

## Handling Blur

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### Lecturers:

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Blur is an unwanted phenomenon, which is common in digital images. It results in smoothing high-frequency details, which makes the image analysis difficult. Heavy blur may degrade the image to such an extent, that neither automatic analysis nor visual interpretation of the content are possible. If we did not have proper tools for processing and analyzing blurred images, many unique images would be lost. Two major approaches to handling blurred images exist. They are more complementary rather than concurrent; each of them is appropriate for different tasks and employs different mathematical methods and algorithms.

**Image restoration** (blue in Figure) is one of the oldest areas of image processing. It appeared as early as the 1960's and 1970's in the work of the pioneers A. Rosenfeld, H. Andrews, B. Hunt, and others. In the last ten years, this area has received new impulses and has undergone a quick development. We have witnessed the appearance of multichannel techniques, blind techniques, and superresolution enhancement resolved by means of variational calculus in very high-dimensional spaces. A common point of all these methods is that they remove the blur from the input image and produce an image of a high visual

quality. However, image restoration methods are often ill-posed, ill-conditioned, and time consuming.

On the contrary, the **blur-invariant** approach (yellow in Figure), proposed originally in 1995, works directly with the blurred data without any preprocessing. Blurred image is described by features, which are invariant with respect to convolution with some group of kernels. Image analysis is then performed in the feature space. This approach is suitable for object recognition, template matching, and other tasks where we want to recognize/localize objects rather than to restore the complete image. The mathematics behind it is based on projection operators and moment invariants.

In the tutorial, we focused on both approaches. We started with blur modeling and analyzed potential sources of blur in real images. In the first part of the tutorial we reviewed traditional as well as modern deconvolution techniques, including blind deconvolution, space variant deconvolution, and multichannel deconvolution. In the second part we discussed invariants to image blurring. The tutorial was completed with numerous demonstrations and practical examples.

The attendance of around 10 people was relatively low. However, the lively discussion during the coffee break and at the end of the tutorial, indicated the deep interest of the attendees.

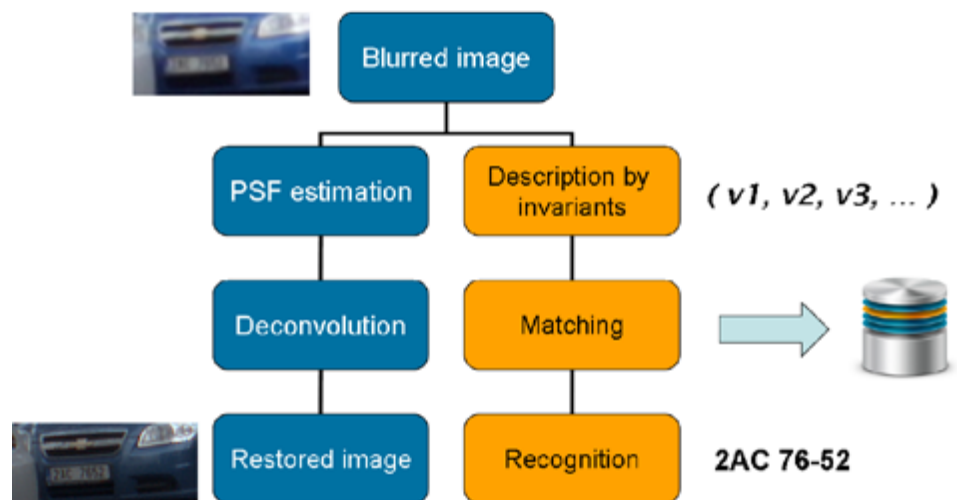


Figure. Two major approaches to handling blurred images exist: image restoration (blue) and blur-invariant (yellow)