Noise Detection in Image Processing: A Review of Techniques And Real-Time Applications

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Abstract: Digital Image Processing (DIP) refers to the application of computer algorithms for processing, creating, analyzing, and displaying digital images using digital computers. It enables the enhancement of image quality by reducing noise and improving clarity through techniques such as Linear Filtering, Median Filtering, and Adaptive Filtering. DIP is widely applied in several domains including satellite-based remote sensing, medical imaging, radar and sonar systems, and robotics. Over time, digital image processing has become increasingly cost-effective and essential in applications such as signature verification, iris recognition, face recognition, forensic analysis, automobile detection, and military operations. Each application area has its own specific requirements and challenges. Modern users demand systems that are faster, more accurate, economical, and capable of handling complex computations efficiently. This paper reviews various image processing operations to explain the fundamental concepts of DIP and demonstrates how these techniques can be adapted to different applications with minor methodological modifications. Advances in modern technology have enabled the efficient manipulation of multidimensional signals, resulting in a wide range of applications for digital image processing.

Keywords: Digital image processing, quantization, noise, face and signature recognition, sampling and applications.

I. INTRODUCTION:

Image – A two-dimensional image that can be observed by human visual system.

Digital image-Representation of a two-dimensional image as a finite set digital values, called picture elements or pixels. Pixels values typically represent grey levels, colours, heights, opacities etc.

Digital image processing-perform digital signal processing operations on digital images. Digital image processing is the use of computer algorithm to perform image processing on digital image. Digital image processing is a very popular and rapidly growing area of application under computer science engineering. Its growth leads by technological innovations in the fields of digital imaging, computer processing and mass storage devices. Fields which have been traditionally using analog imaging are now switching to digital systems, for their edibility and affordability. Important examples are medicine, and video production, photography, remote sensing, and security monitoring. In digital image processing noise is random variation of brightness or color information in image and is usually an aspect of electronic noise. It can be produced by the image sensor and circuitry of a scanner or digital camera. Conversion of digital images into normal images form involves key processes are below, jointly referred to as digitization.

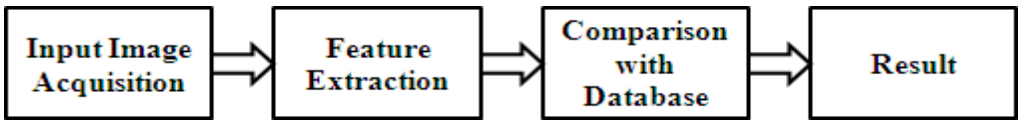


Fig 1 - Block Diagram of a DIP System

II. SAMPLING: Sampling is a process used in statistical analysis in which a predetermined number of observations are taken from a larger population. The sampling rate determines the spatial resolution of the digitized image, while the quantization level determines the number of grey levels in the digitized image. A magnitude of the sampled image is expressed as a digital value in image processing. Sampling represents the image by measurements at regularly spaced sample intervals. Two important criteria:-

- **Sampling**
  - Distance between sample points or pixels.
- **Tessellation**
  - The pattern of sampling points

The number of pixels in the image is called the resolution of the image. If the number of pixels is too small, individual pixels can be seen and other undesired effects (e.g. aliasing) may be evident.

Types:

Up sampling: It is the increasing of the spatial resolution while keeping the 2D representation of an image which does not used to storage.
Down sampling: It is the decreasing of the spatial resolution while keeping the 2D representation of an image and typically used to reduce the storage. So we can use down sampling in digital image processing.

III. QUANTIZATION: Quantization, involved in image processing is a loss compression technique achieved by compressing a range of values to a single quantum value. It is a process of converting a continuous range of value into finite range of discrete values. Quantization uses an ADC (analogue to digital converter) to transform brightness values into range of integer numbers.

Example:

For an image of 512 by 512 pixels, with 8 bits per pixel: Memory required = 0.25 megabytes Images from sources (e.g. video camera) arrive at 25 images, or frames, per second: Data rate = 6.55 million pixels per second
The capture of video images involves large amounts of data occurring at high rates.

Digital image processing focuses on two major tasks:
1. Improvement of pictorial information forhuman interpretation.
2. Processing of image data for storage, transmission and representation for autonomous machine perception.

IV. NOISE IN IMAGE:

Image noise is random variation of brightness or color information in the images captured. It is degradation in image signal caused by external sources .Images containing multiplicative noise have the characteristic that the brighter the area the noisier it. But mostly it is additive.

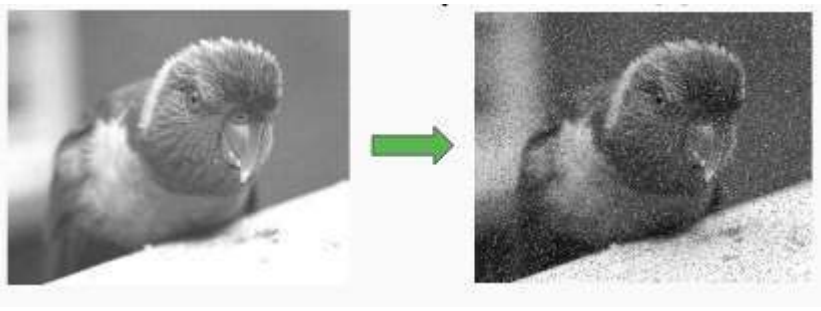


Fig 3-Addition of random noise in an image

Sources of Image noise:

- While image being sent electronically from one place to another.
- **Sensor heat** while clicking an image.
- With varying **ISO Factor** which varies with the capacity of camera to absorb light.

Types of Image noise:

There are different types of image noise. They can typically be divided into 3 types.

1. Gaussian Noise:

Gaussian Noise is a statistical noise having a probability density function equal to normal distribution, also known as Gaussian distribution. Random Gaussian function is added to Image function to generate this noise. It is also called as electronic noise because it arises in amplifiers or detectors. Source: thermal vibration of atoms and discrete nature of radiation of warm objects.

2. Speckle Noise:

A fundamental problem in optical and digital holography is the presence of speckle noise in the image reconstruction process. Speckle is a granular noise that inherently exists in an image and degrades its quality. Speckle noise can be generated by multiplying random pixel values with different pixels of an image.

3. Salt and Pepper Noise:

Salt Noise: Salt noise is added to an image by addition of random bright (with 255 pixel value) all over the image.
Pepper Noise: Salt noise is added to an image by addition of random dark (with 0 pixel value) all over the image.
Salt and Pepper Noise: Salt and Pepper noise is added to an image by addition of both random bright (with 255 pixel value) and random dark (with 0 pixel value) all over the image .This model is also known as data drop noise because statistically it drop the original data values . Source: Malfunctioning of camera's sensor cell.

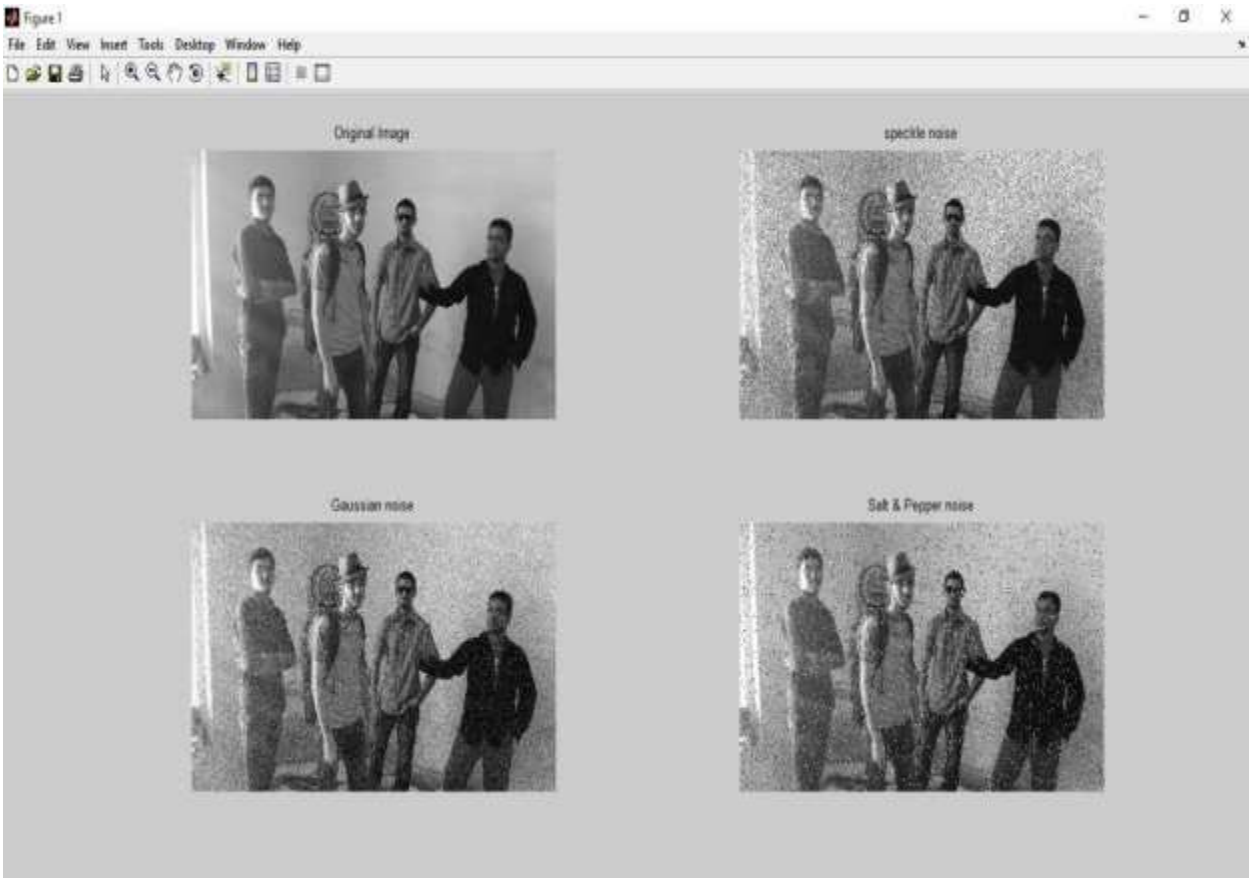
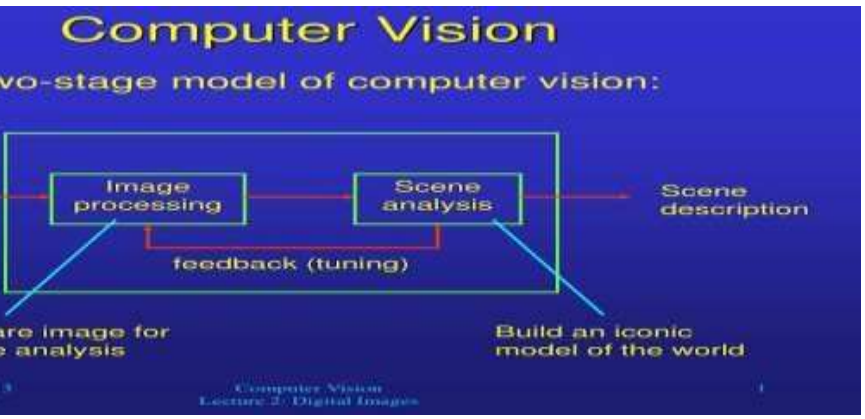


Fig 4 – noise detection in image



V. REAL TIME APPLICATIONS:

1. Computer Vision: Computer vision is a kind of automated watchdog, which uses both science and technology and it is a field that includes methods for acquiring ,processing ,analyzing and understanding image known as image analysis or computer vision. Being a discipline from science, computer vision is related to theory for design of artificial systems that can acquire information from images. The image input may be of many formats, such as a video signal sequence, or multiple views from different cameras, or data input from a medical scanning machine. Examples of applications of computer vision include systems for controlling processes such as an industrial robot or an autonomous vehicle; for detecting events such as in visual surveillance or people counting.

Fig 5 – computer vision diagram

2 .Face Detection: In this method important facial features are detected and else are ignored. Face detection can be treated as a specific case of object class detection. The objective of face detection is to find the specified features such locations and sizes of a known number of faces. Various face detection algorithms are focused on the detection of frontal human faces. It is also an attempt to solve the more general and difficult problems of multi view face detection.

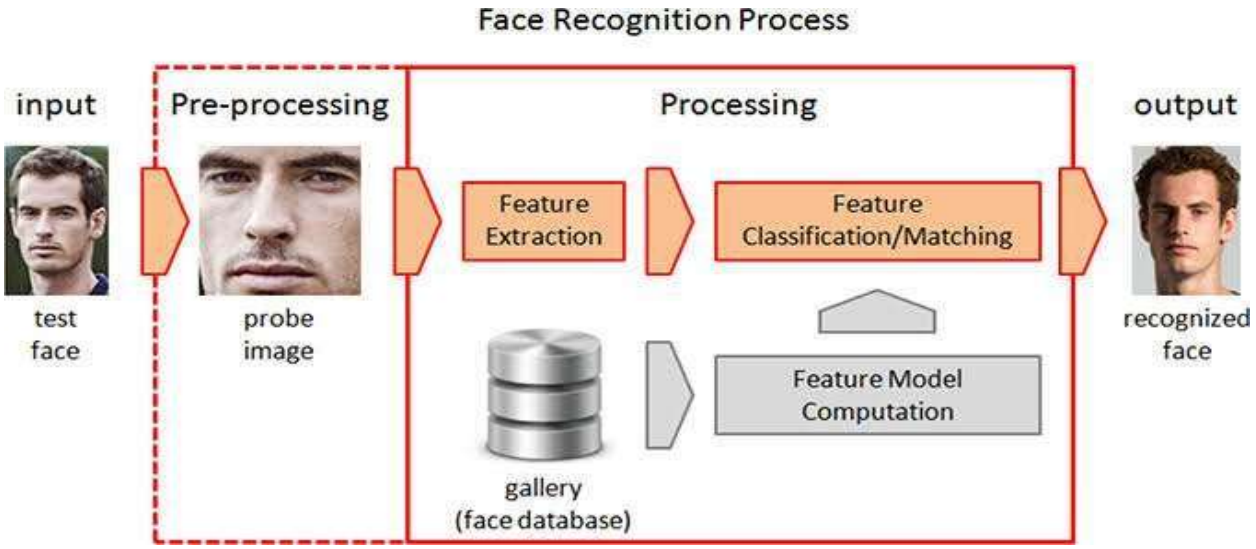
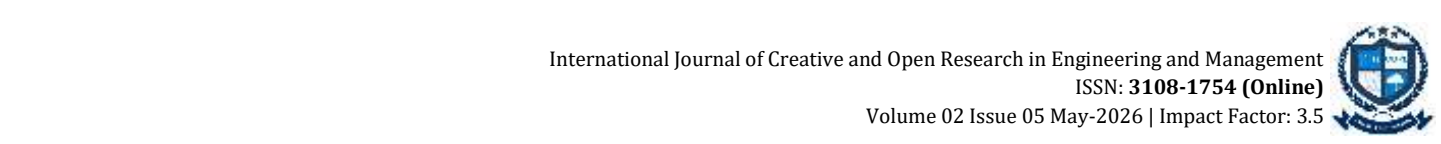


Fig 6 – Face recognition process

3. **Digital Video Processing:** In different engineering and computing applications video processing is a particular and an important case of signal processing. Here the input and output signals are video files or video streams. Video processing techniques are used in television sets, VCRs, DVDs, video codec, video players and other devices. For example commonly only design of various systems and video processing methodology is different in TV sets by different companies.



4. **Remote Sensing:** Remote sensing is basically an acquisition of small or large scale information signals from an object or phenomenon, by the using various real-time sensing devices that are wireless in nature, or not in physical or direct contact with the object (such as aircraft, spacecraft, satellite or ship). Practically remote sensing is a collection of different data signals using variety of devices for gathering information on a given object or area. The monitoring of a parolee using an ultrasound identification system, Magnetic Resonance Imaging (MRI), Positron Emission Tomography (PET), X-radiation (X-ray) and space probes are all examples of remote sensing.

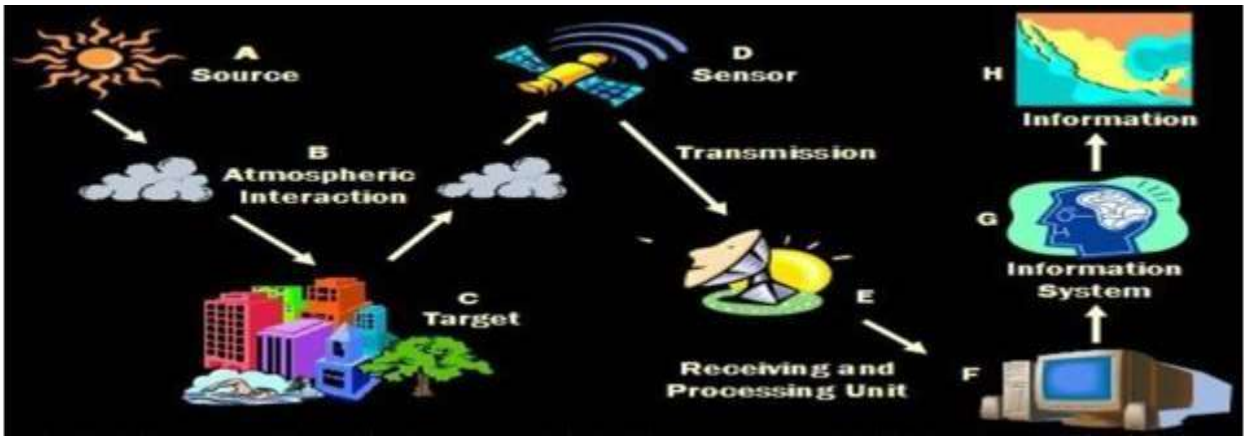


Fig 7– remote sensing process

5. **Biometric Verification:** It refers to the automatic identification or recognition of humans by their behaviors or characteristics. Biometrics recognition is such an efficient type of identification and access control. It can also be used to recognize individuals in groups that are under observation. The purpose of such a technique is to ensure that the rendered services are accessed only by a legitimate user and no one else. A biometric system is theoretically a pattern recognition system that is based on acquiring biometric data from an individual. The operating principle is based on extracting set of defined features from the acquired data, and comparing this feature set against the template set in the database. Depending on the type and mode of application, a biometric system may work under verification mode or identification mode.

6. **Signature Recognition:** Signature verification and recognition is also an important application, which is to decide, whether a signature belongs to a given signer based on the image of signature and a few sample images of the original signatures of the signer. Handwritten signatures are imprecise in nature as their corners are not always sharp, lines are not perfectly straight, and curves are not necessarily smooth. Furthermore, the fonts can be drawn in different sizes and orientation in contrast to handwriting which is often assumed to be written on a baseline in an upright position. Therefore, a robust handwritten signature recognition system has to account for all of these factors.

VI. APPLICATIONS OF IMAGE PROCESSING:

Visual information is the most important type of information perceived, processed and interpreted by the human brain. One third of the cortical area of the human brain is declared to visual information processing.
Digital image processing, as a computer-based technology, carries out automatic processing, manipulation and interpretation of such visual information, and it plays an increasingly important role in many aspects of our daily life, as well as in a wide variety of disciplines and fields in science and technology, with applications such as television, photography, robotics, remote sensing, medical diagnosis and industrial inspection.

- Computerized photography(e.ge, Photoshop)
- Space image processing (e.g., Hubble space telescope images, interplanetary probe
- Automatic character recognition (zip code)
- Finger print/face/iris recognition.
- Remote sensing: aerial and satellite image interpretations
- Reconnaissance
- Industrial applications

VII. CONCLUSION:

The future of digital image processing involves new intelligent, digital automated robots created entirely by research scientists in various nations of the world. It includes advancements in various digital image processing applications. Due to innovations in image processing and other related technologies, there will be millions and millions of robots in the world in a few decades of time span, transforming the way the world is managed. Advance researches in image processing and artificial intelligence will involve voice commands, anticipating the information requirements of governments, translating languages, recognizing and tracking people and things, diagnosing medical conditions, performing operation & surgery, reprogramming defects in human DNA, and automatic driving all formats of transportation**.** The basics of image processing such as Image, image-analysis and understanding, image-transforms, compression techniques, optical character recognition (OCR) and its applications such as video and 3D graphics firmness, Remote Sensing, Pattern gratitude, Visual content analysis, Biometrics, Statistical image processing.

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