AUTOMATIC MATERIAL IDENTIFICATION TECHNIQUE USING DIGITAL IMAGE PROCESSING

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Abstract- **The material identification and its classification is one of the important processes in the manufacturing industries. The prominent methods used for material identification are Microscopy and X-Ray Fluorescence. These two methods have several drawbacks. In Microscopy process preliminary preparation of the specimen is necessary whereas the X-Ray Fluorescence method requires an XRF gun which uses Fluorescence rays for individual atoms to determine the composition of the material and it is a time-consuming process. Both methods are costlier. In this paper we have presented new technique for material identification and its classification using digital image processing i.e. Automatic Material Identification Technique (AMIT). This technique is efficient in saving time and money, avoids practical errors, gives accurate result and it requires less human effort. It is also easy to carry and can be programmed as per our requirement. The MATLAB software is used for image processing and performing the experiment.**

Key Words: **Automatic Material Identification Technique, Digital image processing, Inspection machine, Microscopic inspection, Microscopy, X-Ray Fluorescence.**

1. INTRODUCTION

The material identification and its classification is one of the important processes in material handling system because it involves cost and time. The processes such as material selection, inspection and composition estimation plays a key role in the manufacturing of the product from raw one to finished goods. These processes are performed on a regular basis to ensure the overall quality of the selected material. This prompts the method of material identification to be fast and effective on a real-time basis. The available methods such as microscopy [1] and X-Ray fluorescence [2,3] are not as time efficient as they should be. They require preliminary preparations before identification; some of them employ technologies that demand a high skill from the operator. Moreover, they are also very uneconomic and are confined to a certain place with least amount of mobility. These drawbacks point towards a dire need for a better material identification system [4].

In Microscopy process, it requires intricate Metallurgical Microscopes to study the micro-structural [5]characteristics of the material and from that study comparisons are drawn to the previous noted images of the structures. The material is identified by these comparisons. It involves many preliminary processes like polishing the material with abrasive and etching. This processis time consuming and requires specialized equipment for metallurgical purposes. The X-Ray Fluorescence methodis a non-destructive analytical technique used to determine the elemental composition of materials. It applies XRF analyzer to determine the chemical composition of a sample by measuring the fluorescent X-ray emitted from a sample when it is excited by a primary X-ray source. Each of the elements present in a sample produces a set of characteristic fluorescent X-rays that is unique for that specific element, which is why XRF spectroscopy is an excellent technology for qualitative and quantitative analysis of the material. The X-Ray Fluorescence method is usually used in guns known as XRF guns which make the process mobile and compact. XRF guns are not as prominently used as Microscopy process because they are not deemed as economic and come with a few drawbacks that restrict them from working on certain elemental materials. For example, XRF can’t be used to determine Beryllium content, which is a distinct disadvantage when measuring alloys or other materials that might contain Beryllium.

The paper is arranged by the various material identification methods in section 1 and section 2 explains the developed technique based on digital image processing programming [6,7,8,9] using MATLAB [10] software. The section 3 discusses the comparison between the results of traditional methods and proposed AMIT followed by conclusion in section 4.

2. PROPOSED MATERIAL IDENTIFICATION TECHNIQUE

A new and efficient material identification system is built here by fusing traditional identification methods with machine-controlled software that yields faster results. By automating the identification process, many of the drawbacks occurring in the traditional identification methods is eliminated. The involvement of a sentient operator can also be greatly decreased with an automated method, in turn reducing the probability for human error. The proposed technique automates the process by using digital image processing and for that MATLAB software is used. This new method can counter any drawback observed in the traditional methods. It is more economic, time efficient and mobile than any of the traditional material identification method known to be used for material identification and material inspection in industries.

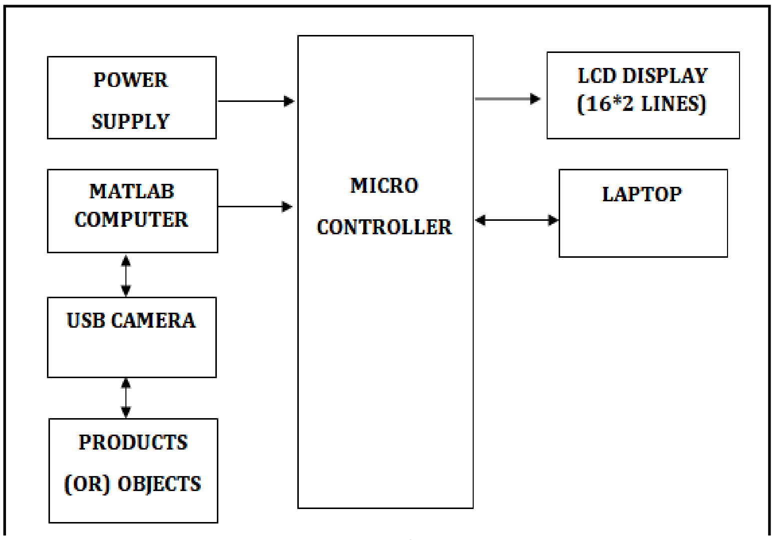


Figure 1. Block diagram of proposed technique

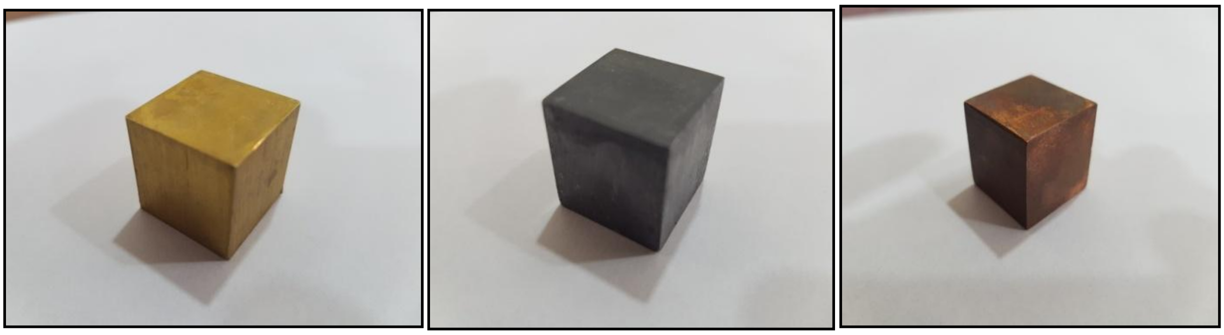
2.1 DESCRIPTION OF BLOCK DIAGRAM

The power supply is a basic AC input. It powers all the elements such as LCD Display, micro-controller(ARM7) and laptop. The specimens such as Copper, Iron and Brass have been used for initial study. During experiment these specimensare kept under a high resolution microscopic camera at 350X magnification. The microscopic camera is connected to computer system which takes the images of the specimen as an input for MATLAB based program.The micro-controller is also connected to the system with a USB port. The LCD Screen is connected through 16 pin connectors to the micro-controller.

2.2 EXPERIMENTAL ANALYSIS

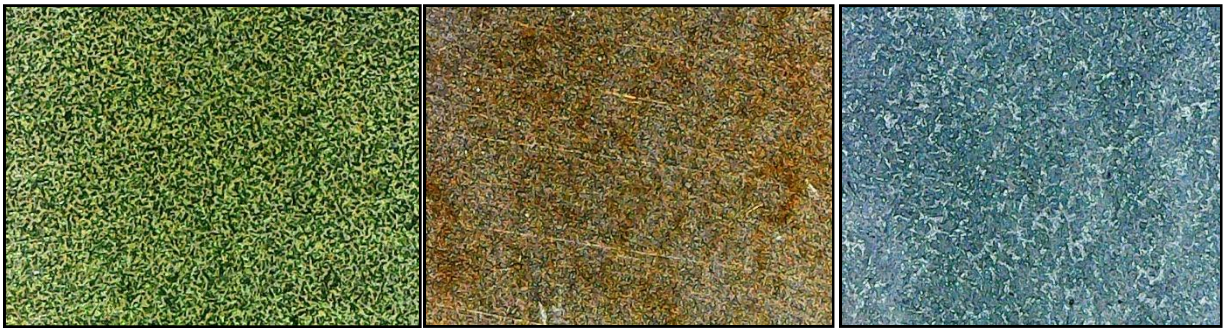
A camera of high resolution and a magnification of 0-500X is used for capturing the microscopic structure. The minimum magnification of a Metallurgical Microscope to see the microstructure is 150X. A camera of higher magnificence is used to counteract and compensate for the precision of the image that the Metallurgical Microscope provides. While testing the material, the optimum magnification was found to be 350X. At the optimum magnification, the image data needed was captured and stored in the program. For analysis, the materials such as brass, iron and copper are used for testing.

Figure 2.USB Camera



(a) (b) (c)

Figure3. Samples of (a)Brass, (b)Iron (c)Copper



(a) (b) (c)

Figure 4. Microscopic Images of (a) Brass, (b) Copper, (c) Iron

Figure 5. Automatic Material Identification Machine

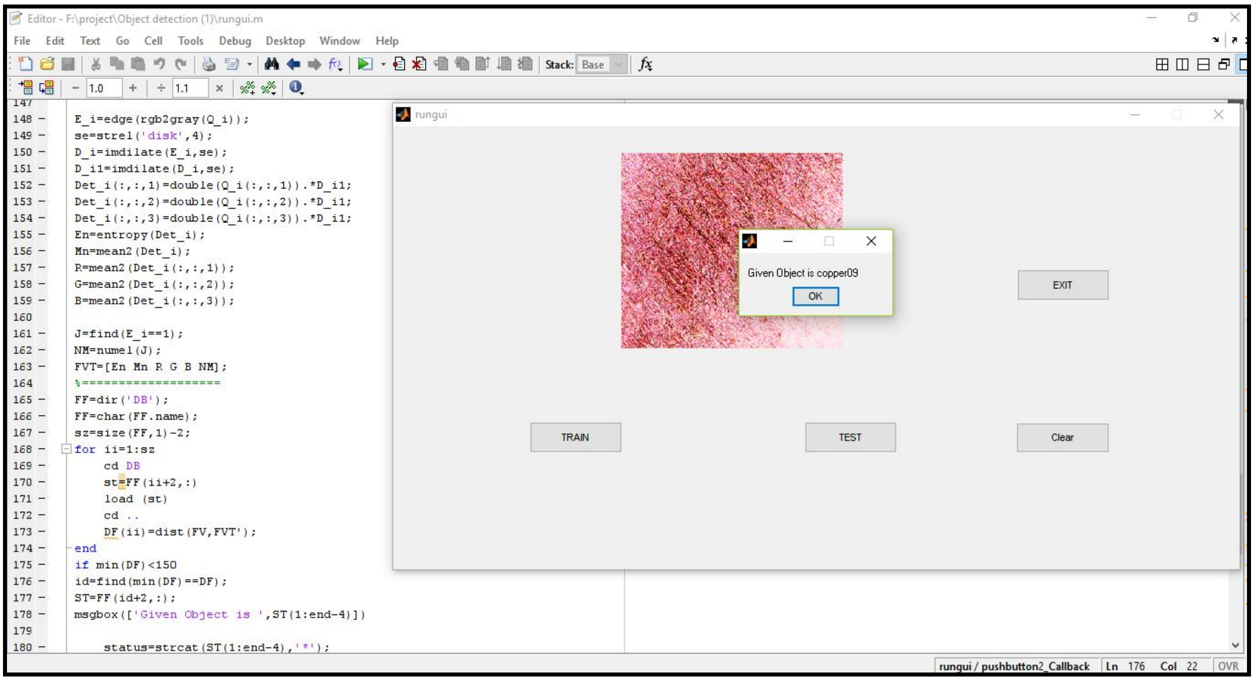


Figure 6. MATLAB program for image identification

These three materials are cleaned properly and polished with sandpaper to remove any of the scratch marks on them. Each material is taken and scrutinized under the microscopic camera. On several tries, the most optimum magnification and focus point is obtained for the best quality of the image. The image of the magnified surface of the material is captured and stored. Then, the specimen position is changed and another part of the magnified surface is captured. This process performed until the entire surface of the specimen is covered by the camera. The two other materials also undergo the same process until all their surfaces are covered and captured in the camera. Many images are taken for the all specimens for digital image processing based material identification.

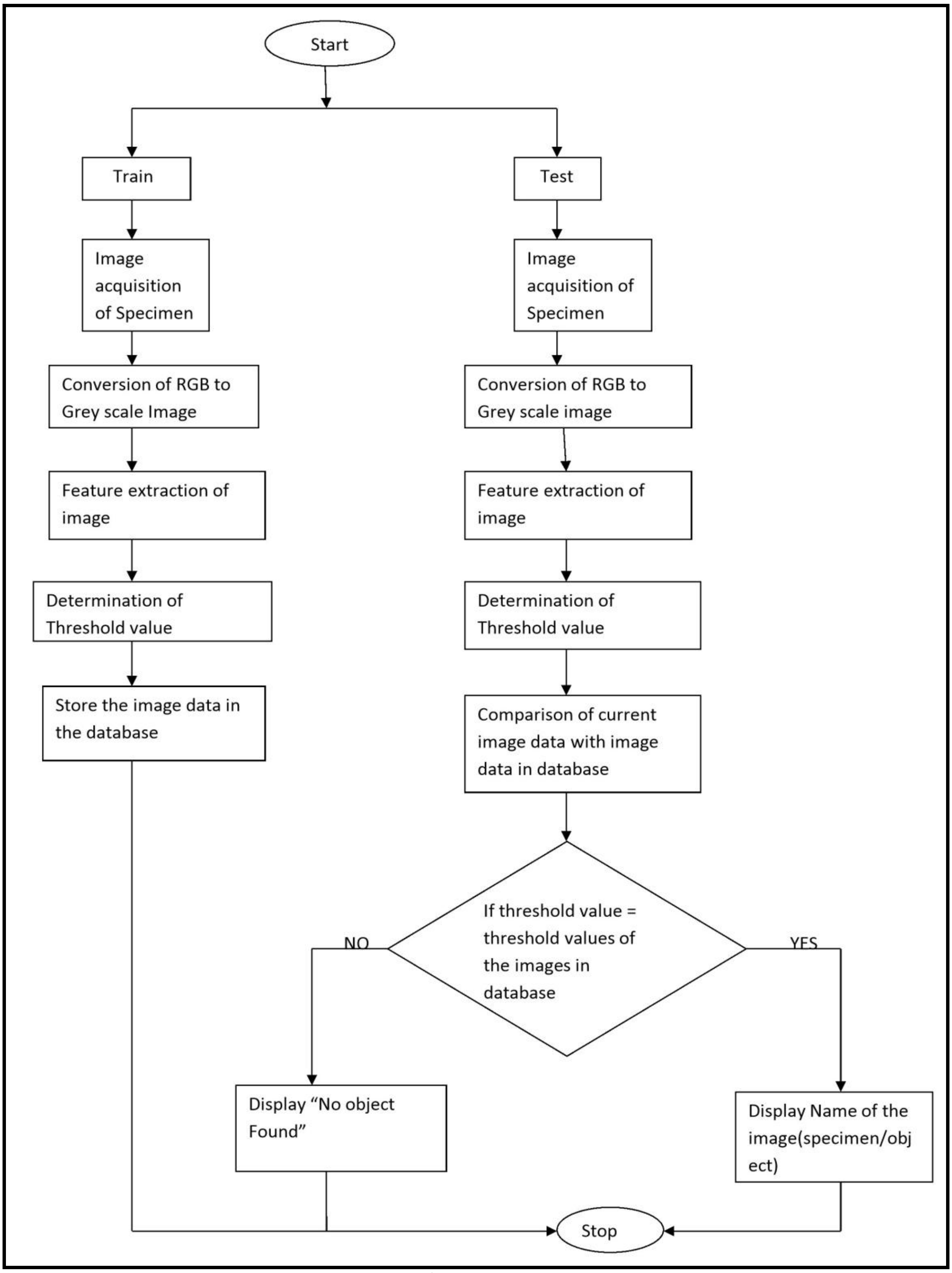


Figure 7. Flow chart of digital image processing program

The image processing program is created in MATLAB software for comparing the images. The program is to be trained before the testing with the image data of the materials. Many images of the specimen are trained using the program and have given specific names to them. A specimen is kept under the microscopic camera and the program takes an image of the specimen and runs it through its directory to find the best match of the image. Once the most similar image is found, the program displays the data which is prescribed to the similar image in the database. The complete experimental setup of the proposed technique is shown in Figure 5 and MATLAB based outcome is shown in Figure 6.

3. RESULTS AND DISCUSSIONS

The proposed technique is successfully able to identify the different materials and it is proved to be efficient in terms of cost analysis and time analysis as given below.

3.1 COST ANALYSIS

A basic Metallurgical microscope's price begins at a minimum of ₹5,000 and ranges to the high extremes of over ₹1,00,000. Based on the application, the suitable kind is chosen at a very high price. The preliminary preparation equipment and materials add to the already high cost of the microscope. The other traditional method that is XRF Gun comes around ₹1,00,000. Although XRF Guns do not require any preliminary testing hence they are faster than Microscopes, but the sensitivity of their internal components may be prone to damage. The cost of repair of XRF Guns proves to be expensive and sometimes the damage is irrevocable. The material identification device proposed here is made with a low budget of ₹8,000. Since economizing the material identification technique is one of the aims of the proposed technique, the most basic form of the device is made. Further modification can be done to the device to incorporate a greater memory and a better processor. With even the best equipment, the device will not be costing more than the basic XRF Gun or a laboratory rated Metallurgical Microscope.

Table 1: Cost Analysis

Serial No.	Device	Cost of Device	Cost of preliminaries
1	Metallurgical Microscope	₹5,000 – over ₹1 lakh	₹20,500
2	XRF Guns	> ₹1,00,000	---
3	AMIT	₹8,000	---

From the Table 1, the cost of the proposed material identification device is drastically lower than those of traditional methods. The Device can be used in a far bigger field than the other two because of its low cost of production and operation.

3.2 TIME ANALYSIS

Of the two traditional methods of Microscopy and XRF Analysis, the most time efficient is the latter. Since there is no need for any preliminary testing or preparation in the XRF Guns, they are more time efficient than the Metallurgical Microscopes. The average time it takes for a XRF Gun to analyze the composition of an element is in the range of 45-75 seconds, the time variance depends on the type and quality of the XRF Gun being used. In Microscopy, the time is a bigger constraint than in XRF Guns. For the preliminary preparation like surface polishing, the optimum time is around 5 minutes (300 sec.) The etching time and drying time can be 30 seconds together. The overall time of the material identification process clocks around the neighborhood of 5-6 minutes depending on the skill of the operator.

Here, the developed automated material identification device takes only 20-30 seconds for the operation. If the optimum magnification of the material to be identified is known then the time can further be reduced. If the digital image processing program is not trained beforehand, it will take a further 60 seconds to be train the program for testing. Hence, the most time efficient way of using the device is to know the optimum magnification and to have the program trained beforehand. The Table 2 shows that the AMIT is 140% faster than the fastest method which is done using the XRF Gun. This will allow the device to be used in environment that demand faster speeds for material identification.

Table 2. Time Analysis

Serial No.	Device	Preparation Time	Operation Time	Percentage change
1.	Metallurgical Microscope	300 seconds	300-400 seconds	82% slower than XRF Gun
2.	XRF Guns	---	45-75 seconds	6 times faster than Microscope
3.	AMIT	60 sec (Tentative)	20-30 seconds	140% faster than XRF Gun

4. CONCLUSION

The paper presents novel technique for material identification at low cost with less processing time by using digital image processing based program. It is unique kind of technique that provides user friendly environment; it can be easily modified and programmed according to requirement. It overcomes the drawbacks of traditional techniques and gives comparatively better performance. The AMIT has capability to identify thousands of materials in single program. It is easy to use, compact and mobile.

In future, the AMIT can be further developed to identify the defects in material such as cracks, holes, scratches and irregularities of the surface.It can also be used for the quality testing and inspection by using intelligent programs.

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