Blind Image De-convolution by Sparse Approximation

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Image processing and analysis have become vital tools in many fields of science and technology. While recent developments in these areas have created new problems, ideas from mathematics and computation provide a deeper understanding of the challenges generated, and new methods to overcome them.

At the forefront of such work is the Centre for Wavelets, Approximation and Information Processing. Critical to the Centre's success has been the drawing together of expertise in applied mathematics, computer science and electronic engineering. One of its members, Assoc Prof Ji Hui, comments that "the multidisciplinary nature of the Centre makes our research work highly innovative and original".

Together with other researchers from the Centre, Assoc Prof Ji recently devised a method of 'blind' image de-convolution to address the ill-posed problem in digital photography of how to recover a high-quality clear image from a blurred image without any information about the blurring process. This, notes Asso Prof Ji, "is a relatively new problem with few working on it" because it is "much harder to solve" than conventional de-convolution. Other methods rely on knowledge of how the image was blurred to reverse the process without adding 'noise'.

That knowledge is not available in blind de-convolution, and the team needed to develop several new mathematical models and techniques to compensate. Rather than using the smooth functions that feature in conventional methods, they devised several new mathematical models and techniques based on wavelet tight frame theory and sparse approximation by the L1-norm. Their results include a wavelet frame coefficient-based functional that defines a clear image with sharp edges, and a new sparsity-based image de-convolution method that can effectively deal with the unavoidable error that arises in estimating the blurring process. Building on these important results, the researchers developed a two-stage computational framework for recovering images that have been degraded by blurring, such as that caused by camera movement.

The team's experiments on digital photographs showed that their method "is very powerful such

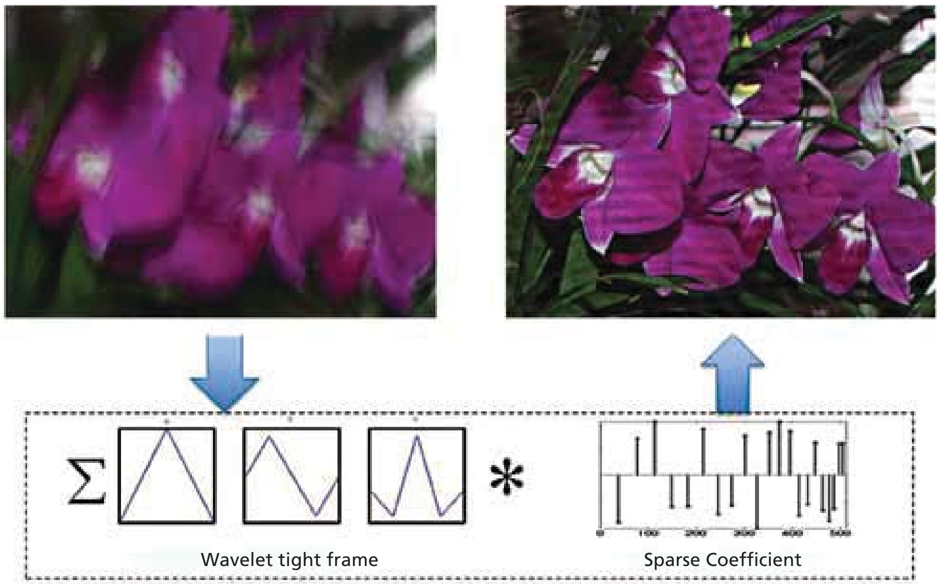

Figure 1. Work flow of blind image deblurring by sparse approximation

that it outperforms the others", Assoc Prof Ji remarks. This has immediate implications for image correction, and the method could be incorporated into post-processing software such as Photoshop or directly into digital camera firmware. The techniques resulting from the research could also be used in imaging science. Assoc Prof Ji stresses that even though his team's efforts focused on optical digital photography, their work "provides a solid foundation to solve problems in bio-imaging". He points to the potential benefits that could be had in x-ray computed tomography, and is hopeful of working with biologists to solve similar blurring problems in cryo-electron microscopy.

With "many open questions" remaining in blind image de-convolution, Assoc Prof Ji and his collaborators are moving ahead with research that will both advance theory and lead to new applications.

Publications:

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Shen, Z. Wavelet frames and image restorations. Proceedings of the International Congress of Mathematicians, Hyderabad, India (2010).