem identification, it is equally important for the team to have careful planning, creative thinking and the good spirit of team work.

Following are the expertise required in vision system:

- Electronic Engineering (Hardware & Software)
- Technical Mathematics
- Mechanical Engineering
- Physics (Optics)



GRAPH12. Components of a machine vision system (High-Tech Digital Technical Support 2012.)

If we carefully analyze the reason why industrial vision system are popular these days and being implemented from big industries to small ones, we will be able to draw some conclusions. The first and foremost reason for industrial vision system to be so popular is mainly because it has been a very useful asset to improve the quality and safety of a product. There were times when each and every product has to be inspected by humans to ensure the quality of the product; however this was a very costly and still it could not ensure full quality guarantees but when vision system was introduced in industries, it would accomplish the same task much more effectively and relatively at a lower price.
Apart from this advantage, vision system considerably reduces the production cost and increases the productivity too since the production process is much better after the introduction of vision system; it helps to increase the efficiency and helps industries in profit maximization. Moreover, vision system also helps in modification of manufacturing processes and it can be configured as per demand. If we consider the return on investment of vision system, the primary investment can little big but the payback time are short since, it considerably reduces the use of labor force which helps to save the cost significantly. (Batchelor & Whelan 2002, 1-5.**)**

3.1 Reason of implementing vision system

There can be hundreds of argument for and against implementing a vision system in an industry. However, no matter how much people are against the idea of implementation; there are clearly few advantages of implementing vision system in an industrial environment. The primary benefits are as follows:

- It increases production speed
- It improves quality
- It improves safety
- Yields return on investment

In the past, vision system was an integral part of an automated production system particularly on the assembly lines. With the use of an automated assembly system with vision integration, high volume of production was achieved. However, the problem persisted if in case the assembly line has to be modified, it cost huge amount of money for

modification. Thus soon the need was realized to develop such a system where the production could be done in small batches with shorter production time and higher degree of flexibility with an ability to handle customized product.

In today's competitive business environment, it is very important for the companies to manufacture various products using flexible production system without compromising on quality. Since the company needs to have various products, it is very important for the vision system to be integrated in the automated process so as to accommodate product design changes and new product manufacturing by reducing the cost of short manufacturing runs.

Furthermore, the use of vision system is not only limited to quality control. As a matter of fact, the application of vision system goes far beyond the line of just quality control. Another biggest advantage of implementing vision system is that it is able to control production processes too. In any manufacturing industry, it is important to produce goods complying with the standards but it is also important to monitor and control the process so as to reduce machine breakdown, reduce throughput time and increase efficiency. Especially in those industrial sectors which are running on low inventory level and those companies implementing Just in Time (JIT); it is very important to closely monitor the process. In these sectors; any adjustments to machines or processes tremendously increase the machine uptime. Similarly, vision system helps to reduce the buffer and the bottle neck in the production system, scheduling of production with resource optimization. (Batchelor et al. 2002, 4-8.)

3.2 Types of Images

A vision system works on a basic principle of capturing images, analyzing the image using a proper software tool and reacting to the execution as demanded by the situation. Thus, there are various types of images used in vision systems of which are discussed below.

3.2.1 Monochrome Image

Monochrome image also known as greyscale images are those kinds of images where the only available color is gray. In other words it can be also described as those kinds of images where the red, green and blue components have equal intensity in RGB space. (R Fisher, S Perkins, A Walker and E Wolfart 2003.)

Let us consider a matrix (GRAPH 13) I,J where $1 \leq I \geq M$ and $1 \leq J \geq N$ and similarly let us denote a function f(I,J) such that $0 \leq f(I,J) \leq W$ where W is the white level in a gray scale image. The function f(I,J) is a part of a picture element.

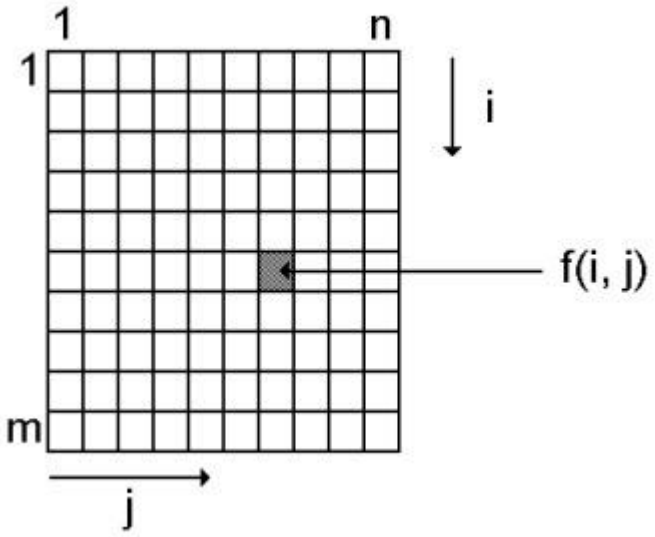
Thus from this matrix we can derive a conclusion that if

f(I,J) = 0 = black

0,33W <f(I,J) ≤ 0,67 = Mid Grey

f(I,J) = W = White

(Batchelor et al. 2002, 19-20.)



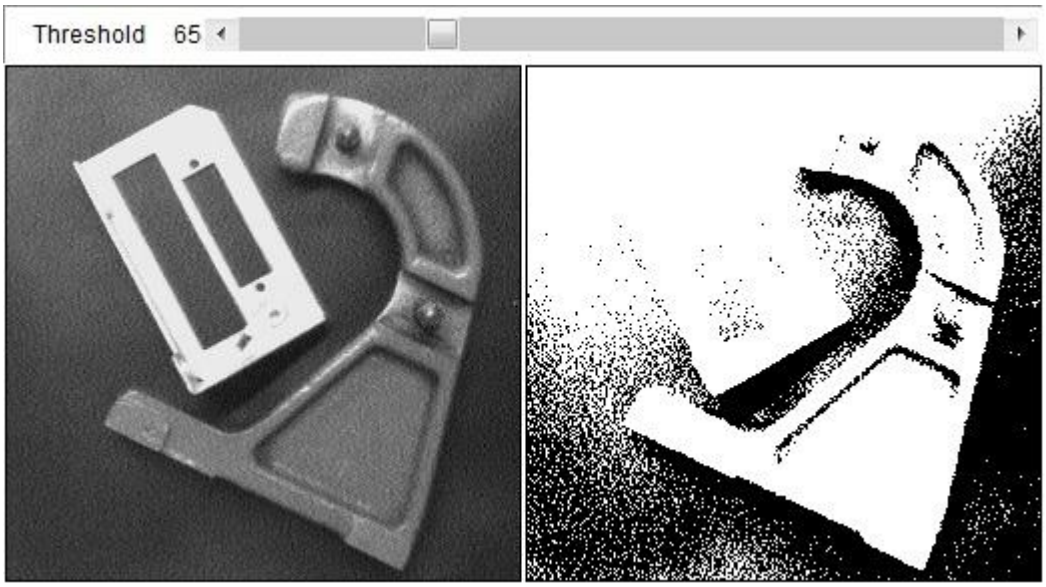
GRAPH 13. Image consisting of an array of M, N Pixels (Batchelor B.G. & Whelan P.F 2002.)

3.2.2 Binary Images

Binary images are those kind of image in which is the images are represented in the form of 0 and 1 or in binary forms. The pixel values of these images are, either 0 or 255 which indicate that they can be either black or white.

Binary images has many application in industrial vision however, use of these images are not always possible. Binary images can be used in those circumstances where the object can be easily silhouetted with the background.

Binary images are obtained by thresholding a greyscale images (Graph 14). While obtaining a binary image, the pixel above the greyscale are assigned to a pixel value of 255 and everything less than the grey level is assigned a pixel value of 0 which results a white object in a black background or vice versa. (Robyn Owens, 1997.)



GRAPH 14. Binary image of a metal clamp (Fitzgibbon A. 2011.)

3.2.3 Texture Analysis

Texture is a pattern which represents in surface and structure of an image. These are very complex patterns of images which could be found on natural or synthetic materials. The texture can vary in shape, size and colors. (G.N. Srinivasan and Shobha G, 2008)

There are two basic technique of texture analysis. They are Statistical Texture Analysis and Structural Texture Analysis.

If the textured image is very high in intensity variation then the surface would be texture however, if the variation of intensity is relatively low then the surface is tone. (Batchelor et al. 2002, 55.)

3.3 Color Image

The value of color is undoubtedly of immense importance to human being. A bright sunny day brings pleasant feeling on the body. Furthermore, it gives good feeling to a body when someone sees a bright blooming flower or a colorful clothes displayed at the shop. All these above examples are good enough to explain the importance of color in someone's life.

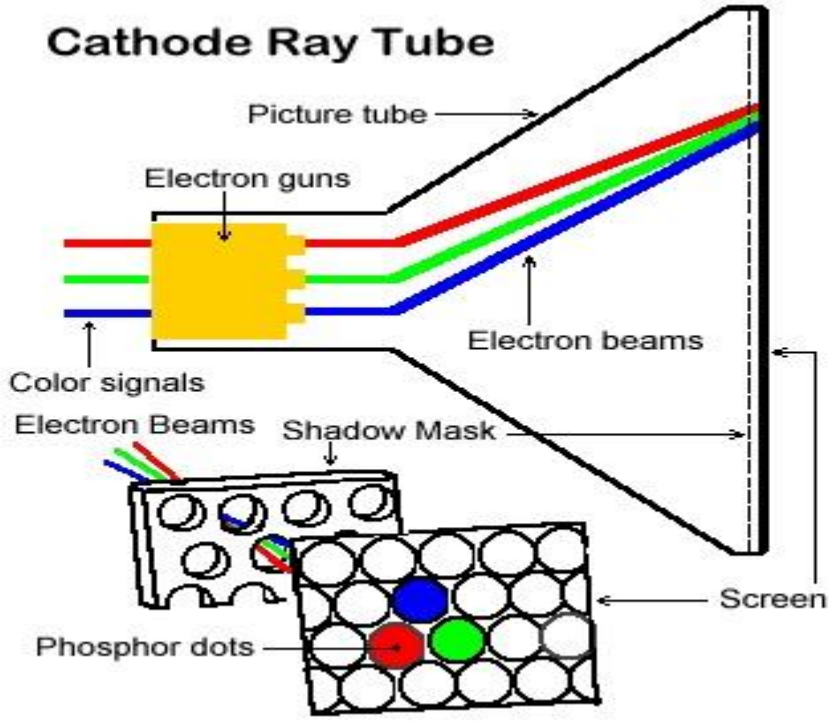
Despite color having so much importance in human beings life, in industrial vision system, not many color images are being used. However, few trial attempts were made in the past to study the possibility of using color images in industrial vision but no remarkable progress has been made so far. The main reason for this could be as follows:

- Most industrial products are monochromatic: In industrial sector, most of the products which vision system has to analyze are monochromatic in nature which means that the products are in single color. For example the metals and the plastics are all monochromatic in nature.
- Color inspections are difficult to analyze: There is great variation in color. Even, a small change in measurement makes a big difference. So to analyze a precise color change, a very highly efficient tool is needed.
- Cost of installation and implementation: At least, if we consider the initial cost of installation and implementation of vision system, it brings a lot of cost especially for small sized enterprises. On top of that if companies try to install system to analyze color images, it brings huge amount of financial burden to the companies which make them reluctant to implement it. (Batchelor et al. 2002, 203-205.)

3.4 Color Cameras

Cathode ray tube cameras are those kind of cameras in which when a beam of light enters through the lenses, a beam splitter splits the light into three different directions. At this point, the cameras are fitted with three different optical filters of three different colors respectively; Red, Green and Blue. When the beam of light passes through these filters, the output colors are Red, Green or Blue depending on the filter through which the light passes

through (Graph 15). These colors ultimately pass through the CRT image sensor and finally beam of Red, Green and Blue light is obtained. (Batchelor et al. 2002, 211-212.)



GRAPH 15.Cathode ray tube (Doom9 Networks 2007.)

3.5 Light Source for Camera

We have noticed in our day to day life that picture that taken in ample sunlight looks nice and lively. On the other hand, pictures taken in dark light are difficult to recognize. Same principle applies to vision system too. The images obtained from sufficient lights are easy to process and accuracy is higher in these kinds of images. On the other hand, the images obtained from insufficient light source are generally difficult to process and the accuracy on interpretation of images plummets considerably. Thus it is important to notice few important factors regarding light sources while designing vision system.

While designing the vision system, it should be taken into account that the analysis of images is much more effective and accurate when there is enough light sources It takes much more into effort to program the system if ample amount of light are not available. Furthermore, at constant light sources should be arranged. A great variation in the light

source in a short interval of time can lead to misinterpretation of an image. Thus the following important points should be considered while designing a vision system.

- Brightness of light should be ample to obtain clear images
- Light source should not generate high level infra-red and ultra violet radiation
- Light source should not vary greatly because it directly affects the quality of image.
- Light source should be constant and stable.
- It is important to develop a mechanism to calibrate the color measuring system. (Batchelor et al. 2002, 214.)

4 RESEARCH METHODOLOGY

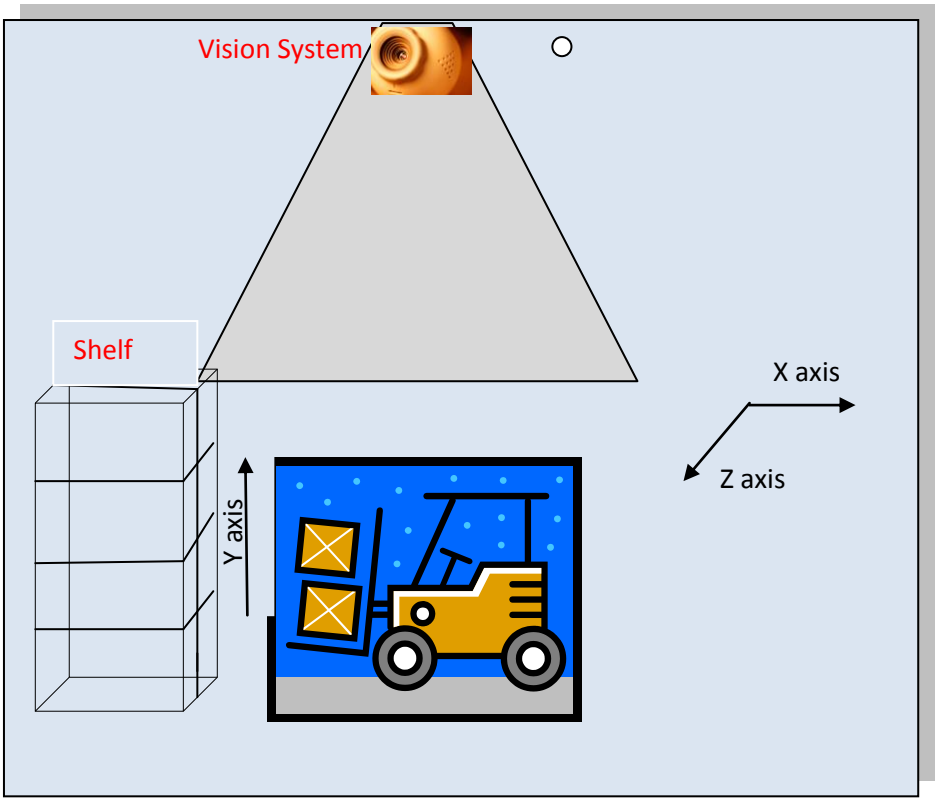
In big industries, thousands of products are used as raw material and hundreds of products are produced and stored in warehouses every day. However, for all big industries, the problem persists on tracking the raw material and finished goods in very short time. Industries are always in search of a good solution to track their products. However, a reliable solution hasn't been found yet. Some companies have implemented the bar code system to track the products. However it hasn't been very effective since in the barcode system there are a lot of chances for human errors.

Especially in a warehouse, a forklift driver is the responsible person to put the raw materials and the finished goods on the right shelves. However, this doesn't happen normally in an industry. Due to the drivers' negligence, ignorance and work pressure, the goods are often stored in a wrong place which costs extra money and resources to locate the item when needed. Thus, in this research project a prototype was designed in which a solution will be developed to track assets inside a warehouse using two cameras on a rooftop, products with RFID tags, a forklift with Wi-Fi to transfer data in real time.

The concept to develop a prototype is based on simple geometry. With use of this simple geometry concept to locate the assets, the exact position of the product will be transferred to the backend database which maintains the inventory level and location of the product and these recorded information can be accessed through the network computer at any time thus reducing the processing time and enhancing the order processing efficiency.

For this research purpose, a vision system will be used on the rooftop which records the X and Z axis of the product and with the help of vertical sensors installed in the forklift and RFID tags installed in the palette, the exact location of product is stored in the database system and it can be accessed at the time of need (Graph 16). The biggest benefit of this demonstration is that after using this technique, no material in the factory will be lost and can be tracked within seconds. Since the process involves no human resources, the error percentage will be close to zero.

Furthermore, in the research project, the target is also to study the light condition, the vertical height required to implement the concept and at the same time to study the accuracy of reading too.



GRAPH 16. Vision system designed to track products in warehouse

4.1 Existing technology on product tracking

While searching on the internet, no similar technology using a camera recognition system has been found. However, Sky-Trax Incorporate, a company developing and supplying solutions to increase the efficiency of warehouse operations has developed a solution for tracking vehicles and assets in a warehouse using two dimensional (2D) barcode system (Graph 17).

The solution developed by Sky-Trax helps to get reliable data which are required to optimize the operations in a warehouse system. To have real time visibility of each asset, Sky-Trax solution monitors the vehicle movements and location in a warehouse with a help of 2D barcodes installed on the ceiling of the warehouse, on which the information on

floor calibration are stored. Similarly, powerful 2D barcode scanners are installed on the top of every fork lifts to read the information on the ceiling of the warehouse. The pallets are also furnished with 2D barcodes and with the help of backend software all these information are integrated and thus the exact location of the product is stored on the database. (Sky-Trax Incorporated 2012.)

GRAPH 17. Vehicle tracking system using 2D barcodes (Sky-Trax Incorporated 2012.)

4.2 Equipment in use

The target in the research was to make the prototype as simple as possible. Keeping our primary target in mind, utmost attention was given to use as little electronics as possible and to keep the design simple. The following equipment and electronic were used for testing purpose.

- Wifibot used as a forklift and installed with Wi-Fi and Windows XP
- Omron F-150 Camera 2pieces
- Extension tubes for cameras
- RFID UHF Faeg Reader (ISC. MU02. 02 –CO)
- RFID UHF Tag
- Camera controller installed with Windows 95
- Laptop used as a server

- Product database on the backend
- Frontend interface for maintaining product location and database on backend
- Frontend interface for floor calibration
- A contrasting circular shape installed on roof of Wifibot.

4.3 Process Description

The project included integration of various electronics in one single place. The basic integration included the camera vision system with RFID tags. There was also Wifibot which was integrated into the system because the camera system should track the movement of the robot too. Thus integration of these various segments was accomplished in different steps.

4.3.1 Camera Installation

The first step in building the prototype included the installation of the two Omron F-150 cameras. While choosing the location of the installation place, special care was given to the light condition available in the room because in a vision system, the light condition plays a very important role because the higher the source of light, better the accuracy of the reading. The height of the camera and the floor (working distance) was around 3 meters. In industrial environment, the distance between the roof and the floor are at around or greater than 10 meters but for our research purpose we choose the height to be only 3 meters. This makes the installation of camera very easy. While installing the cameras, special attention was given to the coverage of the cameras and it was ensured that the two cameras do not overlap their field of vision. If the cameras overlap their fields of vision, it was very likely that there will be an error in the reading.

After successfully installing the two cameras on the top of the laboratory, the cameras were connected to the camera controller via Omron F150- VS camera cable and the controller was connected to the main server via serial port which means the communication between the controller and the server took place through RS-232 port.

The camera controller basically controls the working of the two cameras simultaneously. An edit flow was created on the controller itself which controls the flow of working mechanism.

While creating the edit flow first of all it was very important to set the magnification of the cameras. To set the magnification of the cameras, the following steps were performed.

- Two straight lines were drawn and their distance was measured
- The average pitch while focusing these two lines was also recorded

In case of our experiment, the distance between two lines was 130 mm. and the average pitch displayed on the controller was 174.

Thus Magnification was calculated as
Magnification = Distance between two lines / Average Pitch
Magnification = 0,747 pixel
The magnification value of 0,744 was inserted on the controller.
After setting up the magnification value, now it was time to put the shutter speed of the camera and it was on 1/500 sec.

Furthermore, now it was time for model registration. In other words it means defining to the camera what it is searching. For this purpose, a circle in black color was printed on a paper and it was defined as a search region. After registering the model, the rotation angle was set to 0 – 360 degrees and similarly the correlation value was set to 30/100.

After successful model registration, it was time to define the data output format which means that it was time to define the controller in which format the data will be retrieved as an output and in our case it was through RS-232/ RS 422 format since it was connected to the computer server.

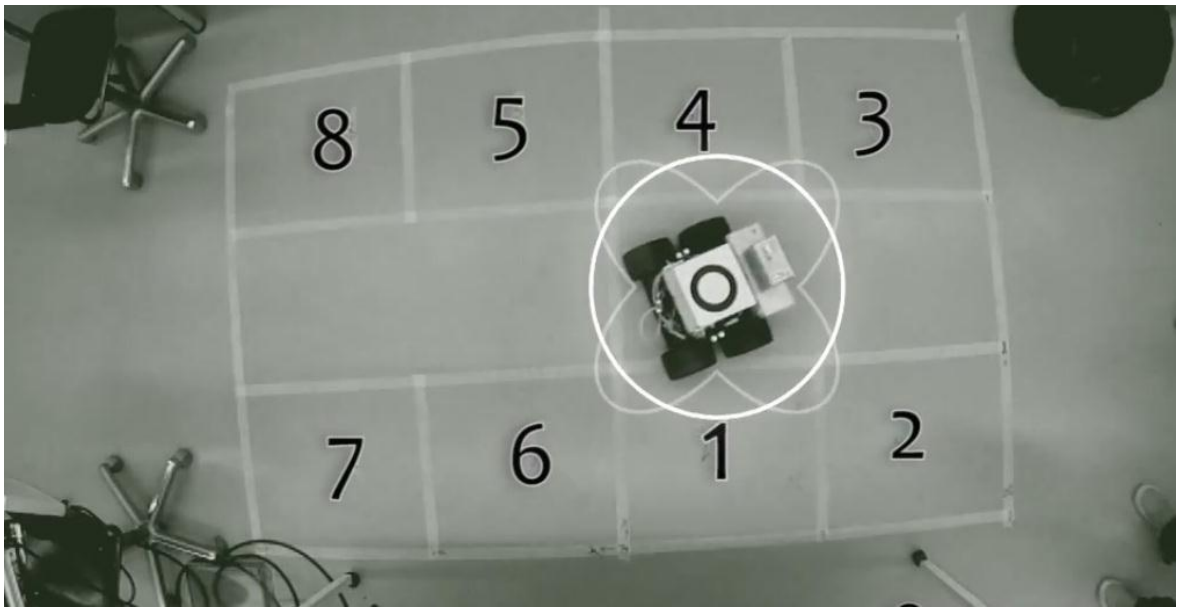
After successfully defining all the parameters, controller is finally connected to the server through RS-232 cable and an internet protocol (IP) address is assigned to it to make the communication between the controller and the server.

4.3.2 Simulated warehouse floor plan

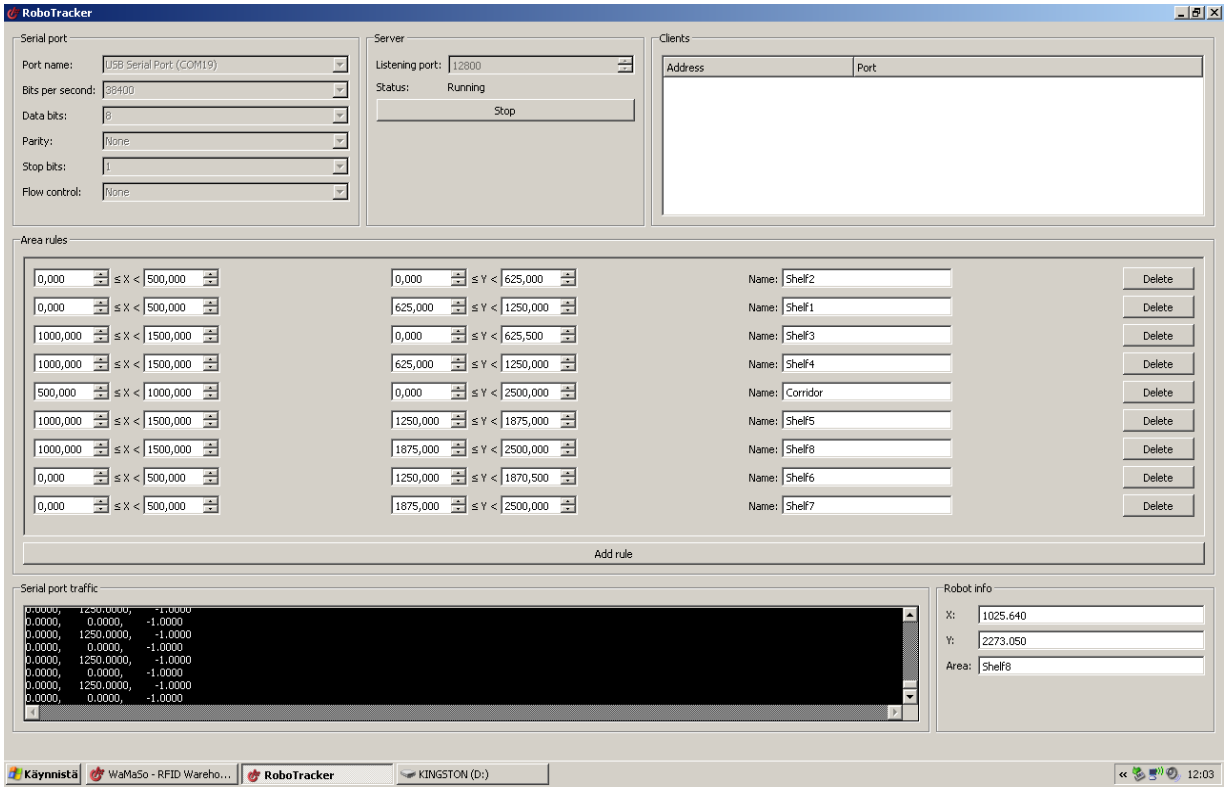
After installing the cameras, it was time to create a simulated floor plan of a warehouse in the laboratory(Graph 18). For this purpose 8 shelves with a corridor was designed. Each size of the shelf was 500mm X 625mm where the X axis of the shelf was 500mm and the Y axis of the shelf was 625mm (Graph 19).

GRAPH 18. Simulated warehouse floor plan

Similarly the size of the corridor was 500mm X 2500mm where the X axis was 500mm and the Y axis was 2500mm.



GRAPH 19. Top view of simulated warehouse floor plan with shelves number



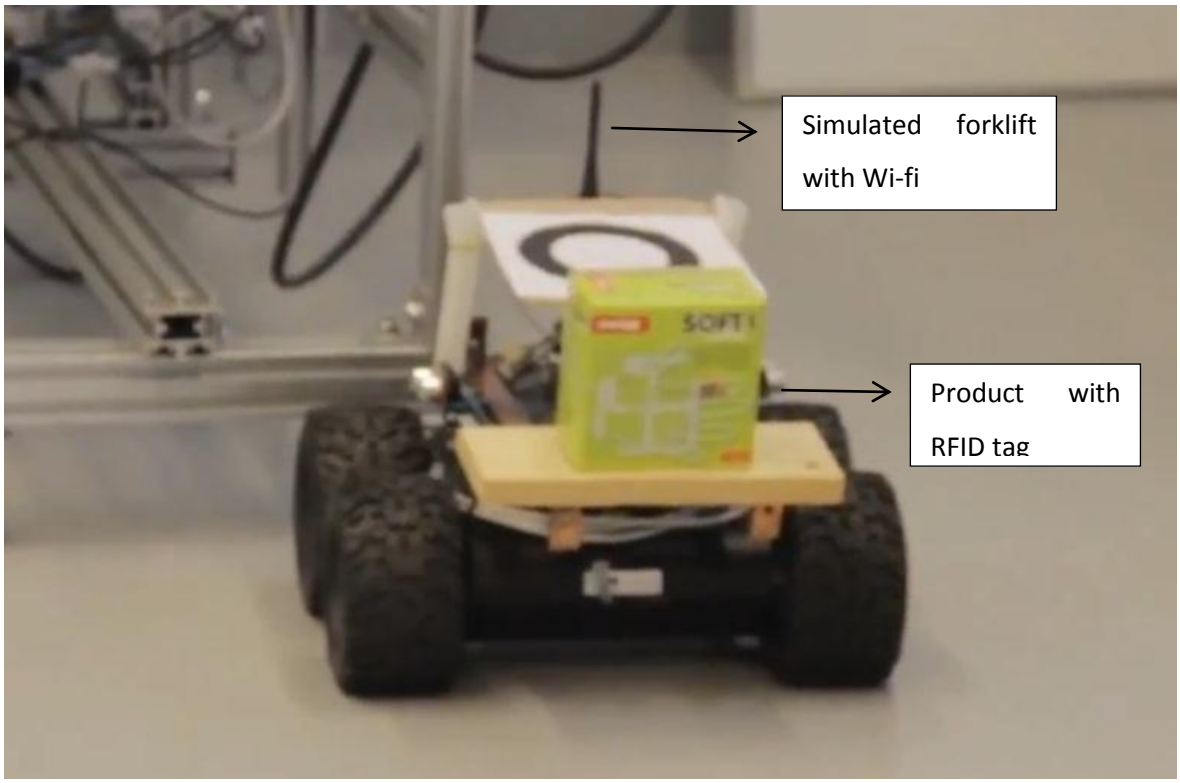
GRAPH 20. Software to insert parameters for shelves and corridor

It was not only enough to create a simulated floor plan of the warehouse but its diameter has to be inserted into the server so that it would be possible to track the movement of the product along its exact X and Y axis and the location can be stored on the database. For this purpose, software was created where the parameters like the number of shelf in the warehouse, the size of each shelf and the size of the corridor could be inserted separately. At the time of creating the software it was made in a flexible way so that the parameters inserted are not fixed and they could be changed at any time according to our need (Graph 20).

4.3.3 Installation of Wifibot

Wifibot is a mobile robot enabled with wi-fi and multi-purpose platforms running both linux and Windows systems. It is a simple robot with flexible and open modular architecture. Due to its small size and low weight, it has great indoor and outdoor mobility with flexible and open modular architecture (Graph 21). These robots are fully

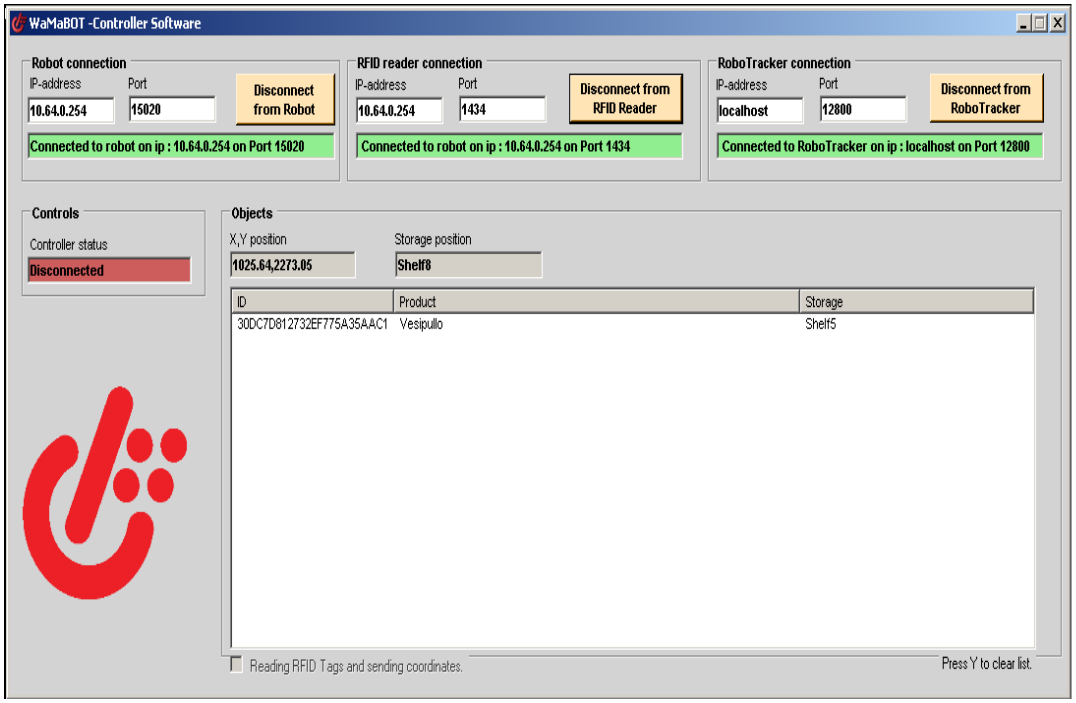
programmable and the data can be transferred to the server through the wi-fi installed on it. (Wifibot Networked Robotics 2003.)



GRAPH 21. Wifibot with integrated wi-fi and Faeg RFID reader used as forklift

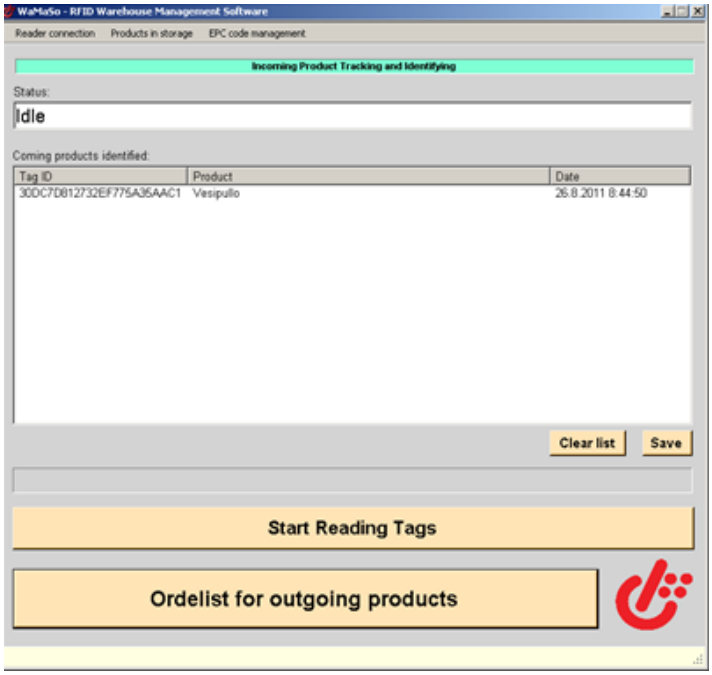
For our experiment purpose, the wifibot was used as a forklift truck. The movement of the robot was controlled through a controller. A separate code on C# was written to control robot with a controller. The controller was connected to the robot via Bluetooth. Similarly a lifter was installed on the front of the robot to lift the products. Furthermore a UHF Faeg reader was installed to the robot too. The data retrieved by the reader was transferred to the server through wi-fi installed on the robot. A separate IP was assigned to the robot to connect to the server (Graph 22).

The Faeg reader reads the data from the product while the fork lift is lifting the product and once the product is stored in the shelves, the vision system sends the location of the shelves including the X and Y coordinates while the data sent from the Faeg reader helps to determine which product has been stored in that particular place. This information could be retrieved at any time of need within few seconds. Thus, in this way the product in any location inside the warehouse could be tracked easily.



GRAPH 22. Software showing connection status of wifibot, camera system and RFID reader with the server

The biggest advantage of this technology is that even if the product is not stored in a particular place and due to someone's negligence is stored in wrong place; still the location could be tracked within no time, thus saving time, money and processing time (Graph 23).



GRAPH 23. Software showing the RFID tag number and the product name on the database

5 LIMITATION, RECOMMENDATION AND CONCLUSION

During the process of developing the prototype, maximum effort was made so that it will meet all the requirements of an industrial environment but still the research had its constraints and limitations.

Discussing the limitations while developing the prototype, the vertical working distance between the camera and the floor was just around 3 meters while in normal conditions in industries, the distance can be way over 10 meters. Thus it is very important that the readings are obtained accurately in industrial conditions. Furthermore, the prototypes were tested in laboratory light conditions and since the importance of lighting conditions are very important in vision system to obtain the precise and accurate readings; the prototype should be tested in actual industrial light conditions.

In addition, the cameras used to develop the prototype were primarily not designed to be used in this kind of purpose. The camera is solely designed to be used in a sorting system in industry which means that the field of vision of camera is very low in this case. This directly affects the area of coverage by the camera. For this reason, cameras designed for industrial use and with larger field of vision are recommended so as to minimize the number of cameras used which can significantly minimize the implementation cost.

In industries it is a common that the information is stored in a central database with the use of Enterprise Resource Planning (ERP) software. So in the future, efforts could be made to integrate the information with existing ERP system of an industry.

Despite having limitations as a prototype, the technology is unique and the test was promising and the readings obtained were highly accurate. Thus, has very high chances to be effectively implemented in industriy and some interests are already shown by companies to implement the idea. So with some efforts in developing the prototypes, the technology could be in very high demand by industries in the future and help companies to increase their productivity.

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