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Biomedical Waste Segregation For Hospice Applications

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Abstract : Bio medical waste management has recently emerged as an issue of major concern not only to hospitals, nursing home authorities but also to the environment It is estimated that quantity of waste generated from hospitals in India ranges between 0.5 and 2kg/bed/day and annually about 0.33million tons of waste are generated in India. WHO fact sheet reported that from total of waste generated by health care activities, 20% are hazardous. The bio medical wastes are segregated into different color bins of yellow, blue and red. The conventional method of bio medical waste segregation completely depends on man power as the color codes for classification of bio medical wastes need to be memorized by them and further segregation steps to be taken accordingly. Considering this problem, we propose a methodology by combining image processing and file sharing concept. Here, the image of bio medical waste is shared from raspberry pi to Matlab. In matlab, the real time image is compared with the stored database using image proceesing.The result is shown by glowing one of the four color leds(red,yellow,blue,green) that represents the respective color bins to which the waste belongs.The proposed method provides healthy workspace for all categories of hospital personnel and improves image of health care establishment.

Index Terms **- Bio Medical Waste, Waste segregation, Error measurement, Image processing.**

I. INTRODUCTION

Biomedical waste (BMW) generated in our nation on a day to day basis is immense and contains infectious and hazardous materials. It is crucial on the part of the employees to know the hazards of the biomedical waste in the work environment and make its disposition effective and in a scientific manner. It is critical that the different professionals engaged in the healthcare sector have adequate Knowledge, Attitudes and Practices (KAP) with respect to biomedical waste management [1]. Now it is a well-established fact that there are many adverse and harmful effects to the environment including human being which are caused by the "hospital wastes" generated during the patient care. The hospital waste is a potential health hazard to the health care workers, public, flora and fauna of the area. The problems of the waste disposal in the hospitals and other health care institution have become issues of increasing concern. According to Bio Medical Waste (management and handling) Rules, 1998 of India "Any wastes which is generated during the diagnosis, treatment or immunization of human beings or animals or in research activities pertaining thereto or in production or testing of biological" [2]. Biomedical waste management is an important precondition to safeguard the healthcare workers and community members, as well as the environment, from being contaminated with infectious substances. However, biomedical waste management practices during the pandemic era of COVID-19 were unknown [3].

The hospital waste, in addition to the risk for patients and personnel who handle them also poses a threat to public health and environment. Biomedical waste (BMW) is any waste produced during the diagnosis, treatment, or immunization of human or animal research activities pertaining thereto or in the production or testing of biological or in health camps. It follows the cradle to grave approach which is characterization, quantification, segregation, storage, transport, and treatment of BMW. The basic principle of good BMW practice is based on the concept of 3Rs, namely, reduce, recycle, and reuse [4]. As per estimates 32% of new Hepatitis B infection, 40 % of Hepatitis C infections and 5 % of new HIV infections occur every year due to contaminated sharps and syringes [5]. The Government of India (notification, 1998) specifies that Hospital Waste Management is a part of hospital hygiene and maintenance activities. This involves management of range of activities, which are mainly engineering functions, such as collection, transportation, operation or treatment of processing systems, and disposal of wastes [6]. Once the segregation of wastes is made based on the color coded wastes, it is subjected to avoid the mixing of two different color code wastes. The whole process is divided into two stages namely color coded waste identification and segregation. Image processing based automatic segregation can be considered safe and reliable compared to the manual waste segregation [7].

II. METHODOLOGY

The proposed automated bio medical waste segregation system classifies the wastes on the basis of its color, size and pattern into different categories of bio medical wastes i.e. Yellow, Red and Blue.

The methodology is distributed in two parts:

1. Software (image processing)
2. Hardware (embedded system)

The proposed bio medical waste classification process begins with the capturing of waste image from pi camera, which is interfaced to the Raspberry pi kit. Standard bio medical wastes pictures are stored in the database of pc/laptop where MATLab does the processing. The conveyor belt is used to transport the bio medical wastes from different wards of hospitals to the master room. Raspberry pi kit is used to control the pi camera, conveyor belt, and LEDs to show the output. The image taken in real time is compared with the stored reference images. Comparing this reference images with the captured image the wastes are categorized. This method reduces dependency on man power. It is more hygienic as it reduces the chances of transmission of contagious diseases like typhoid, cholera, hepatitis and AIDS through injuries from contaminated syringes and needles, reduces injuries from sharps leading to infections to all categories of hospital personnel and waste handler and limits the risk associated with hazardous chemicals, drugs to persons handling wastes at all level.

III. SYSTEM DESIGN AND IMPLEMENTATION

The Raspberry Pi 3 is the third generation Raspberry Pi. Raspberry pi 3 is a credit card sized computer that can perform the computations like a Central processing unit. It is smaller in size which can be kept in pocket. Hence it can also be referred as a pocket sized CPU. It has features similar to the CPU of a laptop or a PC that are used in daily life. But the resources present here are limited and hence computations are slower. The original Raspberry Pi is based on the Broadcom BCM2835 system on a chip (SoC), which includes an ARM1176JZF-S 700 MHz processor, Video Core IV GPU, and was originally shipped with 256 megabytes of RAM, later upgraded (models B and B+) to 512 MB. The system has Secure Digital (SD) (models A and B) or Micro SD sockets for boot media and persistent storage. One powerful feature of the Raspberry Pi is the row of GPIO (general purpose input/output) pins along the edge of the board, next to the yellow video out socket. These pins are a physical interface between the Pi and the outside world. At the simplest level, you can think of them as switches that you can turn on or off (input) or that the Pi can turn on or off (output). Seventeen of the 26 pins are GPIO pins; the others are power or ground pins and its functional block diagram is as shown in Fig.1

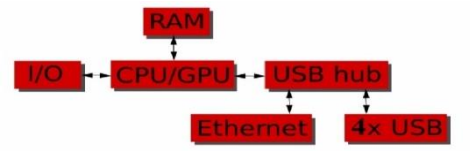

Fig. 1 Functional block diagram of Raspberry Pi 3

The CSI connector consists of two smaller interfaces. The first interface is for the transfer of data and clock signals from the camera to the processor in one direction only. The second interface consists of SCL / SDA lines, which is a bidirectional control link. The two data lanes on the CSI-2 bus provide a theoretical 2 Gbps bandwidth, which approximates to around 5 MP resolution. It is very likely to have a maximum video recording resolution of 1920 pixels × 1080 pixels at around 30 frames per second. Display Serial Interface (DSI) is a specification by the Mobile Industry Processor Interface (MIPI) Alliance aimed at reducing the cost of display controllers in a mobile device. It is commonly targeted at LCD and similar display technologies. It defines a serial bus and a communication protocol between the host (source of the image data) and the device (destination of the image data). Biomedical Waste Segregation for Hospice Applications categorizes the waste into three different color bins (i.e. red, yellow, blue). The pi camera captures the image of the waste from the conveyor belt in regular interval of time.

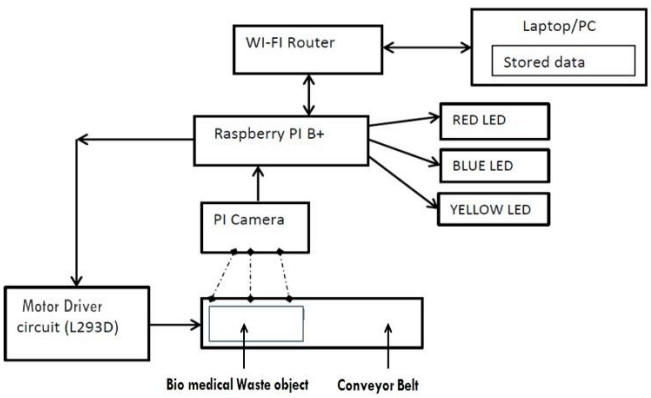

Fig. 2. General block diagram of the system

The wi-fi router is used to create a home group and will provide IP addresses to the Raspberry Pi and Laptop/PC as shown in Fig. 2. The image captured from pi camera will be sent and stored in the Laptop/PC using File Sharing concept. The MATLab program will run on the Laptop/PC and output will be generated and stored as text files in the shared folder of Laptop/PC. This result is

transferred to Raspberry Pi and depending on the received result respective LED will glow to show the output. The latest version of Raspbian can be downloaded directly or via the torrents. It will need an image writer to write the downloaded OS into the SD card (micro SD card in case of Raspberry Pi B+ model). Once the write is complete, eject the SD card and insert it into the Raspberry Pi and turn it on. It should start booting up. After the reboot from the previous step, if everything went right, then process will end up on the desktop.

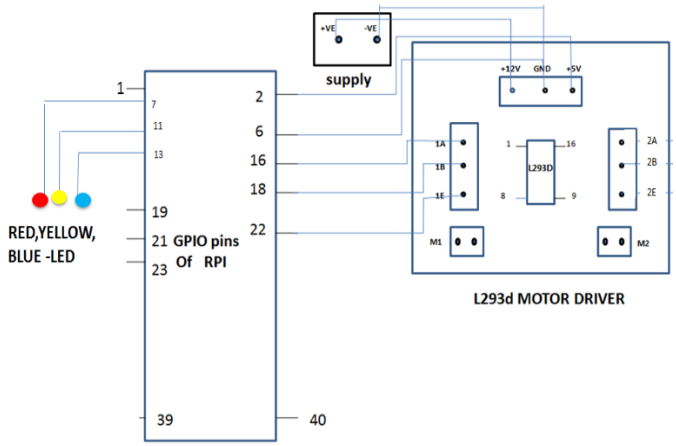

Fig. 3. Motor interfacing to Raspberry Pi 3 Fig. 4 conveyor belt setup

Conveyor belts are loops of material that move parts or other items from one location to another. They are often driven by variable speed electric motors or by other moving parts in a complex system. These belts are commonly found in factories, grocery stores, warehouses and public transportation centers. These devices also proved useful for transporting heavy or hazardous products, reducing worker injuries. Many conveyor belts work on the principle of variable speed control. If a particular belt moves too slowly, workers may find themselves waiting for parts. If one moves too quickly, parts may be damaged or workers may become overwhelmed. Fig. 3 and Fig. 4 show the motor interfacing and conveyor belt setup.

MATLAB is being used as a platform for laboratory exercises and the problems classes in the Image Processing half of the Computer Graphics and Image Processing course unit. This describes the MATLAB development environment using. .

MATLAB is a data analysis and visualization tool designed to make matrix manipulation as simple as possible. In addition, it has powerful graphics capabilities and its own programming language. The basic MATLAB distribution can be expanded by adding a range of toolboxes, the one relevant to this course is the image-processing toolbox (IPT). The basic distribution and all of the currently available toolboxes are available in the labs. The basic distribution plus any installed toolboxes will provide a large selection of functions, invoked via a command line interface. MATLAB's basic data structure is the matrix. In MATLAB a single variable is a 1 x 1 matrix, a string is a 1 x n matrix of chars. An image is a n x m matrix of pixels. Pixels are explained in more detail below. The handout summarizes how the image processing operations discussed in lectures may be achieved in MATLAB; it summarizes the MATLAB programming environment. Further help is available online, by either clicking on the "Help" menu item, or typing help browser at the command prompt.

Methods have been defined to compress the image by coding redundant data in a more efficient fashion, or by discarding the perceptually less significant information. MATLAB supports reading all of the common image formats. Image coding is not addressed in this course unit. Zero are fixed at zero, values greater than 255 are truncated to 255.Images are normally captured with pixels in each channel being represented by eight bit integers. The histogram of an image measures the number of pixels with a given grey or colour value. Histograms of color images are not normally used so will not be discussed here. The histogram of an image with L distinct intensity levels in the range [0, G] is defined as the function h(rk) = nk , rk is the kth intensity level in the image, and nk will be the number of pixels with grey value rk. G will be 255 for a uint8 image, 65536 for uint16 and 1.0 for a double image. Since the lower index of MATLAB arrays is one, never zero, r1 will correspond to intensity level 0, etc. For the integer valued images, G = L-1. We often work with normalized histograms. A normalized histogram is obtained by dividing each element of h(rk) by the total number of pixels in the image (equal to the sum of histogram elements). Such a histogram is called the probability density function (pdf) and reflects the probability of a given intensity level occurring with p(rk) = nk/n. To check whether an image is similar to other images in a database, an error measurement is needed. Let i2 be the database image and i1 the image to be checked. Then;

$$D = \text{sqrt}(\text{sum}((i2(:) - i1(:)).\hat{}2)) / \text{sqrt}(\text{sum}(i1(:).\hat{}2)) \qquad (3.1)$$

If D is zero, the two images are exactly same. As D value increases, the similarity between the images decreases. Depending upon the different images in each folder of database, threshold value of D is calculated. In real time the waste image is captured and converted to gray scale. Using imhist() instruction histogram of image is calculated. The database images in the three different folders (yellow, blue, red) are converted into gray scale and histogram is taken. Now, the captured image is compared one by one with each folder images. If the captured image is matches with yellow folder, the result will be displayed as "matched yellow bin waste" and yellow LED will glow to show the output. If not yellow, the control goes to next folder i.e. blue. If matches with blue folder then the result will be displayed as "matched blue bin waste" and blue LED glows. Similarly, for Red folder. If the captured image doesn't match with any of the three folders it is considered as a non-medical waste and a green LED will glow to show this.

IV. RESULTS AND DISCUSSIONS

The Biomedical waste image captured from pi camera in real time is compared with the database images to check whether it belongs to yellow, blue or red bin waste. If the waste is a scalpel blade which comes under red bin waste category according to bio-medical waste color coding, then the image will show positive result with respect to red folder i.e. the D value will match the threshold value for red folder and the output will be generated such as "matched red bin waste" will display and along with it Red LED will glow.

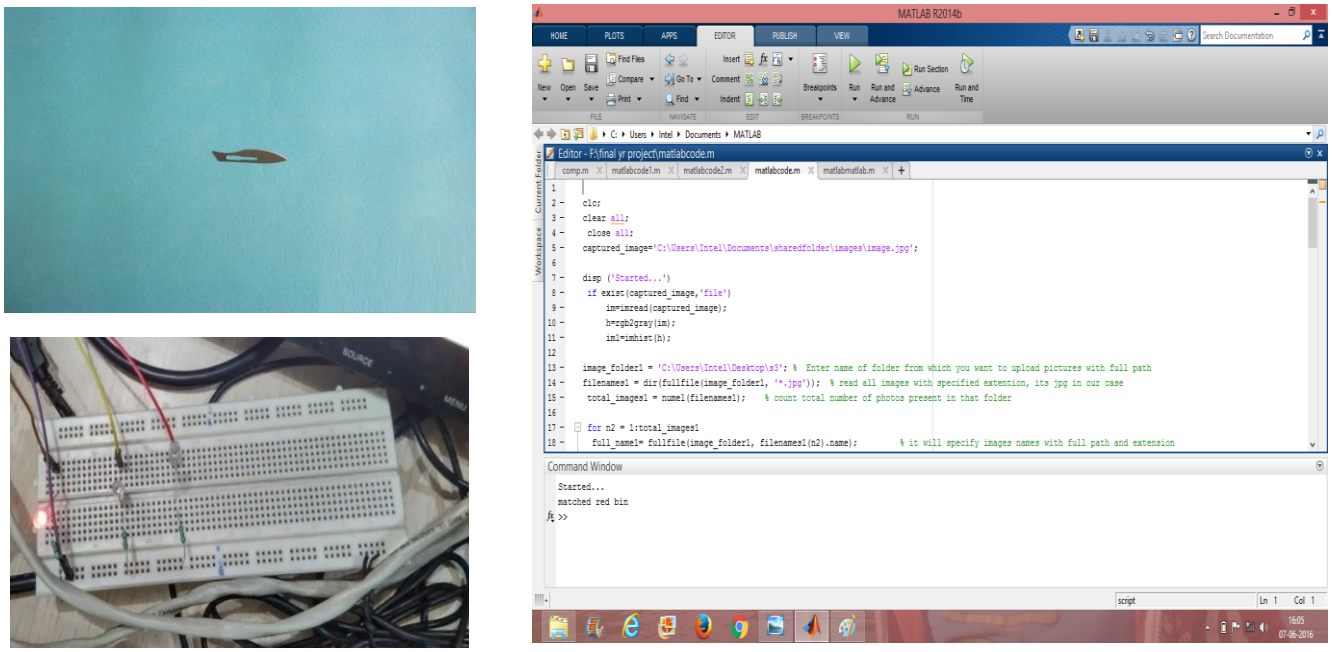

Fig. 5. Captured image of scalpel blade(red bin waste) and the matched bin output

Table 4.1: Segregation of bio medical waste based on value of D

Waste	Value of D	LED	Bin
Cotton with blood	0.35	Yellow	Yellow
Blade	0.54	Red	Red
Syringe	0.25	Blue	Blue

Table 4.1 displayed D values based on the waste in the bin.

V. CONCLUSION

The system successfully segregates the bio medical waste based on color codes. The system has the advantage of not requiring to memorize the color codes. Mixing of two color codes wastes are avoided. There is possibility of infections when hospital staff try to dispose the waste themselves without the knowledge of becoming infected, this can be avoided. However, if more than one waste is put on conveyer belt at a time, it cannot be segregated. Software has no feature extraction techniques. Raspberry pi has less memory so it takes more time to process. The processing time will be high compare to other systems. Running .m files and .py files in the same shell is difficult process. Running high number of external peripherals is not possible because of the limited GPIO pin availability.

This technology concentrates on helping the medical community making the bio medical waste segregation automatic and hence reducing the human dependency. Reduction in possibility of diseases and deaths due to improper way of disposing infectious medical wastes. The hospital generated waste has many adverse and harmful effects on human being as well as the environment.The conventional method of bio medical waste segregation completely depends on man power as the color codes for classification of bio medical wastes need to be memorized by them and further segregation steps to be taken accordingly. This project reduces the dependency on man power as the classification and segregation of the wastes are done by the machine.This project provides a more hygenic environment for the waste handlers and hospital staffs as the chance of transmission of contagious diseases reduces with comparatively less human contact required.

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