

Image Processing in Various Fields: A Survey

Sarmistha Palai¹ Sunil Kumar Panigrahi² Kapildev Surujal³

^{1,2,3} Department of Computer Science and Engineering, Einstein Academy of Technology & Management,
Bhubaneswar, India

Abstract

This paper explores the application of image processing in various engineering fields, focusing on its potential in quality inspection. It discusses the challenges of object recognition and feature extraction in image processing, and highlights its applications in construction, fluid flow, thermal imaging, medical, fruit and vegetable, and rock carving industries.

Keywords: Image processing; Machine vision; Data acquisition; Strain measurement; Thermal; Fluid flow

I. Introduction

Image processing technique can be used for processing images, 3d models, printouts and to obtain the required data from the images. Researchers use a broad range of basic procedure of image interpretation while adopting analog visual techniques. This type of image processing is just restricted within the area of knowledge of the analyst. So analysts may apply a blend of personal knowledge and data in image processing. In digital image processing, computer based algorithms are developed to perform image processing technique. Considering the advantages of digital image processing against analog image processing and due to huge number of algorithms available that can be used with the input data. In digital image processing, few problems during processing such as noise creation, signal distortion etc., can be minimized and removed during preprocessing technique called signal processing. In late 2000, due to the advancement that happened in digital image processing with aid of computers has become the emerging form of image processing which is more versatile, and also the cheapest one. Image processing has strong relation with computer vision and computer graphics. The following steps describe the procedure for image processing: Hallucination (identifying the hidden objects), Image restoration and sharpening (for creating sharpened image), Image repossession (search for the area of interest), Measurement of pattern (calculating the color range of objects) and Image acknowledgment (differentiating the region of interest). In this study, a review on digital image processing, applied in various field has been given with suitable algorithms.

II. Image processing in different fields

It can be noticed that substantial amount of investments has been going on civil infrastructures since past few decades. To assure the safety of the civilians, the priority has to be given to maintenance and the interventions should be defined to reduce both environmental impacts and costs. Due to climatic changes, the former leads to different new maintenance strategies. To achieve quick and reliable diagnostics, focused solution has to be developed to maintain the structures' robust. Thus the developed solution ought to ensure be effective, reliable and economical forever. The availability of the digital and optical equipment's gained importance in structural assessment. Currently, in construction sector to perform land survey, structural damage monitoring, structural health assessment, deformation and damage study [2]. Terrestrial Laser Scanning (TLS) method has been widely adopted. By means of 3D images of structures, this accurately collects both qualitative and quantitative information. For characterization and monitoring, Terrestrial Photogrammetric (TP) has been widely adopted [3]. Photogrammetric allows cost effective high-resolution 3D structural imaging systems. [4] It is not possible to characterize fluid flow pattern with high velocity. Image processing technique is most widely adopted to visualize and characterize complicated 3D fluid flow to acquire clear image of the physical phenomena for further processing. The foremost interests for researchers in fluid flow are pattern formation and flow structures, by analysis the phenomena through acquired images. Much more study has been carried out on jet origination, propagation, hypersonic jet flows, flow structures and patterns and also morphological flow properties, and their emission, by means of image processing [10]. Severe heat generation occurs in case of friction during machining, generation of electricity and flow of electricity. Even in building construction too, heat loss occurs due to poor wall finishing, roof performance and poor insulation. If the insulation provided is too weak then it loses its effectiveness, and can lead to even worst damage to the structure and also to the interior of the building. For example, motors running at a same load conditions continuously, should be inspected for change in thermal properties, so that early detection may avoid catastrophic failure[24]. The diagnosis of various human diseases can be completed through common available medical tests. Biomedical images are acquired from living beings and they are used for clinical diagnostics, disease treatment and

continuous monitoring. Medical imaging can be applied to observe and study the function and behavior of internal organs without the need of surgery. Computer Tomography (CT), Magnetic Resonance Imaging (MRI) and X-ray inspection are the few commonly used imaging techniques in contemporary medical field. Virtual reality and augmented reality are the innovation that has been applied to save and improve the quality of life. Several sensors can be also being employed to study and monitor the health condition of the human like blood pressure, body temperature, air respiratory, glucose level, skin perspiration etc., however molecular analysis study using microscopic images can be used to recognize the symptom of the diseases. Study of strain developed on a specimen during different types of loading, say tensile, compression, shear, bending, twisting, etc., and plays an important role in prediction of life of the specimen. Even fluctuating stresses causes a major problem on components subjected to dynamic loads. The prediction of strain distribution and evaluation of strain localization behavior before the failure of the components is the major area that has to be concentrated. In this method, a random pattern is etched on the top layer of the sample, in order to determine the spatial displacement of the pattern on the sample due to different loading conditions using digital correlation calculation. The deviation of the electrochemically or laser etched grid patterns on the sample has been analyzed by developing computer based algorithms [11].

III. Algorithms used in Image Processing

3.1 Image processing in construction industry

Image processing can be seen as automated system to perform the health monitoring and evaluation system to assess the damage occurring in concretes and structures due to natural calamities [5]. This deals with the characterization of crack patterns, measurement of strain fields subjected to different loads. The automation in characterization leads to measuring and comparing the entire crack length over a period of time, eliminating the human error with high accuracy [6]. The main drawback is the resolution quality of the image obtained which has a vital role in image acquisition [7]. Algorithms has been developed to detect a crack developed on the surface of the concrete structure based on image acquired using an automated robot [1,8,9]. The processes involved in image acquisition and image processing on concrete structures are show.



Figure1. (a) and (b) Visible cracks on Pre-cast surface.



Figure 2. Mobile robot for image acquisition.

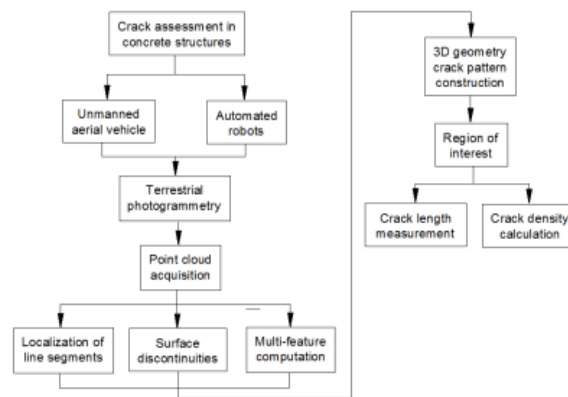


Figure 3. Flow chart to process crack detection and analysis in construction

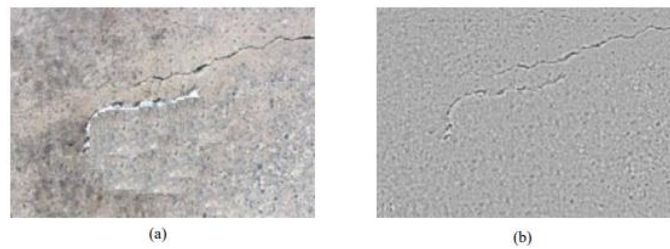


Figure 4. (a) Original image with crack;(b) converted image with image processing for further analysis.

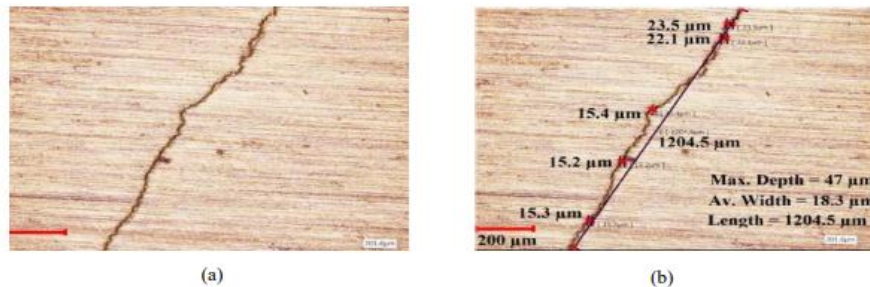


Figure 5. (a) Acquired image through image processing;(b) density analysis of the formed crack [6]

3.2. Image processing in fluid flow applications

The exclusive pattern of the supersonic jet structure formation, propagating into a stationary gas at an ambient temperature, is shown in figure 6 [12]. The pattern is obtained from a supersonic jet, impacted on an ambient material and accelerated through a bow shaped obstacle, whereas, the outflow decelerates in a Mach disk or jet shock. Image processing is carried out with the radiation obtained from a point x-ray backlighting source, which develops a point-projection shadow of the developed experimental setup on an x-ray film. This type of technique only gives jet flow pattern images of short scale lengths. By using an electron beam, fluorescent images can be produced to characterize and analyze the propagation of hypersonic jets at a long scale [13]. Mach number, jet velocity and jet-to-ambient density ratio, was considered as the main output parameters to study the fluid flow pattern. To analyze the developed output parameters, an image based algorithm as shown in Figure 7 is adopted to indicate the way the curvature looks of the developed head [14].

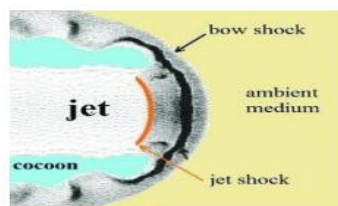


Figure 6. Structure of a jet head

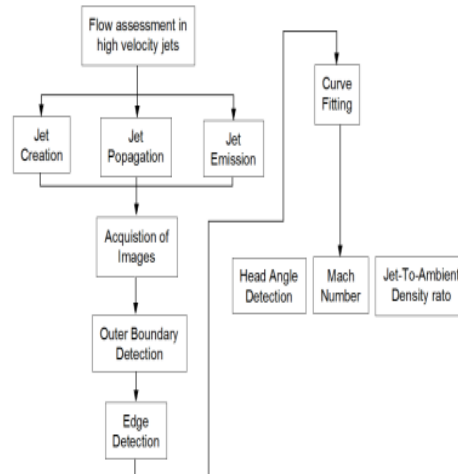


Figure 7. Algorithm used for image processing in fluid flow

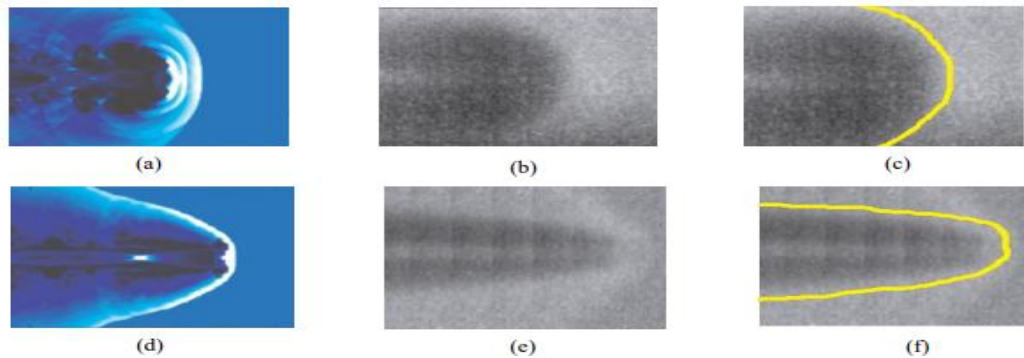


Figure 8. (a) Original image of jet initiation;(b) processed image of jet initiation;(c) image with curve fitting;(d) original image of jet propagation;(e) processed image of jet propagation;(f) image with curve fitting [15].

3.3. Image processing in thermal applications

A thermal imaging inspection in a refractory can even stop catastrophic failure leading loss in production and safety related problems. Thermal images can be also used for analyzing vehicle category in night time traffic. Thermal imaging cameras are most suitable in regions, where conventional cameras or image scanners could not be applied due to lack of illumination. Due to advancement in thermal imaging, application is also extended to border surveillance and security (cooled and un cooled cameras), considering their ability to detect sized targets in absolute darkness at extreme weather conditions. Application of thermal imaging are food industry, medicine, building diagnostics, tool condition monitoring, solar panels, volcano logy, weather forecasting, Study of prototypes, by using thermal imaging cameras, may help the researchers and engineers to examine and determine the flaws in the prototypes and parts. Infrared technology can be applied for better and long lasting parts [16]. The flow chart given in Figure 9, clearly depicts the thermal imaging procedure that is mostly adopted.

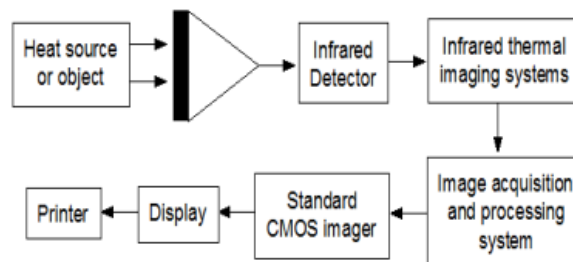


Figure 9. Steps of image processing used in thermal applications

By the application of Kantorovich (S-K) algorithm, thermo-graphic images were reconstructed and their resolution has been enhanced.

3.4. Image processing in medical applications

Brain MRI can be used to diagnose glioma, HIV and cancer metastasis, in the similar way mammograms are used to detect breast cancer and CT scans are employed to detect cardiovascular diseases. Even the skin disorders like eczema, acne, melanoma, mycosis, etc., can also be recognized by microscopic images. The RGB scale of the images are taken into consideration to analyze the diseases. Different color shades using hue saturation value (HSV) and YCbCr like blackish, reddish, bluish, whitish and grayish are used to distinguish the region of interest. The contrast of the image can be adjusted more precisely by mapping the Region of Interests (ROI) with normalization of the gray image intensity. The whole MR and MRI images obtained can be stretched within the gray level region (0,255) and the noise in the images can be removed by normalizing the RGB within 0 to 1 using the following equations, where g' , R' , G' and B' are the new values of gray level and RGB at the pixel i, j .

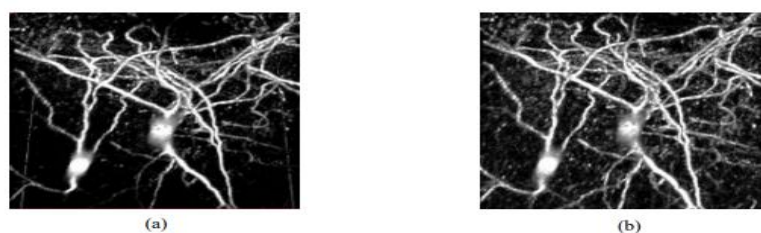


Fig 10. (a) the original image of tissues; (b) the normalized image with full gray level (0,255)

This kind of process in medical field can be implemented even to study the skin disorders by normalizing the average skin color to gray intensity level so that the digitization errors can be minimized [17].

3.5. Image processing in food industries

Image processing is intended to use for food safety and standards. Moreover, this is a contemporary technique used to ensure consumer satisfaction mostly in a range of food-related fields. Mainly focuses on the detection of adulteration, ensures virgin fruits, vegetables and meat to customers. Even image processing is used to sever products and check & evaluate food-producing tools. This all eventually intense to meet quality in life-saving products, especially in foods. Consider the fruit Orange which has infected regions in a different color in nature may be brown Figure 14 (a). By distinguishing these colors by Image processing the go or no go status of fruits will be decided. The pixels near the different colors or pixels which are a mixer of both (orange and brown) colors are identified and it is spotted and bounded by multicolor [23]. This multi-color represents the boundary to be detect called the region of interest (ROI).

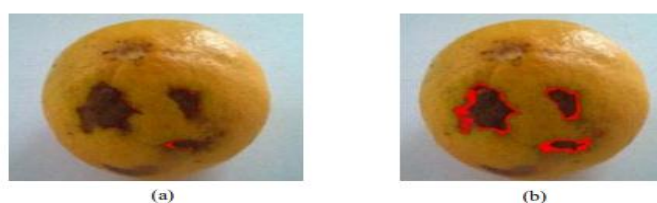


Figure 11. Edge detection with gray intensity (a) level 100; (b) level 255.

Same as all other processes food industry also follows image capturing, image segmentation, object measurement or feature extraction, and classification. This method is pervasive to maintain a good quality of food. Fuzzy logic has also considered brightening the boundary. By adjusting the threshold value the RGB [25, 26] image can be converted to grayscale figure 12.



Figure 12. Normalized image with different thresholds of RGB

Actually, the conversion of RGB to grayscale or black & white is to increase the processing time and reduce the computational time. Even color intensity will not have any influence over the results.

IV. Conclusion

Computer aided Image processing techniques is pervasive in all the field and also a contemporary field of research. Several applications of image processing like construction, fluid flow, medical treatment, material screening, medical and food processing were studied in this review. Most of these applications adapt the same procedures like filtering the initial input image, segmentation and separation of the region of interest, area extraction and classification based on these required features. Although each area required special treatment, there are few common methods like edge detection, edge sharpening, noise detection and smoothening, and conversion to gray scale image for identification. All these are done through normalizing the RGB and gray values by adopting few algorithms like neural networks, fuzzy clustering, decision trees, random forests, etc. Eventually Potential for doing research in computer aided image processing techniques are substantial and challenges to be solved and yet to find in each field are boundless. The concept and methodology to implement these techniques is almost similar in all fields which can infer to the new researchers with wide opportunities. Eventually it is proven that substantial innovations and researches are in progress in and around the computer aided digital image processing and this going to lead the future unanimously.

References

- [1]. PrateekPrasanna, Kristin J Dana, Nenad Guncunski, Basily B Basily and Hung M La 2014 Automated Crack Detection on concrete bridges, *IEEE Transactions on Automation Science and Engineering*, Vol. 13 (2), pp. 1-9.
- [2]. Valenca J, Puente I, Julio E, Gonzalez Jorge H and Arias Sanchez P 2017 Assessment of cracks on concrete bridges using image processing, *Laser scanning survey, Construction and Building Materials*, Vol. 146, pp. 668-678.
- [3]. Jingsi Yang and Jesse Zhu 2015 Cluster identification using image processing, *Particulogy*, Vol. 23, pp. 16-24.
- [4]. Jin- Young Park, Jung-Ho Chung, Jung-Seok Lee, Hee-Jim Kim, Seong-Ho Chol and Ul-Won Jung 2017 Comparison of the diagnostics accuracies of optical coherence tomography, micro computed tomography, and histology in periodontal disease: an ex vivo study, *Journal of Periodontal and Implant Science*, Vol. 47(1), pp. 30-40.
- [5]. Jeong Choi, Yun Lee, Yun Yong Kim and Bang Yeon Lee 2017Image processing technique to detect carbonation regions of concrete sprayed with phenolphthalein solution, *Construction and Building Materials*, Vol. 145, pp. 451-461.
- [6]. Hesham M Shehata, Yasser S Mohammed, Mohammed Abdellatif and Taher H Awad 2018 Depth estimation of steel cracks using laser and image processing techniques, *Alexandria Engineering Journal*, Vol. 57 (4), pp. 2713-2718.
- [7]. Maheswari Subramanian and ReebaKorah 2018 A framework of secured embedding scheme using vector discrete wavelet transformation and Lagrange interpolation, *Journal of computer networks and communications*, Vol 20, pp. 1-9
- [8]. N. Petrellis, "A smart phone image processing application for plant disease diagnosis." In *Modern Circuits and Systems Technologies (MOCAST)*, 2017 6th International Conference on, IEEE 2017, pp. 1-4.
- [9]. V. Kumar, T. Lal, P. Dhuliya, and Diwaker Pant. "A study and comparison of different image segmentation algorithms." In *Advances in Computing, Communication, & Automation (ICACCA)*(Fall), International Conference on, IEEE 2016, pp. 1-6.
- [10]. R. Radha, and S. Jeyalakshmi. "An effective algorithm for edges and veins detection in leaf images." In *Computing and Communication Technologies (WCCCT)*, 2014 World Congress on, IEEE 2014, pp. 128-131.
- [11]. Y. Fang, X. Wang, P. Shi, C. Lin, and R. Zhai. "Automatic identification of two growth stages for rapeseed plant: Three leaf and four leaf stage." In *Agro-Geoinformatics (Agro-geo informatics)*, 2015 Fourth International Conference on, IEEE 2015, pp. 148-153.
- [12]. V. Singh and A. K. Misra. "Detection of unhealthy region of plant leaves using Image Processing and Genetic Algorithm." In *Computer Engineering and Applications (ICACEA)*, 2015 International Conference on Advances in, IEEE 2015, pp. 1028-1032.
- [13]. A. Le Bris, T. Francois, and C. Nesrine, "Contribution of texture and red-edge band for vegetated areas detection and identification." In *Geoscience and Remote Sensing Symposium (IGARSS)*, 2013 IEEE International, IEEE, 2013 pp. 4102-4105.
- [14]. Acuña, R. G. Gonzalez, Junli Tao, and Reinhard Klette. "Generalization of Otsu's binarization into recursive colour image segmentation." In *Image and Vision Computing New Zealand (IVCNZ)*, 2015 International Conference on, IEEE, 2015 pp 1-6.
- [15]. S. K. Tichkule and D. H. Gawali. "Plant diseases detection using image processing techniques." In *Green Engineering and Technologies (IC-GET)*, 2016 Online International Conference on, pp. 1-6. IEEE, 2016.
- [16]. H. Chi, C. Jian, C. Wu, J. Zhu, X. Wang, and C. Liu. "Scaffolding progress monitoring of LNG plant maintenance project using BIM and image processing technologies." In *Research and Innovation in Information Systems (ICRIIS)*, 2017 International Conference on, pp. 1-6. IEEE, 2017.
- [17]. N. Senthilkumaran, and R. Rajesh. "Edge detection techniques for image segmentation—a survey of soft computing approaches." *International journal of recent trends in engineering* 1, no. 2 (2009): 250-254.
- [18]. A. Devbrat, and J. Jha. "A Review on Content Based Image Retrieval Using Feature Extraction " *International Journal of Advanced Research in Computer Science and Software Engineering* Volume3, March 2016.
- [19]. L. H. Thai, T. S. Hai, Nguyen Thanh Thuy . "Image Classification using Support Vector Machine and Artificial Neural Network" *International Journal on Information Technology and Computer Science*, 2012, 5, 32-38 .
- [20]. S. Tharani and L. Sankari. "A Study on Image Segmentation Using Different Types of K-Means Clustering" *International Journal of Advanced Research in Computer Science and Electronics Engineering (IJARCSEE)* Volume 33, December 2015

- [21]. A. Bala, A. K. Sharma. "Color Image Segmentation Using K-means Clustering and Morphological Edge Detector"International Journal of Latest Trend in Engineering and Technology. ISSN: 2278-621, 2016.
- [22]. K. Sumithra, S. Buvana, R. Somasundaram. "A Survey on Various Types of Image Processing Technique" International Journal of Engineering Research & Technology (IJERT), ISSN: 2278-0181, Vol. 4, March-2015
- [23]. P. Gupta, "A Survey Of Techniques And Applications For Real Time Image Processing." Journal of Global Research in Computer Science (UGC Approved Journal) 4, no. 8 (2013): 30-39.
- [24]. G. B. Souza, G. M. Alves, A. LM Levada, P. E. Cruvinel, and A. N. Marana. "A Graph-Based Approach for Contextual Image Segmentation" In Graphics, Patterns and Images (SIBGRAPI), 2016 29th SIBGRAPI Conference on., IEEE 2016, pp. 281-288.