Forensic Image Analysis - A Frame work

R. B. Hanji(1), and Vijay S. Rajpurohit(2)
(1) Gogte Institute of Technology Belgaum, Karnataka (India), e-mail: hanji_rb@git.edu
(2) Gogte Institute of Technology Belgaum, Karnataka (India)

Abstract - The large volume and variety of digital images currently acquired and used in different application domain has given rise to the requirement of image analysis. Images can be found in many application domains such as journalism, advertising, medicine, weather forecasting, video surveillance, map production, remote sensing, computer aided designs etc. In particular, there is an increasing need for the development of image analysis in the forensic science, to place the perpetrator at the scene of a crime. While each application has requirements unique from the others, all are concerned with faster, cheaper, and more accurate results.

Ease with which the images can be created, they may be manipulated to sway opinions or for monetary gains; one needs to be aware that seeing does not always imply believing, especially in courtrooms. And also the human visual system is, at times remarkably inept at detecting simple geometric inconsistencies that might result from photo tempering. Even sometimes, simple differences may not be identified by the visual system. Analysis of images for information extraction has become very prominent area of interest in recent past. This article provides an overview of various issues used for forensic image analysis (FIA) using the three main components: Pre-processing, Feature extraction and the Image analysis. Embedding such capabilities of image analysis components in visual surveillance systems may automatically detect hostile intent in advance.

Key words: Forensic image analysis, Feature extraction, pre-processing, soft computing

1. INTRODUCTION

Forensic image analysis is the application of image science & domain expertise to interpret the content of an image and/or image itself in legal matters. Regardless, of the type of image analysis performed, forensic experts need to perform mainly three tasks such as image interpretation, image examination and technical preparation in day today activities [2-7]. First, Interpretation is the application of specific subject matter expertise to draw conclusions about subjects or objects depicted in images. Examples include a podiatrist drawing conclusions about foot shape from an image, a shoeprint expert drawing conclusions...
about the provenance of a shoe, or a military expert drawing conclusions about force distribution from remote sensing data. Secondly, Examination is the application of image science expertise for extraction of information from images, the characterization of image features, and the interpretation of image structure. Examples include image alteration evaluation, as well as the development of case-specific image exploration strategies. Image enhancement, image restoration, and other image processing activities intended to improve the visual appearance of features in an image are also examination tasks. Lastly, Technical preparation is the performance of tasks such as preparation of evidence or images for examination, interpretation, or output. Note that there is a wide gamut of technical decision making within the various responsibilities covered by technical preparation actions. Some responsibilities may involve minimal technical decision making, such as feeding paper into a scanner that has been previously calibrated. Some responsibilities may involve a great deal of technical decision making, such as determining appropriate color balance, sampling during acquisition, or output resolution [2-7].

Several solutions exist for machine image analysis; this paper tries to give a general framework consisting of preprocessing, feature selection, image analysis and the other issues. The literature survey shows a need, for the development of novel approaches to address forensic image analysis issues with soft computing tools. The processing, analysis and extracting image features provide decision support data from the images in question.

2. FORENSIC IMAGE ANALYSIS

The objective of forensic Image analysis is to recognize the features, similarity measure components in the image and to extract intended information from them for comparison and/or analysis. With the success of such machine image analysis will provide the novel, non-obvious, and previously unknown features for better image understanding. Five categories of forensic image analysis can be defined.

2.1 Photo image comparison

Photo comparison deals with the similarities among the given query image and known image, primarily involves the tasks of:

- Determining the similarities and dissimilarities

- Finding a comparison of class and individualizing characteristics in imagery from the criteria defined in terms of threshold.

The issues of impression evidences such as shoeprints, tool marks, tire tracks, bite marks, and marks on a fired bullet, injuries & marks on bodies, fingerprints & other marks needs to be compared for individualizing, uniqueness and for analysis.

2.2 Image Content Analysis (ICA)

ICA is the process of drawing conclusions about an image. Targets for content analysis include, but are not limited to:

- the subjects/objects within an image;
- the conditions under which, or the process by which, the image was captured or created;
- the physical aspects of the scene (e.g., lighting or composition); and/or
- the origin of the image.

Examples in ICA include blood spatter analysis, patterned injury analysis, correlation of in-
juries inflicted in an image sequence with autopsy results, determination of the presence of computer-generated imagery in an alleged "snuff" film, vehicle license plate number identification, and determination of the type of camera used to record a specific image and so on. As in the figure 2(a); to answer the questions of Is it blood? Human blood or animal? Blood age estimation, Blood spatter analysis, Blood stain dropping height, Point of convergence and other mathematical analysis.

![Figure 2: (a) Blood spatter image (b) Pattern injury (c) Type of camera used (d) Vehicle number plate identification](image)

2.3 Image Authentication

Image Authentication is the verification of the information content of the analyzed material is an accurate rendition of the original data by some defined criteria. These criteria usually involve the interpretability of the data, and not simple format changes that do not alter the meaning or content of the data.

Examples include:

- Determining whether an image contains feature-based modifications such as the addition or removal of elements in the image (e.g., adding bruises to a face).
- Determining the degradation of a transmitted image;
- Determining whether an image or a video is an original recording or an edited version;
- Evaluating the degree of information loss in an image saved using lossy compression [7].

The above image does have any additional information of manipulation as it does contain watermarking and/or digital signature. Only based on the image manipulation model [18] to authenticate the image, it is a hard problem as it may not involve simple cut & paste, but also some post processing to the entire image to make the image more realistic. With the pixel based, the format based, statistical based, geometric based and physics based forensic image analysis coupled with supervised and unsupervised learning techniques are the recent research trends.

2.4 Image Enhancement and Restoration

Common problems in surveillance images being: poor resolution, especially in video images, poor contrast due to under/over exposure, corruption with noise, motion blur or poor focus, misalignment of rows from line jitter in images.

Enhancement and clarification usually refers to correcting image blur, reducing image noise, or adjustments to brightness and contrast to bring out details that are otherwise difficult to discern. The information gained from the image analysis can then be used for the reconstruction of the incident and the evaluation of the statements of the witnesses and the crime participants [6]. Unsolved identification of persons in the CCTV (Closed Circuit TeleVision) is increasing because lack in enhancement issues.
2.5 Photogrammetry

“Photogrammetry is the art, science, and technology of obtaining reliable information about physical objects and the environment through the processes of recording, measuring, and interpreting photographic images and patterns of electromagnetic radiant energy and other phenomena.” [from “The Manual of Photogrammetry, 4th Edition, 1980, ASPRS]. In forensic applications, photogrammetry (sometimes called “mensuration”) most commonly is used to extract dimensional information from images, such as the height of subjects depicted in surveillance images and accident scene reconstruction. Other forensic photogrammetric applications include visibility and spectral analysis [2].

3. METHODOLOGY

Image Analysis is to extract the image content in an automated fashion is essential task in all types of organizations for varied applications. Any image under processing is subjected to the following steps as depicted in figure 5.

1) The Pre-Processing Stage that enhances the quality of the input image & locate the data of interest subjective to the analysis required.

2) The feature extraction stage that captures the distinctive characteristics for the image understanding.

3) The image analysis stage that identifies the image; groups them accordingly and helps in their efficient understanding followed by the recognition.

Figure 4: A typical CCTV Images

Figure 5: System outline for Forensic Image Analysis

3.1 Pre-Processing

After Image acquisition preprocessing is done on the image for bringing the image in a suitable form for further analysis. Preprocessing is normally performed on the pixel level, may also be extended to semantic (based on the structure) level to imitate the human vision or to explore the data which remarkably human being may not be able to extract because of visual limitations. Such preprocessing includes: thresholding to reduce a grayscale or color image to a binary image, reduction of noise to reduce extraneous data, segmentation to separate various components in the image, and, finally, thinning or boundary detection to enable easier subsequent detection of pertinent features and objects of interest.

3.2 Feature Extraction

Feature extraction involves the extracting of the meaningful information from the image. The features extracted from the whole image (global features) & the features extracted from the part...
of the image (local features) will be the support for the forensic image analysis in the tasks of interpretation, examination and technical preparation to establish the scientific base for the identification or the elimination. This process of dimensionality reduction reduces the storage and processing time. There can be several categories of features: textural, geometric, component, structural and content based [13, 14, 15]. The extractions of global and local features will be provided as input to image analysis algorithm/techniques. One of the most important advantages of feature extraction is that: it significantly reduces the information (compared to original image) to represent an image for understanding the content of the image. The sample of features should reflect the entire feature set obtained in the image for understanding. Simple feature extraction methods that use the similarity and dissimilarity features such as Euclidian distance has been the most widely is Euclidian distance measures (Flickner et al., 1993) and the other popular measures have been weighted Euclidian distance, the city-block, the general Minkowsky distance on the assumption that the images that are close each other in the feature space are also visually similar. The selection of the criteria is based on the relevance feedback from the user. Few researchers (Harlick at all, 2001) showed some performance of selection criterion on the feature normalization and likelihood-based similarity for image retrieval. But all the existing methods use more or less the trial and error method to select the threshold for the feature selection. In this regard, soft computing methods such as other evolutionary algorithms, meta-heuristics and swarm intelligence needs investigation for these non predictable, uncertain forensic problems as the knowledge of image manipulation is involved.

3.3 Forensic Image Analysis

It is a general rule that any evidence that needs to be presented in court must be open to scrutiny and be testable. In the case where processed digital images are presented in court one has to establish two things:

- The authenticity of the original images and the digitized versions of these images.
- The validity of any processing performed on the images for enhancement or other purposes.

The area where images are processed using proprietary software, for example Photoshop where the implementation details of any image processing algorithm are inaccessible. Some algorithms are quite complex and the results may be sensitive to subtleties in the implementation. An image that has been extensively processed using proprietary software may well be challenged in court. Refuting that challenge will be difficult if one does not have access to the source code. The research survey intents the Forensic Image Analysis requirement for the scientific base for Recording of the processing used, Access to implementation details, Numerical accuracy. In this regard the MATLAB and OPENCV are suggested by many researchers.

3.4 Forensic Image Analysis Use

A famous saying by Mark Twain concludes the use of FIA as “It’s not what you know that hurts you, it’s what you think you know and it’s not so, hurts a lot”. In this view, Forensic Image Analysis attempts to provide inductive and deductive logic though Statistical data, Pattern analysis, Results of laboratory analysis, Identification use of scientific testing, Physical properties, Chemical properties, Morphological (structural) properties, Biological properties, Immunological properties needs to be investigated for the qualification of evidence effectively to fulfill the Locard’s Exchange Principle [23,24, 25].

4. CONCLUSION AND FUTURE SCOPE

The image analysis for the purpose of finding the vital information for establishing its authenticity, individualization in an automated fashion is a challenging task and hence an open issue for the research community. In this article, we provide brief summary of basic building blocks
that comprise of forensic image analysis system which modifies pictures to improve them (enhancement, restoration), extract information (analysis, recognition), and aids in knowing its content which the human visual system is, at times remarkably inept at detecting the comparison from the known image, its content, its authenticity. There is a need to analyze the images efficiently and accurately. So, forensic image analysis is very challenging field of research with the continuous growth of interest and increasing security requirements for the development of the modern society. The computer assisted image analysis will aid the forensic experts, legal experts, and policy makers in deriving appropriate conclusions for the investigation.

5. REFERENCES

