Super Resolution for Automated Target Recognition

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Abstract—**Super resolution is the process of producing high-resolution images from low-resolution images while preserving ground truth about the subject matter of the images and potentially inferring more such truth. Algorithms that successfully carry out such a process are broadly useful in all circumstances where HR imagery is either difficult or impossible to obtain. In particular we look towards super resolving images collected using longwave infrared (LWIR) cameras; high resolution sensors for such cameras do not currently exist. We present an exposition of motivations and concepts of super resolution in general and current techniques, with a qualitative comparison of such techniques. Finally we suggest directions for future research, in particular with applications to LWIR images.**

I. Introduction

Super resolution (SR) is a collection of methods[1] that augment the resolving power of an imaging system. For typical imaging use-cases high resolution images are preferable to low resolution images; higher resolutions are desirable in and of themselves and as inputs to later image processing transformations that can degrade image quality (e.g. by virtue of quantization or compression). Here by resolution we mean in particular the ability of the imaging system to distinguish spatial features in the image plane rather than the closely related notions of spectral resolution (ability to distinguish frequencies) or temporal resolution (ability to distinguish motions). In theory the resolving power of an imaging system is primarily determined by the number of independent sensor elements that comprise that imaging system and each of which collects a component of the ultimate image; naturally then a way to increase the resolution of such a system is to increase the density of such sensor elements per unit area. Unfortunately, and counterintuitively, since the number of photons incident on each sensor decreases as the sensor shrinks, Poisson noise[2]. thwarts that idea. Furthermore, while sensor density is primary, secondary effects due to physical optics limit spatial resolution as well; the point spread of a lens system, i.e. the impulse response of the system, chromatic aberrations (differing indices of refraction for differing wavelengths of light), and motion blur all function to erase high frequency details from the image plane.

In domains such as satellite/aerial photography, medical imaging, and facial recognition high-resolution reconstruction of low-resolution samples is eminently useful, since ab-initio acquisition of high-resolution images is either logistically difficult or impossible due to aforementioned imaging apparatus limitations. For example in the instance of satellite imagery, acquisition of high-resolution imagery is primarily hampered by optics and physics[3]. In contrast, in the cases of medical imaging (where procedures are invasive and patient exposure time needs to be minimized[2]) and facial recognition (e.g. for purposes of surveillance) the primary challenge is logistics and access to repeat collection opportunities.

The benefit of enhancing images using super resolution techniques includes not only more pleasing or more readily interpretable images for human consumption but higher quality features for automated learning systems as well. In particular object detection systems trained on super-resolved images outperform those trained on the low resolution originals[3].

Practically speaking, there exist hardware and software solutions for increasing the resolution of an imaging system, but owing to a ”Ship of Theseus” consideration, we discount such propositions as, for example, increasing the number of pixels per unit area on the imaging sensor, or replacing the optics, and focus exclusively on software techniques.

Of particular interest are situations for which imaging sensors

II. Background

III. Classical Algorithms

IV. Deep Learning Algorithms

V. Future Research

VI. Conclusion

Acknowledgments

[1]We will often use the verb form ”to super resolve” in order to denote the use of one or more such methods.

[2]Otherwise known as shot-noise, this is the result of incoming photons being distributed $\sim \text{Pois}(\lambda)$ and hence with $\text{SNR} = \sqrt{\lambda}$.

[3]The angular resolution R of a telescope with optical diameter $D = 2.4m$ observing visible light ($\sim 500nm$) is approximately[1]

$$R \approx 1.220\frac{\lambda}{D} = 1.220\frac{500\text{nm}}{2.4\text{m}} \approx 0.06\text{arcsec}$$

From an altitude of 250 km this corresponds to a ground sample distance of 6cm. This ”loss of resolution” is further exacerbated by diffraction through the atmosphere.

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