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Applications Of Super Resolution In Pattern Recognition

Navdeep Kaur*
Research scholar
Department of CSE
Sri Guru Granth Sahib World University
Fatehgarh Sahib, Punjab , India

Usvir Kaur
Assistant Professor
Department of CSE
Sri Guru Granth Sahib World University
Fatehgarh Sahib, Punjab, India

Abstract:Pattern Recognition is the assignment of a label to a given input value. An example of pattern recognition is classification, which attempts to assign each input value to one of a given set of classes. Pattern recognition is the science for observing the environment, learning to distinguish patterns of interest from their background and making sound decisions about the patterns or pattern classes .There are various approaches of pattern recognition. Hybrid approaches to pattern recognition combine aspects of both statistical and structural pattern recognition. Super-Resolution (SR) image reconstruction a single High-Resolution (HR) image is created from a sequence of Low-Resolution (LR) frames. Super-resolution reconstruction produces one or a set of high-resolution images from a set of low-resolution images.

Key Terms:- super-resolution, pixel resolution, spatial resolution, frequency domain approach, nonuniform interpolation approach, regularized image reconstruction approach.

I. Introduction

Pattern recognition encompasses two fundamental tasks: description and classification. Given an object to analyze, a pattern recognition system first generates a description of it and then classifies the object based on that description . Two general approaches for implementing pattern recognition systems, statistical and structural, employ different techniques for description and classification. Statistical approaches to pattern recognition use decision theoretic concepts to discriminate among objects belonging to different groups based upon their quantitative features. Structural approaches to pattern recognition use syntactic grammars to discriminate among objects belonging to different groups based upon the arrangement of their morphological features. Hybrid approaches to pattern recognition combine aspects of both statistical and structural pattern recognition.

Structural pattern recognition systems are difficult to apply to new domains because implementation of both the description and classification tasks requires domain knowledge. Knowledge acquisition techniques necessary to obtain domain knowledge from experts are tedious and often fail to produce a complete and accurate knowledge base. Consequently, applications of structural pattern recognition have been primarily restricted to domains in which the set of useful morphological features has been established in the literature and the syntactic grammars can be composed by hand. To overcome this limitation, a domain independent approach to structural pattern recognition is needed that is capable of extracting morphological features and performing classification without relying on domain knowledge. A hybrid system that employs a statistical classification technique to perform discrimination based on structural features is a natural solution. While a statistical classifier is inherently domain independent, the domain knowledge necessary to support the description task can be eliminated with a set of generally useful morphological features. Such a set of morphological features is suggested as the foundation for the development of a suite of structure detectors to perform generalized feature extraction for structural pattern recognition in time series data.

II. Need Of Super Resolution In Medical Imaging

SR reconstruction deals with combining several LR images to create a HR image. SR techniques have been suggested in recent years as a means for increasing resolution without altering the existing imaging hardware. Thus, they can be seen as a means for extending current medical imaging resolution limitations. The goal of SR algorithms is to improve the image resolution in cases in which the image was under sampled.Such cases involve the following: first, the imaged object has high-frequency content. Second, the sampling frequency as defined by the detectors, does not fulfill the Nyquist frequency; thus, aliasing and degradation in the high frequency content can be observed. The SR process helps overcome the detector sampling limitations by practically increasing the sampling rate, and thus utilizing additional high-frequency information and reducing the aliasing effects. Note that in cases in which no frequencies higher than half of the detectors sampling frequency exist, SR will in effect result in the averaging of noise; in such cases, no additional improvements in the image resolution can be obtained by SR.

III. Super Resolution

Super-resolution reconstruction produces one or a set of high-resolution images from a set of low-resolution images. Super-Resolution (SR) image reconstruction a single High-Resolution (HR) image is created from a sequence of Low-Resolution (LR) frames. In most digital imaging applications, high resolution images or videos are usually desired for later image processing and analysis. The desire for high image resolution stems from two principal application areas: improvement of pictorial information for human interpretation; and helping representation for automatic machine

perception. Image resolution describes the details contained in an image, the higher the resolution, the more image details. The resolution of a digital image can be classified in many different ways: pixel resolution, spatial resolution, spectral resolution, temporal resolution, and radiometric resolution.

a)Spatial resolution: a digital image is made up of small picture elements called pixels. Spatial resolution refers to the pixel density in an image and measures in pixels per unit area.

b)Pixel resolution: pixel resolution with the set of two positive integer numbers, where the first number is the number of pixel columns (width) and the second is the number of pixel rows (height), for example as 7680 by 4320.

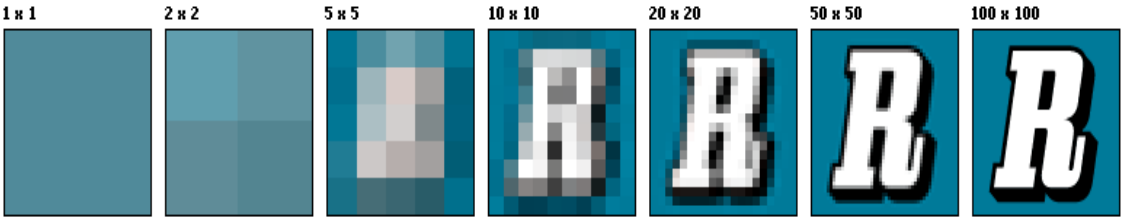


Fig1: Example of pixel resolution

c)Spectral resolution: Color images distinguish light of different spectra. Multispectral images resolve even finer differences of spectrum or wavelength than is needed to reproduce color. That is, multispectral images have higher spectral resolution than normal color images.

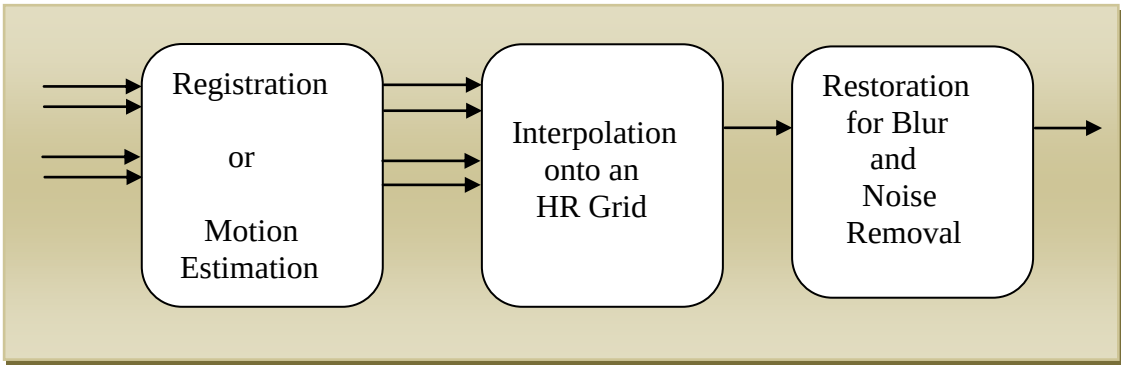
d)Temporal resolution: Movie cameras and high-speed cameras can resolve events at different points in time. The time resolution used for movies is usually 24 to 48 frames per second (frames/s), while high-speed cameras may resolve 50 to 300 frames/s, or even more.

e)Radiometric resolution: Radiometric resolution determines how finely a system can represent or distinguish differences of intensity, and is usually expressed as a number of levels or a number of bits, for example 8 bits or 256 levels that is typical of computer image files. The higher the radiometric resolution, the better subtle differences of intensity or reflectivity can be represented.

IV. Super-Resolution Image Reconstruction Algorithms

a)Non-uniform Interpolation

This approach consists of three stages i) registration, ii) non-uniform interpolation and iii) de-blurring



With registration of input images, a composite image on non-uniformly spaced sampling points is obtained. In the second step, uniformly spaced sampling points are obtained by direct or iterative reconstruction procedure. After getting a high resolution image with non-uniform interpolation, restoration is carried out to remove blurring.

b)Frequency Domain Approach

The relationship between low resolution images and the high resolution image is described by them using relative motion between the low resolution images. This approach is based on following three principles,

i) the shifting property of Fourier transform

ii) the aliasing relationship between the continuous Fourier transform (CFT) of an original HR image and the discrete Fourier transform (DFT) of observed LR images

iii) the assumption that an original HR image is band-limited

It is thus possible to formulate the system equation relating the aliased DFT coefficients of the observed low resolution images to a sample of the CFT of an unknown image.

c)Regularized Image Reconstruction Approach

The super-resolution image reconstruction approach can be an ill-posed problem because of an insufficient number of low resolution images and ill-conditioned blur operators. Regularization is the procedure adopted to stabilize the inversion of ill-posed problem. This is achieved by imposing prior knowledge on the solution. There are two types of approaches, i) deterministic approach ii) stochastic approach.

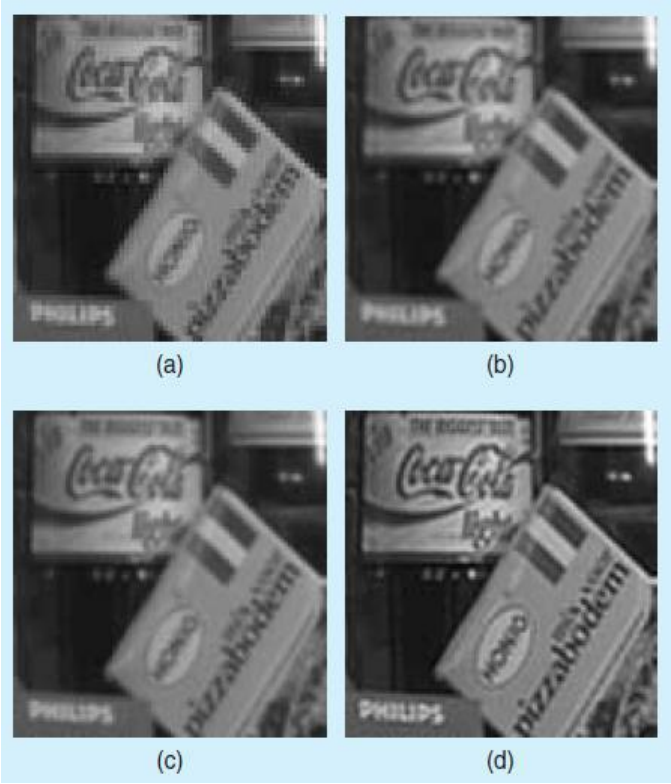


Fig 3 : Nonuniform interpolation SR reconstruction results by (a) nearest neighbor interpolation, (b) bilinear interpolation, (c) nonuniform interpolation using four LR images, and (d) debluring part

IV. Conclusion

Spatial resolution is to reduce the pixel size by sensor manufacturing techniques. As the pixel size decreases,the amount of light available also decreases. It generates shot noise that degrades the image quality severely. Another problem with the spatial resolution is to increase the chip size, which leads to an increase in capacitance. Since large capacitance makes it difficult to speed up a charge transfer rate, this approach is not considered effective.Pixel resolution is better than spatial resolution because in this two positive integer value are used which makes it easy to use. The advantage of the nonuniform interpolation approach is that it takes relatively low computational load and makes real-time applications possible. However, in this approach, degradation models are limited i.e. they are only applicable when the blur and the noise characteristics are the same for all LR images. The goal of image restoration is to recover a degraded (e.g., blurred, noisy) image, but it does not change the size of image. Another problem related to SR reconstruction is image interpolation that has been used to increase the size of a single image. Theoretical simplicity is a major advantage of the frequency domain approach. That is, the relationship between LR images and the HR image is clearly demonstrated in the frequency domain. The frequency method is also convenient for parallel implementation capable of reducing hardware complexity.

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