

A STUDY AND COMPARATIVE ANALYSIS OF VARIOUS IMAGE ENHANCEMENT TECHNIQUES

SUMMARY

of

THESIS

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SUMMARY

In the present digital era, various kinds of images are needed to be analyzed, enhanced and converted into a suitable form for better interpretation as highly perception quality for human viewers and imaging applications. In the field of digital image processing, image enhancement is one of the challenging research fields in processing the image in such a way that the resultant image is more visually appealing with greater clarity. In recent years, the dynamic range of imaging sensors has increased and the new challenge is the demand for better image quality in low-light conditions and noisy backgrounds.

In this dissertation, various image enhancement methods in the spatial and the fuzzy domain have been studied in details with quantitative and qualitative observations. It has been observed that the classical spatial methods produce the enhanced image which is not natural in visual clarity due to saturated with very bright or dark intensity levels. To overcome this drawback, the fuzzy set theory is used to handle both brightness preserving and contrast enhancement. In a fuzzy domain, the inexactness of gray levels is handled in a better way as compared with classical spatial domain methods. For this, a fuzzy inference system consisting of input membership function, inference system using if-then rules and output membership function, are studied and a range of case studies is performed using different membership functions for gray-scale contrast enhancement. Using this Mamdani fuzzy inference system (FIS), better membership functions based on the observations and findings are identified from comparative results and analysis. A novel fuzzy Mamdani FIS is then proposed utilizing the optimization of fuzzy image quality in order to preserve the brightness and contrast of the image between the combination of membership functions. Our proposed optimization algorithm solves the problem of under-exposed or over-exposed and unnatural enhancement.

Our criterion is to determine the optimum results through the selection of best cases of membership function combinations that are based on the fuzzy quality parameter. The algorithm calculates and compares the fuzzy quality for the different cases and it stops only when minimum fuzzy quality is achieved for given membership functions.

Next study is on edge detection techniques using classical and fuzzy logic approaches for various types of images such as medical images and normal images. Observations and drawbacks found based on the results and analyses are highlighted.

CHAPTER I

This chapter provides the introduction of signal processing, image enhancement, edge detection and their applications. The research challenges in the domain of image enhancement and edge detection are discussed. The existing solutions for both the image enhancement and the edge detection along with advantages, disadvantage and motivations are presented. A brief overview of all the domains in image processing such as spatial, fuzzy and frequency domain is described. The performance metrics used for evaluation are defined with expression at the end of the chapter. These performance metrics are used throughout the thesis for analysis of proposed image enhancement techniques.

CHAPTER II

The second chapter covers the existing literature on histogram-based, fuzzy logic-based enhancement and edge detection technique. It consists of a brief description of research works from various sources in the area of image enhancement. According to the obtained findings, it is observed that a very little information about the image enhancement using fuzzy inference system (FIS) is available. A FIS consists of input membership function, inference system with

fuzzy rules and output membership function based on fuzzy set theory. The various FIS based methods for image enhancement designed in the present research work are efficient, effective and simple in design for various applications. The main goal of this chapter is to discuss the literature on contrast enhancement and on edge detection using classical methods and fuzzy methods.

CHAPTER III

This chapter presents the comparative analysis of various contrast enhancement techniques applied to different types of the images. Contrast enhancement based on classical approach is a technique of image processing for the enhancement of contrast in the spatial domain where the image pixel values are manipulated based on global information obtained from a histogram of the input image. An analysis of contrast enhancement techniques is conducted in details on the basis of performance parameters such as PSNR, MSE, and visibility. Observation findings based on this study are presented at the end of the chapter. The contents of this chapter have been presented and published in the proceedings of:

- **International Conference on Green Computing and Internet of Things, ICGCIoT, 8-10 October 2015, IEEE Explore, Organized by GCET, Greater Noida, India.**

CHAPTER IV

This chapter deals with Image enhancement technique based on fuzzy logic as the motivated by the results and discussions of the previous chapter. It addresses different membership values and fuzzy techniques for contrast enhancement. A fuzzy technique has been designed based on human perception for better improvement of contrast in the given image. As discussions in previous chapters, the contrast enhancement techniques using fuzzy have shown improved image

quality using the method of adjustment of parametric value for different membership functions. To get more insight into it, the different existing methods of classical contrast enhancement techniques have been compared with the fuzzy-based image enhancement method. A detailed results analysis of images has been done using different qualitative attributes of the image in the simulation. The results show that the merits and demerits of image enhancement for both the approaches.

The contents of this chapter have been presented and published in the proceedings of:

- **International Conference on Green Computing and Internet of Things, ICGCIoT, 8-10 October 2015, IEEE, Organized by GCET, Greater Noida, India.**
- **3rd Lucknow Science Congress (LUSCON- 2015), organized by Babasaheb Bhimrao Ambedkar University (A Central University), Lucknow, India.**
- **International Conference on Computing for Sustainable Global Development, 16th-18th March 2016, Organized by Bharti Vidyapeeth University, Delhi, India, IEEE.**
- **International Conference on Computing for Sustainable Global Development, 1st-3rd March 2017, Organized by Bharti Vidyapeeth University, Delhi, India, IEEE.**

CHAPTER V

In this chapter, various case studies have been considered to get more insight into fuzzy enhancement for Mamdani fuzzy inference system (Mamdani FIS) using different shaped membership functions (MFs). In fuzzy set theory, fuzzy inference systems are used as the best-known approach that shows the potential use of different shaped membership functions. It relies on the mapping of input and output membership functions by using the rule-based design for

transforming the input image into an enhanced image. Using different shaped membership functions, a study is presented with the help of fuzzy IF-THEN rules and fuzzy logic operators for image contrast enhancement. The case study based on mapping the rules and different membership functions for both input and output of FIS is presented in details. Results and analysis show that the images with good steps of grays between black and white are commonly the best images for the aim of human perception. The contents of this chapter have been published in:

- **International Journal of Image, Graphics and Signal Processing (IJIGSP), ISSN: 2074-9074(Print), ISSN: 2074-9082 (Online), MECS Publisher, Hong Kong.**

CHAPTER VI

In this chapter, a novel approach is proposed using a Mamdani fuzzy inference system (FIS) for contrast image enhancement through different and multiple shaped membership functions combinations and optimization is done to achieve best-satisfied enhancement. A potential use of different shaped multiple membership functions (MFs) and its combinations in the fuzzy domain are described in details. According to intuitions based on local image quality, an algorithm for generating fuzzy IF-THEN base for Mamdani FIS is also proposed in order to modify the membership functions for achieving overall resultant enhanced image quality. Analysis of this chapter shows that the use of multiple shaped membership functions in the different set of combinations for Mamdani FIS shows the best handling of non-linear pixel modification intensities when optimization is done based on fuzzy quality. Thus, the overall contrast of input image is shown to be improved after applying optimization in the fuzzy domain. The fuzzy quality is determined by the ratio of average fuzzy contrast and fuzzy contrast. The overall

intensity is handled by the average value of fuzzy contrast while fuzzy contrast value indicates the spread of the gradient. The resultant obtained images using our scheme have been measured with the help of statistical matrix parameters so that accuracy of the different combination of contrast enhancement methods can be observed distinctly. The contents of this chapter have been submitted in:

- **An Optimized Multiple Fuzzy Membership Functions based Image Contrast Enhancement Technique”, KSII Transactions on Internet and Information Systems. VOL. 12, NO. 3, March 2018. Impact factor: 0.452 (SCI).**

CHAPTER VII

This chapter is based on various spatial edge detection methods and fuzzy based edge detection methods. It described the spatial edge detection methods and fuzzy if-then-else methods and compared to each other to know which method will be more suitable to determine the edges in a better way. A change of intensity is an important issue of the edge detection. In the spatial edge detection method, various masks are used to detect edges and in the fuzzy domain, masks are used with the fuzzy if-then-else method. Statistically parameters such as PSNR, MSE value detect that fuzzy domain gives better results of edge detection as compared to spatial domain method. It is helpful to analyze an image in various applications. The contents of this chapter have been published in:

- **The IUP Journal of Computer Sciences, ISSN: 0973-9904, India.**
- **International Journal of Information Engineering and Electronic Business (IJIEEB), Vol.8, No.6, pp.62-68, 2016, MECS 2016.**

CHAPTER VIII

In this chapter, the contribution and advantages of the research work presented are highlighted. From the work, it is observed that for finding any anomalies in a specific image or for the purpose of diagnosing, images must be clearly visible, enhanced and sharpened. Otherwise, uses of low contrast, blurred or noisy images are risky and failed to analyze. Throughout work is based on contrast enhancement and edge detection of gray images using classical methods and fuzzy methods in the spatial domain. The experimental results presented in the thesis are analyzed on the basis of statistical matrix parameters, shall be very helpful for further research. The present work can also be extended as a future scope for color images in the spatial domain as well as in frequency domain. Fuzzy edge detection can be extended to implement different filtering techniques. Optimization concept can be extended to different fuzzy methods as well as in neural network and neuro-fuzzy system.