Super Resolution Applications in Modern Digital Image Processing

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ABSTRACT
This paper gives the various applications of Super Resolution (SR) in today's time modern digital image processing. It has been seen that SR implementation results are always increasing the performance of digital image processing techniques. Modern digital communication includes many applications which generate the data in the form of images and videos. Along with the other techniques of processing of images and videos, Super resolution of images has also grown. In the world of powerful processors and advanced display systems, SR has shown its existence and an overview of various applications based on super resolution has been given in this paper.

Keywords
FMRI, PET, OCT

1. INTRODUCTION
Super resolution is one the very basic technique in order to increase the resolution of images [1]. Mostly images with lower resolution are converted to the higher resolution with the help of these techniques.SR is having its applications in many fields mostly in areas where digital image processing is involved [2][3]. SR changes the low resolution image to the high resolution image. It could be single image based or multiple image based system. In today's time modern image processing techniques require good visual quality of image so SR is beneficial in this regard. In this paper further sections explore the major applications of SR in image processing systems. In the paper, Section 1 provides the introduction; Section 2 discusses the various application of SR and last sections include the conclusion and references.

2. APPLICATIONS
2.1 SR in satellite image processing:
In the field of satellite imaging it is often desired to have the higher resolution of images. In order to execute this task SR plays very significant role. Satellite image processing area includes the image rectification, restorations, enhancement and also information extraction. All these areas many times need the techniques of super resolution. Super resolved image increases the number of pixels which enhances the display of the digital image i.e visual interpretation increases. Moreover It could help in removal of distortions and geographical information can be further enhanced .In the further processing , SR can also be combined in further classification of areas or geographical locations .It could also include learning based techniques which are useful in land map constructions[4].

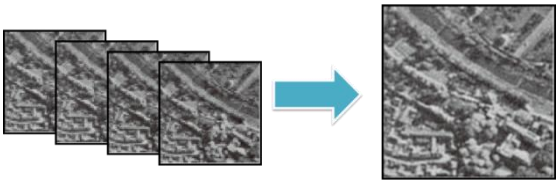

Fig 1: SR for satellite image [22]

[5] has proposed the mapping of satellite images with super resolution using Hopfield neural networks. They have used the neural based methods for the classification of spatial fields .This is helpful in super resolution mapping task. It is giving accurate and robust method for indentifying target fields using remote sensing imagery. It is one the application of SR in mapping using satellite imaging.

One of the other SR application is associated with the multi-angle remote sensing imaging [6].Multi angle information of the area might be having the similar information but not exactly same. However with the application of SR it could be used for getting more information from images. [6] has proposed the adaptive based methods to combine the multi angle information . An adaptive weighted super-resolution reconstruction technique has been used to lessen the restrictions of the different resolutions.

Other area of satellite image includes the classification of different types of areas which could also be enhanced with SR. Super resolution mapping can improve the spectral information offered by the sensors. [7] has done work in this area, has proposed the improvement with contextual classification approach in super resolution mapping and have applied it in identification and extraction of tree crown objects[7].

2.2 SR In Medical Image Processing
In the field of medical industry Super resolution has its own role. It has been that in literature good work has been done to improve the good quality of medical images [15]. As in CT scan, MRI and in other medical imaging techniques high contrast and good enhancement of image is needed this could only be fulfilled by the SR methods.

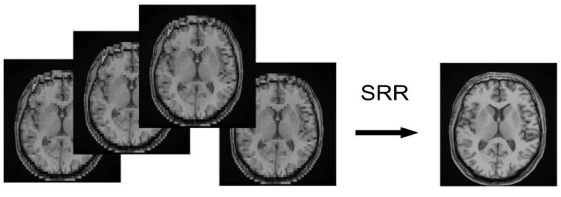

Fig 2: SR in Medical Imaging [23]

Most of the images in medical field are of low resolutions, geometric deformations and with low contrast i.e. X ray is having lower contrast, ultrasound having noisy images etc. Moreover if more time is given for imaging due to patient movement blurring may also be possible. So in order to get rid of these issues super resolution of images can be involved [8].

In today's time many of the medical imaging applications are fast and accurate with the involvement of SR. It is always desirable to detect the disease at an early stage .However at that early time imaging of the matter is usually with lower contrast. It has been made possible to have higher resolution and early visualization of diagnosis for clinical and medical researchers with the advents of novel imaging methods.

Super resolution does not require much hard ware changes, usually as per literature implemented with software [9, 10, 14]. Functional MRI (FMRI) [13], positron emission tomography imaging system (PET) [11, 12], X-ray digital mammography and Optical Coherence Tomography (OCT) are the applications of Super resolution in medical field. Medical imaging is the important for diagnosis, therefore having higher resolution significantly improves corrective treatment. Moreover, a higher resolution may substantially improve automatic detection and image segmentation outcome [9]. The algorithms used in medical imaging for diagnosis are frequently based on standard SR algorithms. Outcomes of the methods illustrated in literature demonstrate the potential of introducing SR techniques into practical medical applications [9].

2.3 SR In Microscopy Image Processing

Super resolution is also playing an important role in microscopic image processing. In this area recently much advancement has been done as per literature. In order to visualize the biological structures including cell and tissue SR is very useful. Super-resolution fluorescence microscopy one of the very significant field in microscopic imaging. 2014 Nobel Prize in Chemistry also has been given in the area of Super-resolved fluorescence microscopy [26].

In the past time, Flurescence microscope is one of the essential tools for examination of the pathways, biological molecules, living cells, tissues, and even whole subjects [16]. It is more useful as compared to electron microscopy. Other techniques like MRI or OCT (optical coherence tomography) can give resolutions in 10s of centimeters and micrometers. However with super resolutions flurescence range can be further increased.

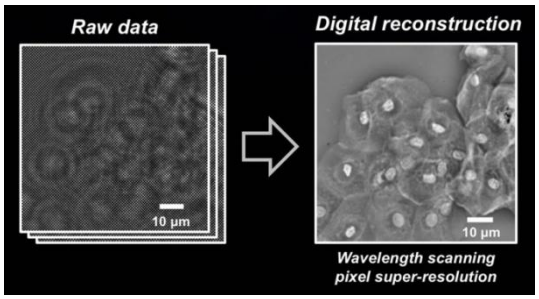

Fig 3: SR in Microscopy [24]

Super resolution based techniques may also provide the information upto nanometer scale. It includes some methods like switchable fluorophores [17] and powerful localization algorithms. Here multiple images taken in switching mode can be combined to give higher resolution. Moreover [17] has explored the area related issues .SR is being proved as very helpful in microscopic image processing.

2.4 SR In Multimedia Industry and Video Enhancement

In today's time multimedia based applications are increasing day by day. Super resolution is also involving in multimedia industry [18]. In today's time movies, animations, visual effects all need the HD data. So SR can also be proved as the useful technique in video enhancements. Many methods used in multimedia based applications uses the SR method for the enhancement of images and videos. Cell phone based applications like image or videos also included SR based techniques to enhance their quality.

2.5 SR in Astrological Studies

In the field of astrological studies, Super resolution is also involved as the significant technique. High resolution astronomical images are always desirable for better computation. Many blurred and noisy images can be combined to get a better view. [19] has used the SR for improvement of quality of astrological images . Many tightly grouped stars and far away objects can be visualizes in better way. In this area many times many unidentified objects could also be visualized in better way.

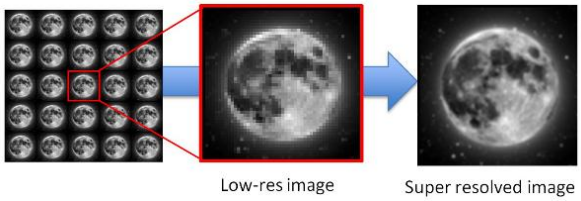

Fig 4: SR in astronomy [25]

2.6 Other Applications

Beyond the previous applications of SR, It is also having applications in areas like object detection, automotive industry, real time processing, scanning, surveillance, military and in forensics. In the area of surveillance [21] has proposed the method based on Conjugate gradient (CG) optimization. In the similar way in military surveillance also super resolution is used [20]. In automotive industry SR is having its recent applications. In auto classification and robotics it is acting as the supportive technique. In forensic application also SR based methods are being employed. So overall in many areas SR research based work is being involved.

3. CONCLUSION

As per the study involved it could be concluded that SR is having many applications almost in every area of digital image processing. Good research has already been involved in this area. In recent modern applications SR is also playing a significant role. Moreover, with involvement of software based techniques no change in hardware is required, so it is possible to upgrade the previous systems. It could be predicted that in future there would be even more scope of super resolution techniques in upgrading of digital image processing.

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