# Super Resolution From Video

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Video Super-resolution from Scene-specific Images CRC Press
Authors Katsaggelos, Molina, and Mateos present in a systematic way the building blocks of the Bayesian framework, which is also used as a reference in reviewing and comparing Super Resolution (SR) approaches which have appeared in the literature. This work should serve as a reference to the graduate student who would like to work in this area, to the practicing engineer, and scientists applying some of the tools and results to other related problems.The authors present a case that there is a strong relationship between the tools and techniques developed for SR and a number of other inverse problems encountered in signal processing (e.g., image restoration, and motion estimation). SR techniques can also be an integral part of an image and video codec and they can drive the development of new coder-decoders (codecs) and standards.

*Video Super Resolution* Springer Science & Business Media

Motion-Free Super-Resolution is a compilation of very recent work on various methods of generating super-resolution (SR) images from a set of low-resolution images. The current literature on this topic deals primarily with the use of motion cues for the purpose of generating SR images. These cues have, it is shown, their advantages and disadvantages. In contrast, this book shows that cues other than motion can also be used for the same purpose, and addresses both the merits and demerits of these new techniques. Motion-Free Super-Resolution supersedes much of the lead author's previous edited volume, "Super-Resolution Imaging," and includes an up-to-date account of the latest research efforts in this fast-moving field. This sequel also features a style of presentation closer to that of a textbook, with an emphasis on teaching and explanation rather than scholarly presentation.

*Data-driven Multi-channel Super-resolution with Application to Video Sequences* Super Resolution of Images and Video

"Human activity is a major concern in a wide variety of applications, such as video surveillance, human computer interface and face image database management. Detecting and recognizing faces is a crucial step in these applications. Furthermore, major advancements and initiatives in security applications in the past years have propelled face recognition technology into the spotlight. The performance of existing face recognition systems declines significantly if the resolution of the face image falls below a certain level. This is especially critical in surveillance imagery where often, due to many reasons, only low-resolution video of faces is available. If these low-resolution images are passed to a face recognition system, the performance is usually unacceptable. Hence, resolution plays a key role in face recognition systems. In this thesis, we address this issue by using super-resolution techniques as a middle step, where multiple low resolution face image frames are used to obtain a high-resolution face image for improved recognition rates. Two different techniques based on frequency and spatial domains were utilized in super resolution image enhancement. In this thesis, we apply super resolution to both images and video utilizing these techniques and we employ principal component analysis for face matching, which is both computationally efficient and accurate. The result is a system that can accurately recognize faces using multiple low resolution images/frames."--Abstract.

*Learning-based Video Super-resolution* BoD – Books on Demand

A method is proposed for super-resolving multichannel data with applications to PREDATOR video sequences. Using a generalization of Papoulis' sampling theorem, a closed form solution has been obtained leading to a high speed algorithm which can be realistically applied to large data sets such as video sequences. In existing multi-frame methods it is a common practice to assume that the channel transfer functions are known and invariant from one frame to another, using empirical models such as Gaussian, sinc, etc. We have assumed that the transfer functions are unknown and may vary even when the same sensor is employed, and hence use the observed data to derive the Point Spread Function (PSF) for each frame. The estimated PSFs are used in the super-resolution algorithm. Results on PREDATOR video images are then given.

**Redundant Discrete Wavelet Transform Based Super-Resolution Using Sub- Pixel Image Registration** Springer Nature

This book is intended to attract the attention of practitioners and researchers in academia and industry interested in challenging paradigms of image and video coding algorithms with an emphasis on recent technological developments. All the chapters are well demonstrated by various researchers around the world covering the field of image and video processing. This book highlights the current research in the image and video processing area such as image fusion, image segmentation and classification, image compression, machine vision algorithms and video compression. The entire work available in the book is mainly focusing on researchers who can do quality research in the area of image and video processing and related fields. Each chapter is an independent research which will definitely motivate the young researchers to ponder into. These eleven chapters available in five sections will be an eye-opener for all who are doing systematic research in these fields.

Efficient Technique for Image/video Super Resolution Springer Science & Business Media

Super Resolution of Images and VideoMorgan & Claypool Publishers

**Super Resolution of Images and Video** Springer Science & Business Media

With the exponential increase in computing power and broad proliferation of digital cameras, super-resolution imaging is poised to become the next "killer app." The growing interest in this technology has manifested itself in an explosion of literature on the subject. Super-Resolution Imaging consolidates key recent research contributions from eminent scholars and practitioners in this area and serves as a starting point for exploration into the state of the art in the field. It describes the latest in both theoretical and practical aspects of direct relevance to academia and industry, providing a base of understanding for future progress. Features downloadable tools to supplement material found in the book Recent advances in camera sensor technology have led to an increasingly larger number of pixels being crammed into ever-smaller spaces. This has resulted in an overall decline in the visual quality of recorded content, necessitating improvement of images through the use of post-processing. Providing a snapshot of the cutting edge in super-resolution imaging, this book focuses on methods and techniques to improve images and video beyond the capabilities of the sensors that acquired them. It covers: History and future directions of super-resolution imaging Locally adaptive processing methods versus globally optimal methods Modern techniques for motion estimation How to integrate robustness Bayesian statistical approaches Learning-based methods Applications in remote sensing and medicine Practical implementations and commercial products based on super-resolution The book concludes by concentrating on multidisciplinary applications of super-resolution for a variety of fields. It covers a wide range of super-resolution imaging implementation techniques, including variational, feature-based, multi-channel, learning-based, locally adaptive, and nonparametric methods. This versatile book can be used as the basis for short courses for engineers and scientists, or as part of graduate-level courses in image processing.

**Unsupervised Video Super-resolution with Temporal Consistency Using GAN** Springer Nature

In this monograph, an overview of recent developments and the state-of-the-art in image/video restoration and super-resolution (SR) using deep learning is presented. Deep learning has made a significant impact, not only on computer vision and natural language processing but also on classical signal processing problems such as image/video restoration/SR and compression. Recent advances in neural architectures led to significant improvements in the performance of learned image/video restoration and SR. An important benefit of data-driven deep learning approaches is that neural models can be optimized for any differentiable loss function, including visual perceptual loss functions, leading to perceptual video restoration and SR, which cannot be easily handled by traditional model-based approaches.The publication starts with a problem statement and a short discussion on traditional vs. data-driven solutions. Thereafter, recent advances in neural architectures are considered, and the loss functions and evaluation criteria for image/video restoration and SR are discussed. Also considered are the learned image restoration and SR, as learning either a mapping from the space of degraded images to ideal images based on the universal approximation theorem, or a generative model that captures the probability distribution of ideal images. Practical problems in applying supervised training to real-life restoration and SR are also included, as well as the solution models.In the section on learned video SR, approaches to exploit temporal correlations in learned video processing are covered, and then the perceptual optimization of the network parameters to obtain natural texture and motion is discussed. A comparative discussion of various approaches concludes the publication.

A Video Super-Resolution Algorithm Based on CNN and Motion Compensation Morgan & Claypool Publishers

Super-Resolution Imaging serves as an essential reference for both academicians and practicing engineers. It can be used both as a text for advanced courses in imaging and as a desk reference for those working in multimedia, electrical engineering, computer science, and mathematics. The first book to cover the new research area of super-resolution imaging, this text includes work on the following groundbreaking topics: Image zooming based on wavelets and generalized interpolation; Super-resolution from sub-pixel shifts; Use of blur as a cue; Use of warping in super-resolution; Resolution enhancement using multiple apertures; Super-resolution from motion data; Super-resolution from compressed video; Limits in super-resolution imaging. Written by the leading experts in the field, Super-Resolution Imaging presents a comprehensive analysis of current technology, along with new research findings and directions for future work.

**Motion-Free Super-Resolution** Springer Science & Business Media

Video super-resolution (VSR) aims to recover a realistic high-resolution (HR) frame from its corresponding center low-resolution (LR) frame and several neighbouring supporting frames. The neighbouring supporting LR frames can provide extra information to help recover the HR frame. However, these frames are not aligned with the center frame due to the motion of objects. Recently, many video super-resolution methods based on deep learning have been proposed with the rapid development of neural networks. Most of these methods utilize motion estimation and compensation models as preprocessing to handle spatio-temporal alignment problem. Therefore, the accuracy of these motion estimation models are critical for predicting the high-resolution frames. Inaccurate results of motion compensation models will lead to artifacts and blurs, which also will damage the recovery of high-resolution frames. We propose an effective wide activated separate 3 dimensional (3D) Convolution Neural Network (CNN) for video super-resolution to overcome the drawback of utilizing motion compensation models. Separate 3D convolution factorizes the 3D convolution into convolutions in the spatial and temporal domain, which have benefit for the optimization of spatial and temporal convolution components. Therefore, our method can capture temporal and spatial information of input frames simultaneously without additional motion evaluation and compensation model. Moreover, the experimental results demonstrated the effectiveness of the proposed wide activated separate 3D CNN.

**Wavelet-based Super-resolution and Video Coding** Scholars' Press

Super-Resolution Imaging serves as an essential reference for both academicians and practicing engineers. It can be used both as a text for advanced courses in imaging and as a desk reference for those working in multimedia, electrical engineering, computer science, and mathematics. The first book to cover the new research area of super-resolution imaging, this text includes work on the following groundbreaking topics: Image zooming based on wavelets and generalized interpolation; Super-resolution from sub-pixel shifts; Use of blur as a cue; Use of warping in super-resolution; Resolution enhancement using multiple apertures; Super-resolution from motion data; Super-resolution from compressed video; Limits in super-resolution imaging. Written by the leading experts in the field, Super-Resolution Imaging presents a comprehensive analysis of current technology, along with new research findings and directions for future work.

***Super-resolution Enhancement of MPEG Compressed Video***

Video super-resolution (VSR) aims to give a satisfying estimation of a high-resolution (HR) image from multiple similar low-resolution (LR) images by exploiting their hidden redundancy. The rapid development of convolutional neural network (CNN) techniques provide numerous new possibilities to solve the VSR problem. Recent VSR methods combine CNN with motion compensation to cancel the inconsistencies among the LR images and merge them to an HR images. To compensate the motion, pixels in input frames are warped according to optical-flow-like information. In this procedure, trade-off has to be made between the distraction caused by spatio-temporal inconsistencies and the pixel-wise detail damage caused by the compensation. We proposed a novel VSR method with the name, Video Super-Resolution via Dynamic Local Filter Network, and its upgraded edition, Video Super-Resolution with Compensation in Feature Extraction. Both methods perform motion compensation via a dynamic local filter network, which processes the input images with dynamically generated filter kernels. These kernels are sample-specific and position-specific. Therefore, our proposed methods can eliminate the inter-frame differences during feature extractions without explicitly manipulating pixels. The experimental results demonstrate that our methods outperform the state-of-the-art VSR algorithms in terms of PSNR and SSIM and recover more details with superior visual quality.

### Wide Activated Separate 3D Convolution for Video Super-Resolution

This book investigates sets of images consisting of many overlapping viewsofa scene, and how the information contained within them may be combined to produce single images of superior quality. The generic name for such techniques is frame fusion. Using frame fusion, it is possible to extend the fieldof view beyond that ofany single image, to reduce noise, to restore high-frequency content, and even to increase spatial resolution and dynamic range. The aim in this book is to develop efficient, robust and automated frame fusion algorithms which may be applied to real image sequences. An essential step required to enable frame fusion is image registration: computing the point-to-point mapping between images in their overlapping region. This sub problem is considered in detail, and a robust and efficient solution is proposed and its accuracy evaluated. Two forms of frame fusion are then considered: image mosaic ing and super-resolution. Image mosaicing is the alignment of multiple images into a large composition which represents part of a 3D scene. Super-resolution is a more sophisticated technique which aims to restore poor-quality video sequences by mod elling and removing the degradations inherent in the imaging process, such as noise, blur and spatial-sampling. A key element in this book is the assumption of a completely uncalibrated cam era. No prior knowledge of the camera parameters, its motion, optics or photometric characteristics is assumed. The power of the methods is illustrated with many real image sequence examples.

*Image Mosaicing and Super-resolution*

The limited resolution of video imagery taken by aircraft, over geographical areas of interest, hinders the accurate extraction of useful information. The frame resolution of the video is determined by the camera that created it. Information exists about the camera which can be used to increase frame resolution beyond the resolution capability of the camera. This is achieved by a process called super-resolution, which uses multiple low- resolution video frames to create one high-resolution image.

*ICDSMLA 2019*

This book focuses on the super resolution of images and video. The authors ’ use of the term super resolution (SR) is used to describe the process of obtaining a high resolution (HR) image, or a sequence of HR images, from a set of low resolution (LR) observations. This process has also been referred to in the literature as resolution enhancement (RE). SR has been applied primarily to spatial and temporal RE, but also to hyperspectral image enhancement. This book concentrates on motion based spatial RE, although the authors also describe motion free and hyperspectral image SR problems. Also examined is the very recent research area of SR for compression, which consists of the intentional downsampling, during pre-processing, of a video sequence to be compressed and the application of SR techniques, during post-processing, on the compressed sequence. It is clear that there is a strong interplay between the tools and techniques developed for SR and a number of other inverse problems encountered in signal processing (e.g., image restoration, motion estimation). SR techniques are being applied to a variety of fields, such as obtaining improved still images from video sequences (video printing), high definition television, high performance color Liquid Crystal Display (LCD) screens, improvement of the quality of color images taken by one CCD, video surveillance, remote sensing, and medical imaging. The authors believe that the SR/RE area has matured enough to develop a body of knowledge that can now start to provide useful and practical solutions to challenging real problems and that SR techniques can be an integral part of an image and video codec and can drive the development of new coder-decoders (codecs) and standards.

*Application of Patch-based Super-resolution Techniques to CCTV Video Enhancement*

Image Resolution is the most important quality factor of videos and images. Multi-frame Super-resolution (SR) is the process of creating a higher resolution image with finer details, by using the information of multiple low-resolution images taken from almost the same scene. In recent years images with higher resolution became the most primary requirement in many of the image processing applications, such as scientific applications, medical imaging, robotics, video sequences and satellite imaging. This book aimed at providing a good guide in analyzing the most appropriate multi-frame super-resolution methods based on spatial and frequency domain. It also presents an optimized method which can be used for many image enhancement applications.

### Recent Advances in Image and Video Coding

This book explores the application of deep learning techniques within a particularly difficult computational type of computer vision (CV) problem — super-resolution (SR). The authors present and discuss ways to apply computational intelligence (CI) methods to SR. The volume also explores the possibility of using different kinds of CV techniques to develop and enhance the tools/processes related to SR. The application areas covered include biomedical engineering, healthcare applications, medicine, histology, and material science. The book will be a valuable reference for anyone concerned with multiple multimodal images, especially professionals working in remote sensing, nanotechnology and immunology at research institutes, healthcare facilities, biotechnology institutions, agribusiness services, veterinary facilities, and universities.

### Real Time Super-resolution Video Using FPGA Devices

Video cameras must produce images at a reasonable frame-rate and with a reasonable depth of field. These requirements impose fundamental physical limits on the spatial resolution of the image detector. As a result, current cameras produce videos with a very low resolution. The resolution of videos can be computationally enhanced by moving the camera and applying super-resolution reconstruction algorithms. However, a moving camera introduces motion blur, which limits super-resolution quality. We analyze this effect and derive a theoretical result showing that motion blur has a substantial degrading effect on the performance of super resolution. The conclusion is, that in order to achieve the highest resolution, motion blur should be avoided. Motion blur can be minimized by sampling the space-time volume of the video in a specific manner. We have developed a novel camera, called the "jitter camera," that achieves this sampling. By applying an adaptive super-resolution algorithm to the video produced by the jitter camera, we show that resolution can be notably enhanced for stationary or slowly moving objects, while it is improved slightly or left unchanged or objects with fast and complex motions. The end result is a video that has a significantly higher resolution than the captured one.

### Depth-guided Super-resolution of 3D Video

This book gathers selected high-impact articles from the 1st International Conference on Data Science, Machine Learning & Applications 2019. It highlights the latest developments in the areas of Artificial Intelligence, Machine Learning, Soft Computing, Human – Computer Interaction and various data science & machine learning applications. It brings together scientists and researchers from different universities and industries around the world to showcase a broad range of perspectives, practices and technical expertise.

### Super Resolution of Images and Video

Super-resolution considers the problem of increasing the spatial resolution of an image or video from one or more observation images or frames. In both cases, the problem seeks to determine a representation of the content at a higher spatial resolution than was originally possible to acquire, store, or transmit. For the case of images, the problem has been considered in the literature for over two decades and a variety of techniques exist. Far fewer results exist for the case of digital video, which is becoming a problem of increasing importance as presence of digital video becomes more prevalent. The problem is considered through two separate processes: modelling, which describes how multiple individual low-resolution observed images/frames are related to a single high-resolution equivalent, and reconstruction, which recovers the unknown high-resolution version from the observations and the results of the modelling process. As presented, the complete problem is driven by the proposed reconstruction solution, and novel aspects of the modelling problem are introduced based on the needs of the particular reconstruction solution. For the case of images, a linear minimum mean-squared error (LMMSE) frequency domain solution is proposed using a filter bank model and a stationary stochastic signal assumption. The solution requires estimation of a high-resolution image's spectral density from its low-resolution observations. Novel parametric spectral models for images are introduced and applied to the problem. In the case of video sequences, the presence of temporal motion over multiple frames necessarily leads to more complex registration models, generally prohibiting the application of most standard still-image solutions. Previously, super-resolution methods intended for video have been limited to relatively simple motion models, e.g., global translational motion, based on a reconstruction requirement that the distortion and motion models commute. Relying on a reverse motion model, the proposed approach removes this limitation, consequently extending the result to cases of arbitrary motion models. With the required modelling in place, a LMMSE spatial domain reconstruction is used to determine the reconstructed sequence.