BEYOND VISION WITH NEW IMAGE SUPER-RESOLUTION ALGORITHMS

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ABSTRACT

The last decade saw an important increase in the use of digital cameras across many different sectors of society. Most mobile phones now incorporate a camera. In most cities, the use of large surveillance systems with CCTV cameras is widespread in places like streets, banks or supermarkets to thwart crime, analyse behaviour and prevent accidents. Also, intelligent automated systems increasingly rely on cameras and computer vision techniques to take decisions based on their environment in order to help or extend the user's abilities (augmented cognition). To be efficient, all these technologies require good quality, detailed images with a high-resolution, i.e. a large number of pixels.

However, in practice, there are many constraints which make the use of high-resolution cameras difficult, if not impossible. First of all, because of electronic limitations, it is not possible to reduce the size of the camera sensor while keeping a large number of pixels. Large sensors require large lenses which are heavy, bulky, fragile and very expensive to manufacture. Furthermore, when the sensor runs on batteries, the transmission of a high resolution image between the camera and the receiver can drain most of its computing power instead of using this energy for sensing its environment.

The framework of our research replaces the traditional single camera setup with a system composed of several cameras (distributed camera network) observing the same scene and located at different unknown viewing positions. Each sensor is a small, independent, low-power camera with a low-resolution and communicating only to the receiver. Thanks to their low-resolution, these cameras are less obtrusive, lighter, more resistant to shocks and cheaper to produce. By distributing the acquisition of a scene amongst several sensors, the system becomes naturally more robust to camera failure than when a single camera is used.

The goal of our research is to generate at the receiver a single detailed high-resolution image from the set of different very low-resolution images acquired by the cameras. This is referred to as an image super-resolution problem and has received much attention in the signal processing community in the past few years. Image super-resolution can be conceptually broken down to two sub-problems known as image registration and image restoration. Image registration consists in finding the disparity between the low-resolution images whereas image restoration aims at removing, after image fusion, any blur and noise introduced by the cameras during acquisition. Although much of the research in super-resolution focuses on image restoration, the critical step is to obtain an accurate registration of the set of images. However this latter becomes more difficult as the resolution decreases.

Through our research, we have developed new methods to extract global and local features from very low-resolution images (64x64 pixels) that allow us to do an exact image registration. To achieve this, we applied recent results from the sampling theory for signal with Finite Rate of Innovation (FRI) to images and exploited known properties of the camera lenses used during the acquisition. Based on our new registration procedures, we developed new image super-resolution algorithms which showed an improved visual quality of the generated super-resolved images.

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[0]Related publications:
1. Distributed acquisition and image super-resolution based on continuous moments from samples, L. Baboulaz and P.L. Dragotti, IEEE Int. Conf. on Image Processing, October 2006, Atlanta, USA.
2. Image super-resolution with B-Spline kernels, L. Baboulaz and P.L. Dragotti, 7th IMA Int. Conf. on Mathematics for Signal Processing, December 2006, Cirencester, UK.