ISSN 2229-5518

Applications of Image Processing in Different Fields- A Survey

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***Abstract*—Image processing is one of the fastest growing technologies in engineering field. It has its applications in various fields. This paper is survey of applications of image processing in different fields such as Automation and Robotics, Remote sensing, Biomedical, Defense, Hand gesture recognition, Biological analysis, Document processing, Photography, Materials Research, Space exploration and Astronomy.**

Keywords*—Image processing, Medical imaging, Remote sensing, Robotics, Biological imaging analysis, Documentation processing, Digital Image Processing, Hand gesture recognition, Astronomy.*

1. Introduction

Image processing is an approach used to perform various operations on images to extract required information. The process involves conversion of images into digital form to extract useful information. Image processing has various purposes such as to detect the objects that are not noticeable, to produce clear images, to measure various objects in an image, to differentiate the objects in an image and to identify the patterns in an image. It has various phases which imports images, analyses and manipulates images and finally gives the result based on the requirement.

There are two approaches available for processing images such as analog and digital image processing. Image processing treats images as two dimensional signals. Analog image processing is applied on two dimensional signals and images are altered by electrical signals. Digital image processing involves computers to manipulate digital images. The digital processing uses certain steps such as pre-processing, enhancement and display information retrieval.

Image processing has its applications in various disciplines which include intelligent transport systems used in traffic symbol recognition, remote sensing in which sensors are used to capture images of earth's surface through satellites, tracking of objects in motion, defense surveillance, medical diagnosis such as detecting heart diseases, lung diseases, breast tumors etc., faulty component detection. Few of its contribution are discussed below.

1.1 **Automation and Robotics**

We all know that the Robots are fed with Artificial Intelligence(AI). AI technology has become popular due to extraordinary contribution by various scientists and researchers in making robots to think and behave almost like humans, helping them in visualizing objects, identifying the foot races. But, one of the major challenges it is facing today is with respect to vision. We have more scientists working towards improvement of the vision of the robot.

Following are some of the applications of image processing in Robotics.
First application is Hurdle detection in which distance between the robot and hurdles is calculated by recognizing different objects in the image as shown in the Figure 1.

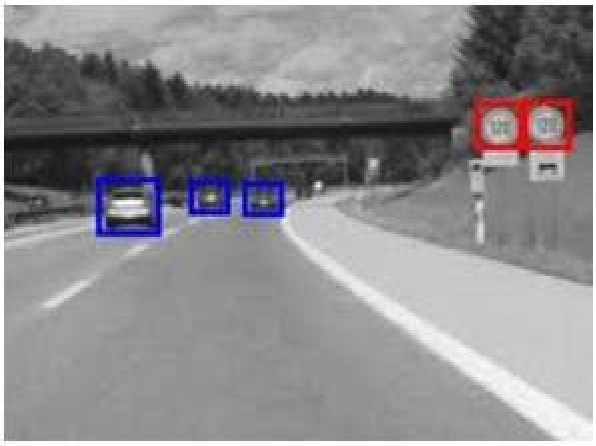

Figure 1. Hurdle Detection

Second application is the implementing Line Follower Robot performs the assigned tasks by following the line in the path as shown in the Figure 2.

Figure 2. Line Follower Robot

1.2 Remote Sensing

It is one of the upcoming applications of image processing in which remote sensors with different properties are used to capture continuous real time data sets from one or more objects from multiple sources and multiple locations. The collected data will be very complex so that it is very hard to analyze.

This digital image processing technology is used in Satellites to scan various images of area of the earth from a high distance and the collected images can be used for analysis. One of the popular applications is to sense infrastructure indemnities caused by earthquakes.

Remote sensing takes very long time to identify damages. Areas affected by earth is so huge so that it becomes very difficult to visualize and assess the damages through human eyes. Even if it is assessed, it is very complex and time consuming process. Hence, remote sensing technology is used as a solution through which images of affected areas can be captured from the high distance from the ground and later images are used to detect various damages occurred due to earthquake as shown in Figure 3.

Figure 3. Remote sensors capturing earthquake images

1.3 Biomedical Imaging

This is one of the rapid growing field of image processing that deals with capturing diagnostic and therapeutic images. This technology uses ultrasound, x-rays (Computed Tomography scan), Magnetism(MRI), Single Photon Emission Computed Tomography(SPECT), Positron Emission Tomography (PET), OCT (Optical Coherence Tomography), light endoscopy to judge the condition of the human organs which helps in monitoring patients from time to time for periodic diagnosis and treatment assessment.

Digital image technology employed in CT scanner allows doctors to watch x rays which helps them in conducting angiograms and biopsies. Biomedical engineers use CT and MRI to evaluate blood profussion of tissue in case of heart diseases. Research scientists are using functional MRI to assess various types of brain related diseases such as strokes and head injuries. PET scans are used to detect metabolic changes such as blood flow and oxygen use.

Optical coherence tomography (OCT) is a novel CT scan technique in which light is passed through the body and images are generated. Ultrasound technology is used in combination with microbubbles. This technology helps in chemotherapy treatment for cancer.

Image processing techniques contribution in medical discipline is priceless as they are bringing new ways of examining into human body by reducing the need for aggressive treatments.
Multi modal imaging is one of the applications of medical image processing that deals with CT, MRI, SPECT, PET. This technology has become popular in clinical and preclinical applications as shown in Figure 4.

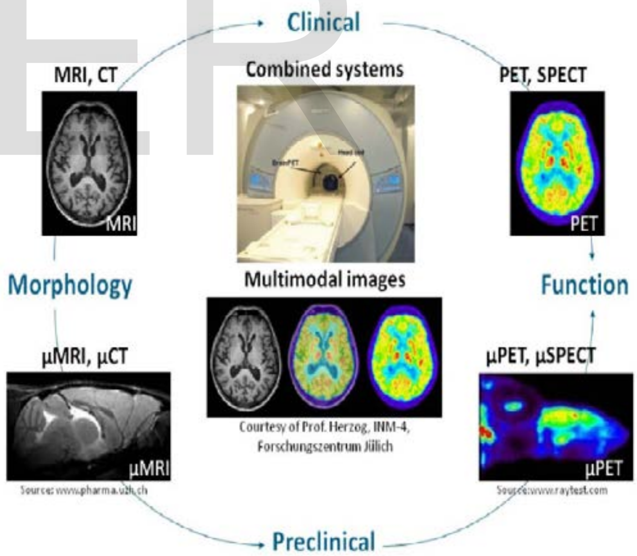

Figure 4. Functional imaging in clinical and preclinical applications

1.4 Document processing

Document Image Processing (DIP) is another application of image processing which helps in managing the documents from the beginning till end. This involves storing scaned images using document scanners, indexing, retrieving, processing, transmitting and printing of documents. It uses optical disks for storage. Multiple users can share DIP systems for files and documents via internet.

ISSN 2229-5518

DIP uses certain techniques to process images of the documents and transforms them into pixels in a format that is understandable by the computers.

DIP uses Optical Character Recognition(OCR) technology for document processing in which data is extracted from files and is stored in electronic format. OCR has its applications in various fields. To mention few banking, health care, industries etc.

DIP is used in classifying mails and organizing books in a library where the information is transformed into an electronic format which are easily manageable.

1.5 Military/Defense

Image processing has its various applications in the field of defense and security such as target detectection and tracking, missile guidance, vehicle navigation, automatic target identification, wide region surveillance. Figure 5 shows the application of image processing in missile guidance in military. Various algorithms are used to detect objects in defense using images captured.

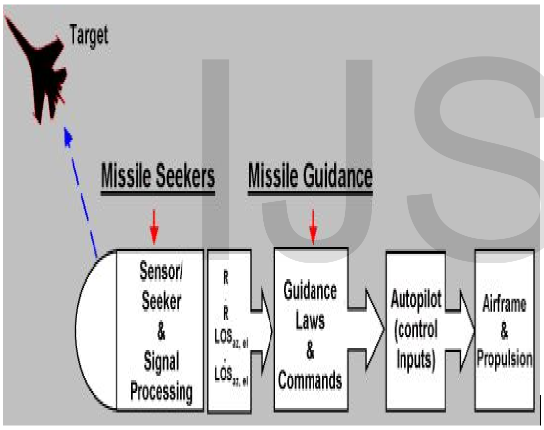

Figure 5. Image processing in Missile Guidance

1.5 Hand Gesture Recognition for Human Computer Interaction

We all know that common way of human computer interaction is through physical devices such as mouse or keyboard. The image processing technology today has come up with advanced human computer interaction system called robust maker-a small hand gesture recognition system which identifies both active and passive hand gestures. The identified gestures are used to perform various tasks such as opening web browsers, launching VLC media player etc. The system is developed to improve human computer interaction and is not limited to hand gesture recognition, but can also be used identify faces, body expressions etc.

The Figure 6 shows how Hand gesture V is used to launch VLC Media player and gesture 3 to launch Google home page in Browser.

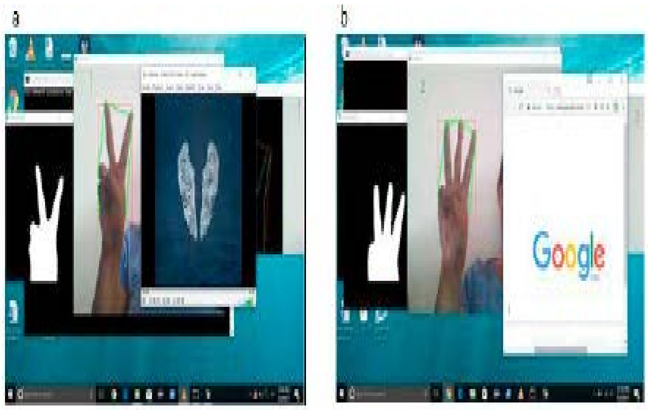

Figure 6. Gesture V launching VLC Media player and Gesture 3 launching Google home page in Browser

1.6 Astronomy

Astronomical image processing is a technology used to detect and analyse the objects captured through telescope or electronic detectors called Charge Coupled Device(CCD). Objects captured through Telescope are always greyscale and they will have some colour information. Various telescopes and detectors have dissimilar sensitivities to different wavelengths (colours). Colour filters can also be used to capture astronomical images.

Filters

NASA/ESA Hubble Space Telescope contains static number of filters. Filters are classified into broad band and narrow band. Broad band filters allow broad range of wavelengths to span through for example, red or green area of spectrum shown in Figure 7. Narrow band filters allow small wavelengths to span through limiting the transmitted radiation to that coming from a given atomic transition letting astronomers to examine every single atomic processes in the object shown in the Figure 8.

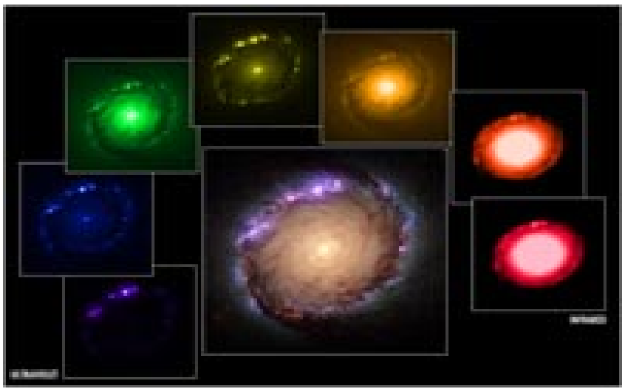

Figure 7. An image constructed from 7 broad band filter

ISSN 2229-5518

Figure 8. An image constructed from narrow band filter

The study of Galaxies is done using broad band filters as they let more light to pass through and is shown in the Figure 9. As the various processes occur in a galaxy are very complex and are based on the outcome of millions of stars, narrow band filters cannot be used.

Figure 9. A broad band image of the NGC 7673 Galaxy

Allotting colours to different filter exposures
The raw data received by the astronomers is quite different from the processed data on the web sites. The pictures or images captured through detectors or telescope may not be sufficient to analyse or understand. Very attractive images constructed from the images taken to understand the physical process for some specific purpose.

Natural colour images
To construct natural colour images, the sequence of the colours allocated to different exposures should be like the lowest wavelength should have a blue hue, the middle wavelength a green hue and the highest wavelength should have red.

Enhanced or improved colour images
Sometimes we don't need to follow the sequence of colors for an image as shown in the Figure 10 which is called as enhanced colour image.

Figure 10. Enhanced Colour image not in a colour sequence

1.7 Biological Imaging Analysis

Image analysis is one of the up growing technologies contributing to biological sciences. Biological image processing is becoming popular with the rapid growth of high resolution microscopes and has its applications in the classification of 3-D genome topology, classification of cell types, morphology growth rate measurements using time lapse image sequences etc.

Earlier days microscopic techniques were used to understand the structural details of cells. But the latest research focuses on the number of cells, its area, concentration, analysis for molecular level studies. Biologists are concentrating more on transforming microscopic images to quantitative measurements.
Image analysis approaches are merging the outcome of laboratory techniques with image analysis software to provide better information.

There are large number of image analysis softwares available in the field of Biological sciences which are costly and require high configuration computers to perform the assigned tasks. These softwares retrieve important required data from the images.

Biological Image processing deals with the analysis of problems such as neuron tracing and quantification, particle detection and tracking.

Neuron Tracing and Quantification

The study of neuronal morphology using 2-D imaging technique results in unclear images. It does not give clarity whether neurites are branching or crossing and human experts are required to resolve such ambiguities which led to the development of neuron tracing shown in Figure 11. The problem of neuron tracing makes use of interactive segmentation methods. It makes use of search algorithm to find a route from a single user selected pixel to all other pixels in the image by minimising the cumulative value of a predefined cost function computed from local image features along the route. Then, the user is allowed to interactively select a desired route and fix the tracing up to some point from where the iteration has begun until the entire structure is traced. The same technique can be used to trace neurons using 3-D images. Various automated methods are also available for the same.

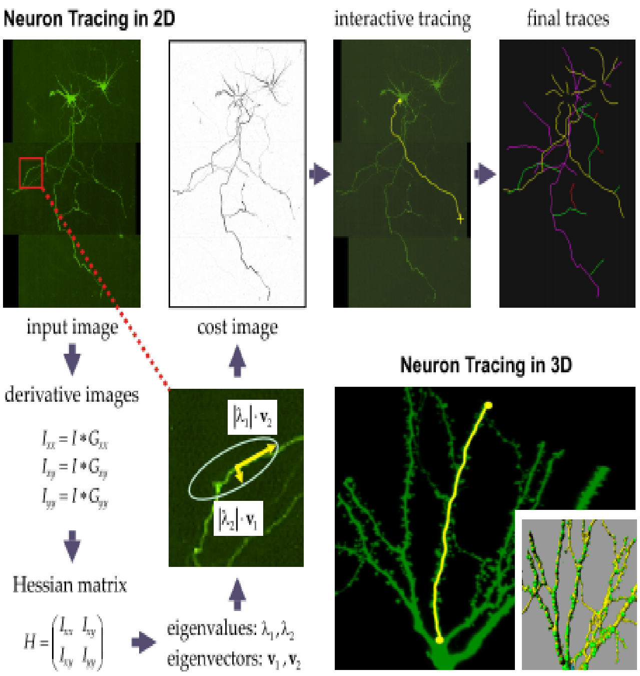

Figure 11. Neuron Tracing and Quantification

Particle Detection and Tracking

Particle tracking has two phases. First, the detection of individual particles per time frame. Second, the linking of detected particles in the consecutive frames shown in the Figure 12. One of the best method for particle detection is to use least squares fitting of a Gaussian model to the images. Various tools are available for particle tracking which still requires human intervention for checking and correcting the results.

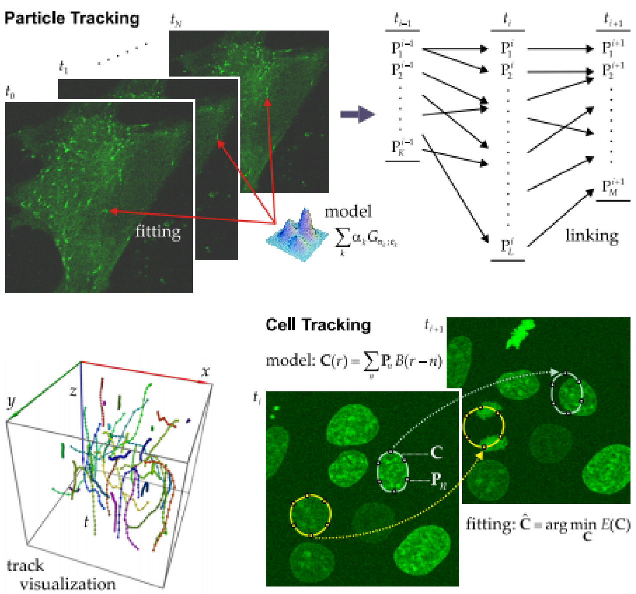

Figure 12. Particle detection and tracking

1.8 Materials Research

This field of image processing deals with recognizing materials or grouping of materials or components using features such as texture, surface or structural rendering, colour, size to construct 3-D images.

Recognition of material attributes from images

Material attribute discovery contains three phases. First, measure perceptual distances between materials through human annotation. Second, define an attribute space based on perceptual distances. Third, train classifiers to reproduce this space from image patches.

Figure 13 shows t-SNE embedding of materials from the raw feature space (a) and from discovered attributes (b). We embed a set of material image patches into 2D space via t-SNE using raw features and predicted attribute probabilities as the input space for the embeddings.

(a) Raw Features (b) Discovered Attributes

Figure 13 shows t-SNE embedding of materials from the raw feature space (a) and from discovered attributes

Though t-SNE has been shown to perform well in high-dimensional input spaces, it fails to separate material categories from the raw feature space. Material categories are, however, clearly more separable with our attribute space.

As shown in the Figure 14, Per-pixel discovered attribute probabilities for four attributes (one per column). These images show that the discovered attributes exhibit patterns similar to those of known material traits. The first attribute, for example, appears consistently within the woven hat and the koala; the second attribute tends to indicate smooth regions. The third attribute shows we are discovering attributes that can appear both sparsely and densely in an image, depending on the context. These are all properties shared with visual material traits. Attributes from a random A do not exhibit any of these properties.

ISSN 2229-5518

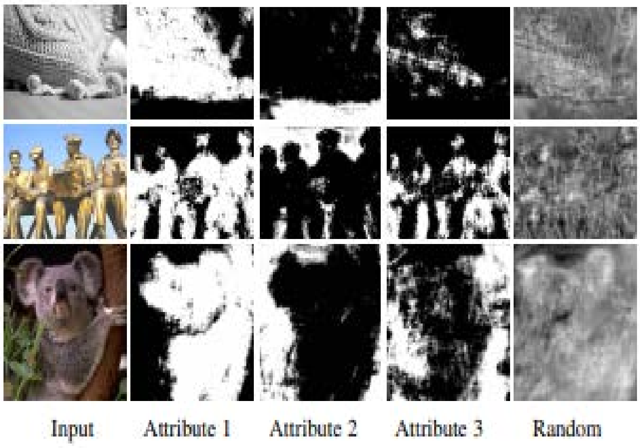

Figure 14. Per-pixel discovered attribute probabilities for four attributes

Materials classification based on image features

This field of research came up with FMD (Flickr Materials Database) to capture the look variations of physical materials comprising unlike sample selection in each group which prevents poor intra class variation found in earlier databases. As shown in the Figure 15, we have various images made up of different materials but belong to the same group. In Figure 16, FDM images surface belong to one of the following material groups. Fabric, Foliage, Glass, Leather, Metal, Paper, Plastic, Stone, Water, and Wood. Human performance on FMD serves as a challenging benchmark for computer vision algorithms.

Figure 15. Objects belong to the same group made up of different materials

It is really a difficult task to differentiate material groups from one another. Images surface shown in Figure 15 vary in their size, colour, texture, shape and object data within and across material groups. Part from these features, a new feature called Histogram of Oriented Gradient is used for material recognition.

Different classifiers such as latent Dirichlet allocation (LDA) model and a discriminative Support Vector Machine (SVM) classifiers used for materials research which quantizes features into dictionaries, concatenated dictionaries for different features, and converted images into "bags of words".

In LDA model, the collections of visual words characterize different material groups. The SVM classifier uses hyperplanes that separate different material categories in the space defined by the shared dictionary of visual words. Both classifiers execute well on FMD.

Figure 16. Objects belong to different groups made up of same material

1.9 Photography

It is a technology which makes use of image processing approach for enhancing images, warping and morphing, video production, compression and transmission.

photography is a process of creating images by recording light or other electromagnetic radiation either using image sensors or using photographic film. Various photographic methods camera, stereoscopy, dual photography, full spectrum, ultra violet, infrared media, light field photography are used in the process of taking images for photography.

Digital Image Processing in Photography

Digital photography deals with capturing set of photos at different exposure levels. The captured images are later combined with High Dyanamic Range (HDR) image during post processing. The final integrated image results in best characteristics of the images captured.

Image enhancement techniques are used to improve the quality (enhanced appearance) of the images given. We have various techniques from simple to complex available for image enhancement. The objectives of image enhancement are image sharpening and to retain the edges of the images as it is by smoothening images in identical regions.

Image enhancement is a technique through which given images are processed for better appearance for a specific purpose. There are two basic image enhancement techniques available such as histogram manipulation and image filtering.

Histogram Manipulation

Histogram is a graph used to represent frequency. It makes use of bars which indicates frequency of data occurance in a given data set. It has x axis indicating an event whose frequency need to be computed and y axis indicating frequency. The different vertical lines (heights) indicate different frequency of data occurrence. Sample histogram is shown in the Figure 17.

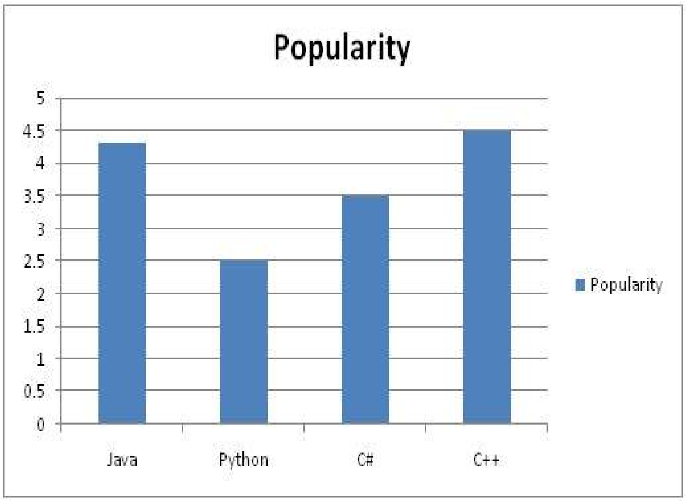

Figure 17. Sample histogram

Histogram of an image

Image histogram determines the frequency of pixels intensity values in which x axis represents gray level intensities and y axis represents the frequency of these intensities. For example, the histogram of the image (Einstein) shown in Figure 18 looks like Figure 19.

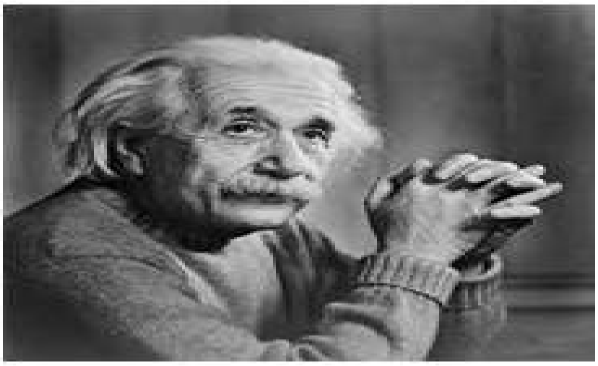

Figure 18. A sample image for histogram

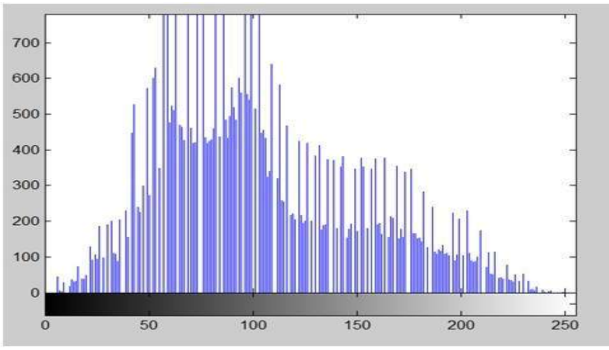

Figure 19. Histogram image

The x axis of the histogram shown in Figure 19 shows the range of pixel values and y axis shows the frequency of these intensities. From the graph we can observe that high frequency lies in the darker portion and the same can be matched with the image shown in Figure 18.

2. CONCLUSION

This survey paper discusses various applications of image processing in different fields such as Automation and Robotics, Remote sensing, Biomedical, Defense, Hand gesture recognition, Biological analysis, Document processing, Photography, Materials Research, Space exploration and Astronomy etc. which helps future researchers to understand the research work carried out by various researchers in various fields so that they can focus on their specific goals in a specific discipline.

REFERENCES

[1] E. R. Davies, "Image processing and its applications," in *Electronics & Communication Engineering Journal*, vol. 12, no. 5, pp. 194-194, Oct. 2000.

[2] P. Deeprasertkul and W. Praikan, "A rainfall forecasting estimation using image processing technology," *2016 International Conference on Information and Communication Technology Convergence (ICTC)*, Jeju, 2016, pp. 371-376.

[3] Roberto Gardel Kurka, Paulo & André Díaz Salazar, Aldo. (2019). Applications of image processing in robotics and instrumentation. Mechanical Systems and Signal Processing. 124. 142-169. 10.1016/j.ymssp.2019.01.015.

[4] M. Panwar and P. Singh Mehra, "Hand gesture recognition for human computer interaction," *2011 International Conference on Image Information Processing*, Shimla, 2011, pp. 1-7.

[5] R. M. Thomas and J. John, "A review on cell detection and segmentation in microscopic images," *2017 International Conference on Circuit ,Power and Computing Technologies (ICCPCT)*, Kollam, 2017, pp. 1-5.

[6] Kapur, Jyotika & J. Baregar, Akshay. (2013). Security Using Image Processing. International Journal of Managing Information Technology. 5. 13-21. 10.5121/ijmit.2013.5202.

[7] S. Pereira, A. Pinto, V. Alves and C. A. Silva, "Brain Tumor Segmentation Using Convolutional Neural Networks in MRI Images," in *IEEE Transactions on Medical Imaging*, vol. 35, no. 5, pp. 1240-1251, May 2016.

[8] L. M. G. Fonseca, L. M. Namikawa and E. F. Castejon, "Digital Image Processing in Remote Sensing," *2009 Tutorials of the XXII Brazilian Symposium on Computer Graphics and Image Processing*, Rio de Janeiro, 2009, pp. 59-71.

[9] Shazia, Akram & Mehraj-Ud-Din Dar, Dr & Aasia, Quyoum. (2010). Document Image Processing - A Review. International Journal of Computer Applications. 10. 10.5120/1475-1991.

[10] A. Ambeskar, V. Turkar, A. Bondre and H. Gosavi, "Path finding robot using image processing," *2016 International Conference on Inventive Computation Technologies (ICICT)*, Coimbatore, 2016, pp. 1-6.

[11] A. Mazhar, F. Hassan, M. R. Anjum, M. Saher and M. A. Saleem, "High resolution image processing for remote sensing application," *2016 Sixth International Conference on Innovative Computing Technology (INTECH)*, Dublin, 2016, pp. 302-305.

[12] I. Pham and M. Polasek, "Algorithm for military object detection using image data," *2014 IEEE/AIAA 33rd Digital Avionics Systems Conference (DASC)*, Colorado Springs, CO, 2014, pp. 3D3-1-3D3-15.

[13] https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3782694/

[14] https://www.tutorialspoint.com/dip/applications_and_usage.htm