**Image super resolution using variational methods**

1.We address the topic of creating a high-resolution image from a single low-resolution image without the need of an external training set in this study. Using just the original low-resolution image and its blurred form, we present a framework for magnification and deblurring. Each pixel in our technique is predicted by its neighbours using the Gaussian process regression. We show that the Gaussian process regression may accomplish soft grouping of pixels based on their local structures when a correct covariance function is used. We also show that our algorithm can extract enough information from a single low-resolution image to generate a high-resolution image with sharp edges that is comparable to, if not better than, the performance of other edge-directed and example-based super-resolution algorithms.

2. We present a variational framework for generating a super resolved picture of a scene from an arbitrary input video in this study. For high precision optic flow estimate, we use a recently suggested quadratic relaxation approach. Following that, we estimate a high resolution picture using a variational method that mimics the image creation process and imposes a total variation regularity on the calculated intensity map. The gradient descent minimization of this variational technique results in a deblurring process with nonlinear diffusion. In contrast to many alternative techniques, the suggested algorithm makes no assumptions about object motion. On a range of real-world cases, we show strong experimental performance.

3. We describe a unique technique to depth map super-resolution based on multi-view uncalibrated photometric stereo. In practise, an LED light source is connected to a standard RGB-D sensor and utilised to capture things from numerous perspectives with unknown mobility. Because of the formulation of an end-to-end joint optimisation issue, this non-static camera-to-object arrangement is described with a nonconvex variational technique that requires no calibration on illumination or camera motion. As demonstrated on demanding synthetic and real-world datasets, solving the proposed variational model yields high resolution depth, reflectance, and camera estimations.

4. MISR integrates complementary information from a series of low-resolution (LR) photos to reconstruct a high-resolution (HR) image. In this paper, we suggest a variational Bayesian-based MISR technique that is both resilient and entirely data-driven. In contrast to previous variational super-resolution (SR) approaches, we employ the l1 norm-based observation model, which accounts for acquisition noise, outliers, and impulse noise. Furthermore, we assessed three common image prior models and picked the best one for our suggested technique. The following benefits are provided by the proposed method: (1) the HR picture and all parameters are automatically calculated in an optimum stochastic sense; and (2) the algorithm is resistant to impulse noise and outliers.

5. Many computer vision applications rely on super-resolution (SR) from a single picture. Its goal is to generate a high-resolution (HR) image from a low-resolution (LR) input image. We offer a unique single picture SR approach that takes advantage of both local geometric duality (GD) and non-local similarity of images to enable a reliable and robust estimate of the HR image. The fundamental idea is to use these two often found picture characteristics as effective priors to confine the super-resolved outcomes. Taking this idea into account, the resilient soft-decision interpolation approach is generalised as an excellent adaptive GD (AGD)-based local prior. A local non-smoothness detection approach and a directional standard-deviation-based weights selection method are used to adaptively create weights for the AGD prior.

6. Because of their excellent feature representation capabilities, deep convolutional neural networks (CNNs) have lately found remarkable success for single image super-resolution (SISR) tasks. The most current deep learning-based SISR approaches concentrate on creating deeper / broader models to learn the nonlinear mapping between low-resolution (LR) inputs and high-resolution (HR) outputs. Existing SR approaches do not account for the image observation (physical) model, necessitating a large number of network trainable parameters and a huge volume of training data. To address these difficulties, we present a deep Iterative Super-Resolution Residual Convolutional Network (ISRResCNet), which takes use of sophisticated picture regularisation and large-scale optimisation approaches by training the deep network iteratively using a residual learning approach.

7. The authors offer a novel Bayesian Super-Resolution (SR) picture registration and reconstruction approach. The novel technique makes use of a prior distribution based on a generic combination of spatially adaptive, or non-stationary, image filters, including an adaptive local strength parameter capable of preserving picture edges and textures. The suggested method, which employs variational methods, enables the automated estimate of all problem unknowns. On both synthetic and actual pictures, an experimental comparison of state-of-the-art approaches and the suggested SR approach was done.

8. A super-resolution reconstruction of a composite image will yield a high-resolution image from a low-resolution image. Because the super-resolution problem is not properly addressed, a limited way of optimising a numeric algorithm is used to eliminate picture noise. Subject to noisy statistical restrictions, the overall variation of the image is minimised. The usage of Lagrange multipliers is subject to constraints. The gradient projection approach is used to arrive at the solution. It is the time-based solution of a partial differential equation with multiple restrictions defined. The solution converges to a continuous picture as t--0o. It is a quick and simple numerical algorithm. The measurements are often cutting-edge, with extremely noisy footage.

9. Light field (LF) cameras may capture images from different angles, introducing useful angular information for picture super-resolution (SR). However, due to differences in LF pictures, including angular information is difficult. We propose a deformable convolution network (LF-DFnet) to tackle the disparity problem in LF image SR in this research. For feature-level alignment, we create an angular deformable alignment module (ADAM). We then propose a collect-and-distribute technique based on ADAM to conduct bidirectional alignment between the center-view feature and each side-view feature. Angular information can be properly included and encoded into features of each view using our technique, which enhances the SR reconstruction of all LF pictures.

10. Most existing super-resolution algorithms that have only been trained on simulated datasets struggle to attain acceptable performance in real-world settings. Furthermore, it is challenging to get well-aligned real-world picture pairings for training between high-resolution and low-resolution regions. We presented a unique super-resolution framework based on variational auto encoder to address this issue. We used a variational auto encoder first to map the degraded low-resolution photos and the real-world low-resolution images to the same latent space. Meanwhile, another variational auto encoder transferred the high-quality pictures to another latent space. To learn the mapping between the two latent spaces, an extra convolutional neural network was deployed. The information in the mapped latent space was then decoded, and the decoder recreated high-resolution pictures. We compared the performance of our suggested technique to that of state-of-the-art methods such as SRGAN, ESRGAN, and CycleGAN. The experimental findings show that the new strategy outperforms the preceding strategies in the real-world super-resolved challenge.

**References**

1. S. Baker and T. Kanade. Limits on super-resolution and how to break them. IEEE Trans.

2.Chambolle, A.: An Algorithm for Total Variation Minimization and Applications. J. Math. Imaging.

3. R. Y. Tsai and T. Huang, "Multiframe image restoration and registration", Proc. Adv. Comput.

4. Proceedings of the IEEE/CVF Winter Conference on Applications of Computer Vision (WACV), 2020, pp. 1-10

5. K. Jiang, Z. Wang, and P. Yi, “Edge-enhanced GAN for remote sensing image super-resolution,” *IEEE Transactions on Geoscience and Remote Sensing*, vol. 57, no. 8, pp. 5799–5812, 2019.

6. Stephane Mallat, "Geometrical grouplets", Applied and Computational Harmonic Analysis, 2008.

7. W. Dong, L. Zhang, G. Shi and X. Li, "Nonlocally centralized sparse representation for image restoration", IEEE Transactions on Image Processing, vol. 22, pp. 1620-1630, 2013

8.International Conference on Digital Image Computing: Techniques and Applications (DICTA), vol. 2012, Centre for Intelligent Systems Research, Deakin University, Geelong, Victoria, Australia, Fremantle, Australia (2012)

9. X. Liu, Y. Chen, Z. Peng and J. Wu, "Infrared image super-resolution reconstruction based on quaternion and high-order overlapping group sparse total variation", Sensors, vol. 19, no. 23, pp. 5139, 2019.

10. Y. Wang, J. Yang, Y. Guo, C. Xiao and W. An, "Selective light field refocusing for camera arrays using bokeh rendering and super resolution", IEEE Signal Process. Lett., vol. 26, no. 1, pp. 204-208, Jan. 2019.