# An application of the least squares plane fitting interpolation process to image reconstruction and enhancement
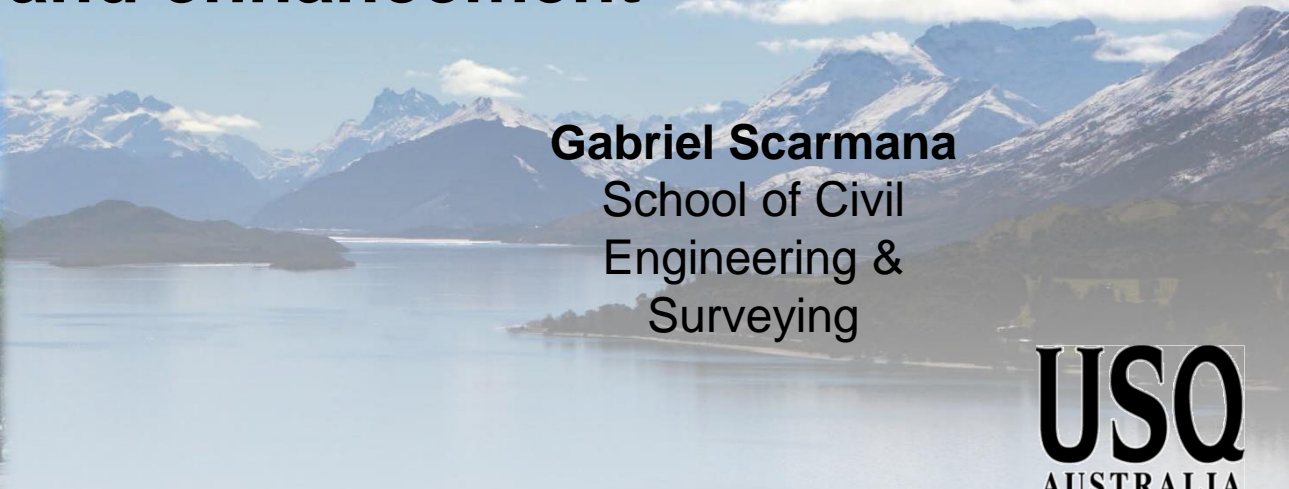
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FIG Working Week 2016

CHRISTCHURCH, NEW ZEALAND 2–6 MAY 2016        Recovery

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## Purpose: Improve Image Quality

A set of low-resolution shifted images are combined at sub-pixel level via multi-frame image enhancement to obtain an improved image.
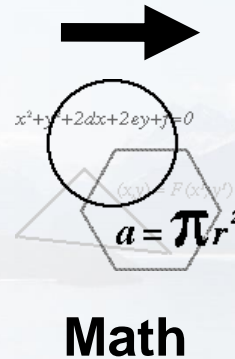


Low-resolution imagery

High-resolution imagery

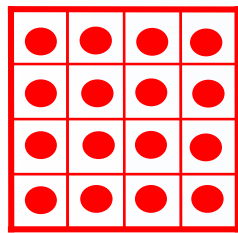# Multi-Frame Image Enhancement: What Is It?



**Math**

Calculates fractional image shifts
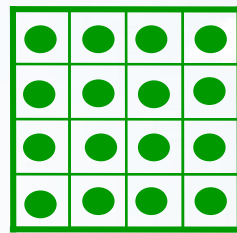
Produces a finer resolution composite

The process usually involves an image enhancement technique referred to as image Super-Resolution (SR).
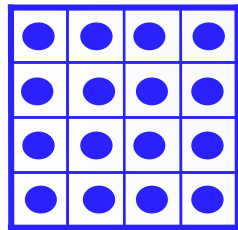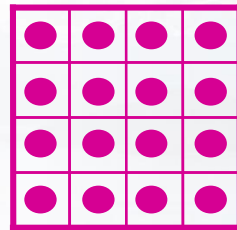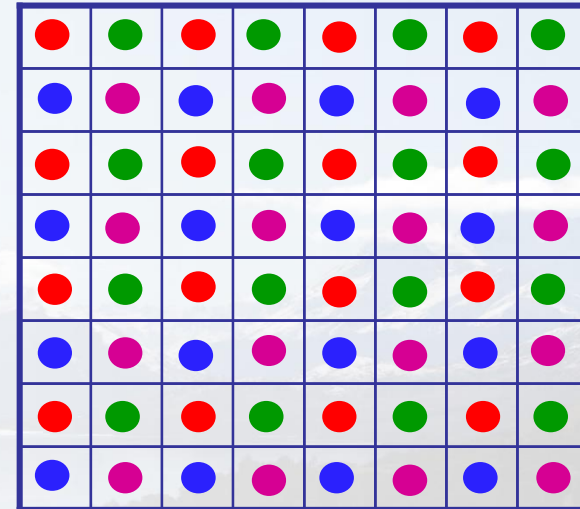
# The Principle



(a)   (b)   (c)   (d)   (SR)

An idealised super-resolution setup. Images (b)-(d) are taken with a sub-pixel shifts of half a pixel in the horizontal, vertical and diagonal directions in relation to image (a). Their pixels can then be interleaved to generate a double resolution image.

# Sub-pixel shifts cause images to be different

In a real world, the randomness of the motions (or sub-pixel shifts) between low-resolution images of the same object cause these images to be different as they are sampled at different positions.
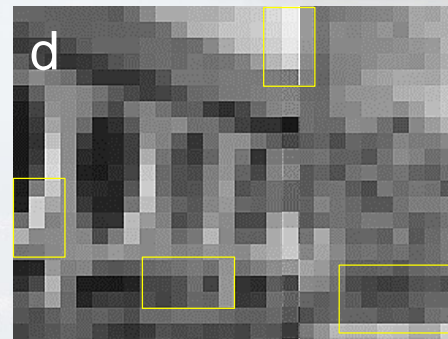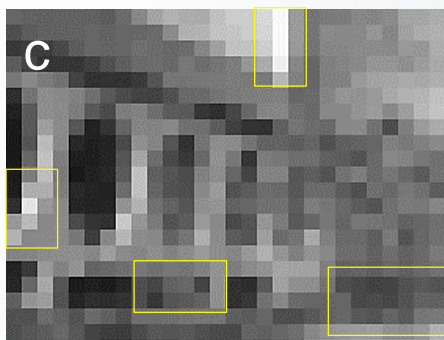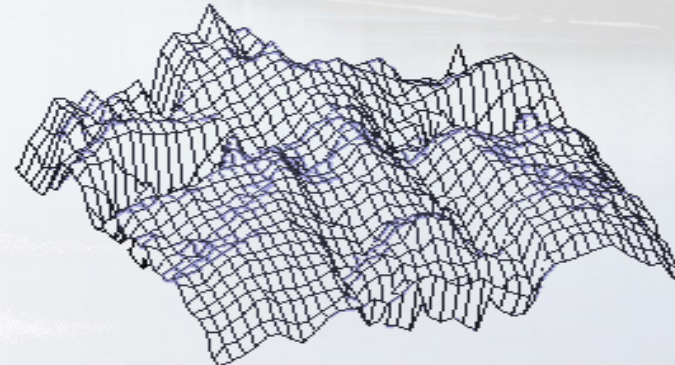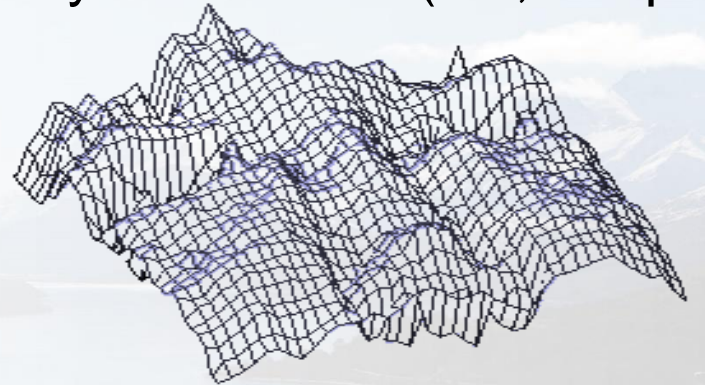
## Image Registration/Matching

Images can be represented as surfaces of pixels intensities. Area based registration techniques can determine the position of each image from the first with an accuracy of 0.1 units (i.e., 0.1 pixel).

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# Merging the Low-Resolution Pixels

The unknown value of the high-resolution pixels (white cell in the centre of the grid) will be estimated based on values of the surrounding pixels of the low-resolution images.
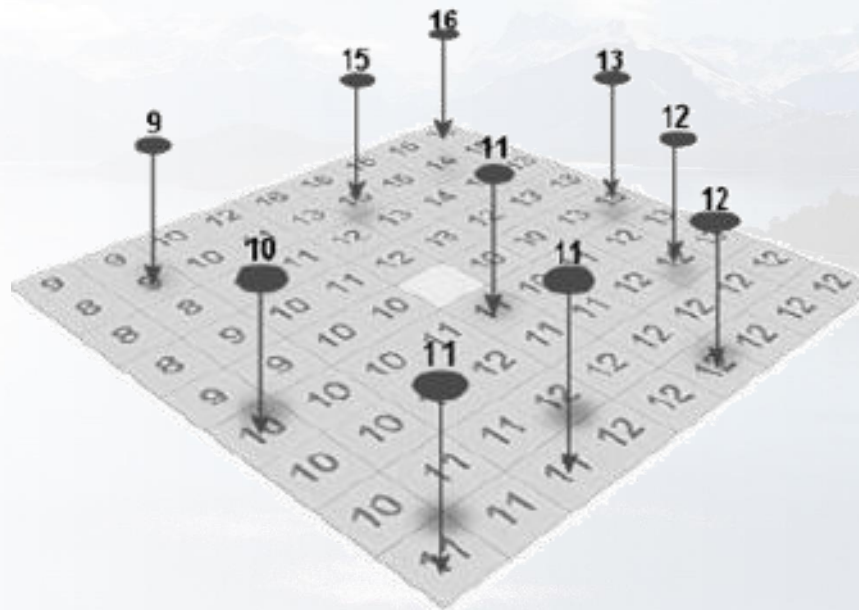
# Least Squares Planes Fitting

$n$ points are selected near the new sample position. A least square plane is fit through those $n$ points and the value of this plane at the new position is the new pixel value. This method (a) is fast (b) it uses the information of data position (c) it estimates the accuracy of each high-resolution pixel and (d) does not create blurring artifacts.
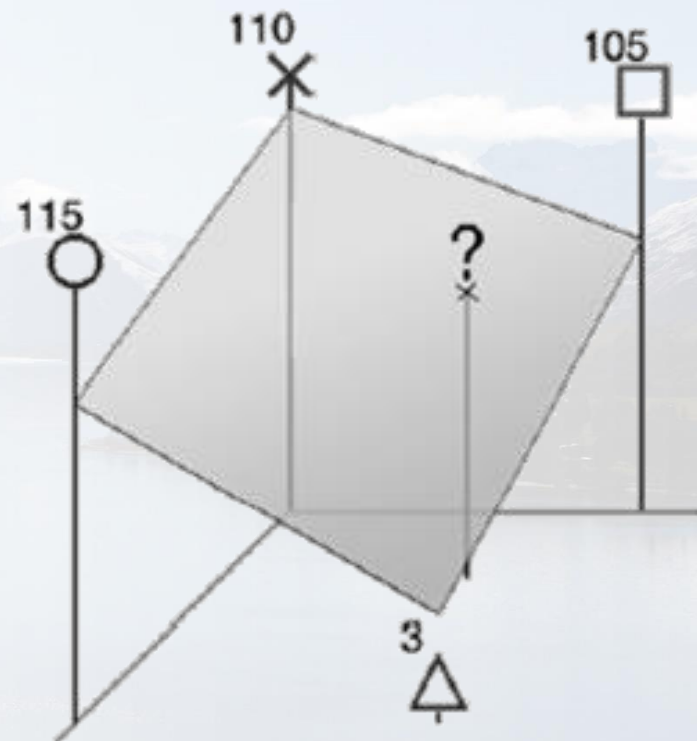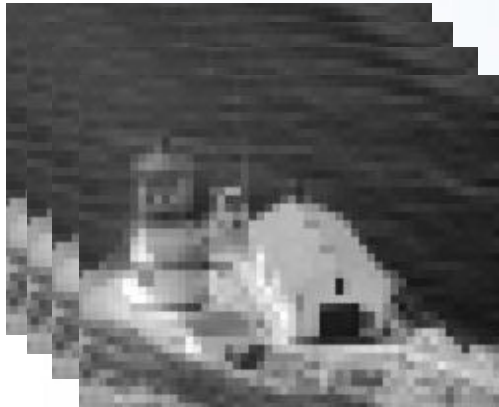
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# What Accuracy Can Be Achieved?
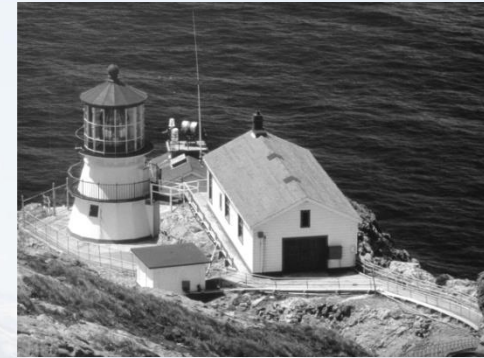
50 low-resolution compressed images — Magnification = 4 → High-resolution composite
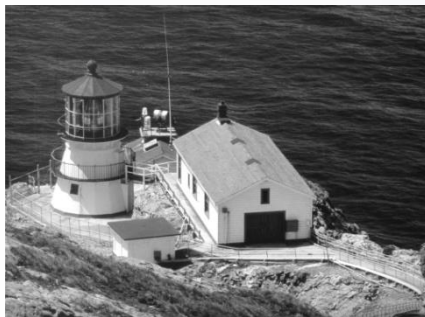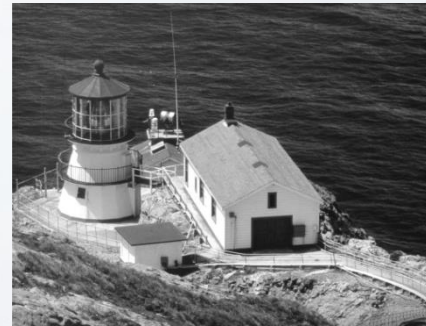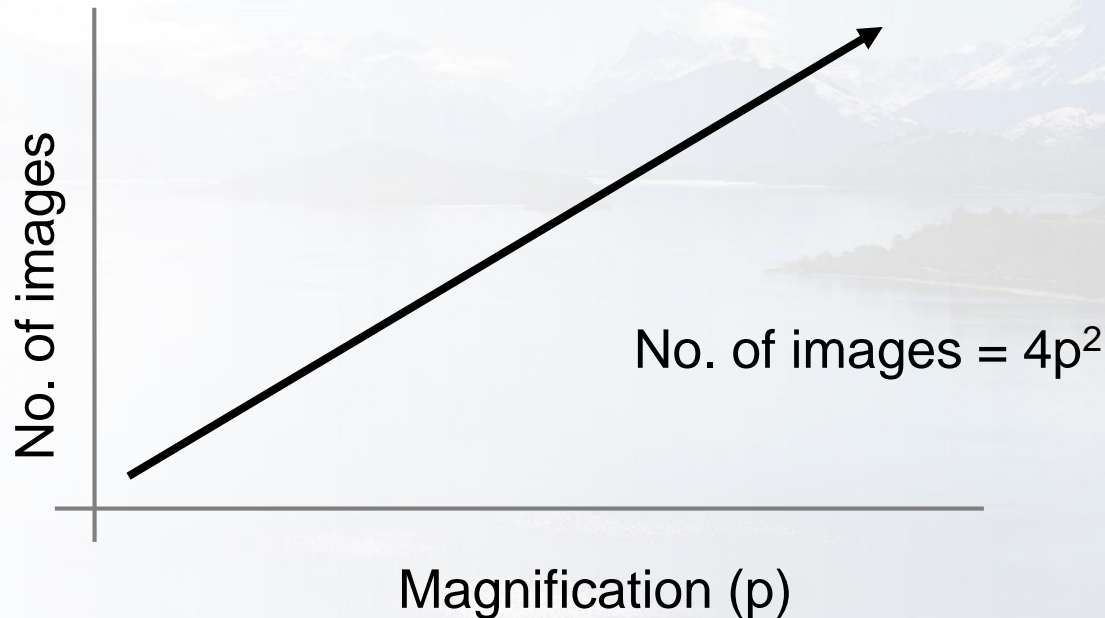
High-resolution composite − Original = +/- 5

## How Many Images Are Required?

The number of low-resolution images generally depends on the magnification factor required, the distribution of the sub-pixel shifts and the amount of noise present in the imagery.

No. of images = $4p^2$

No. of images (y-axis)

Magnification (p) (x-axis)

## Limitations
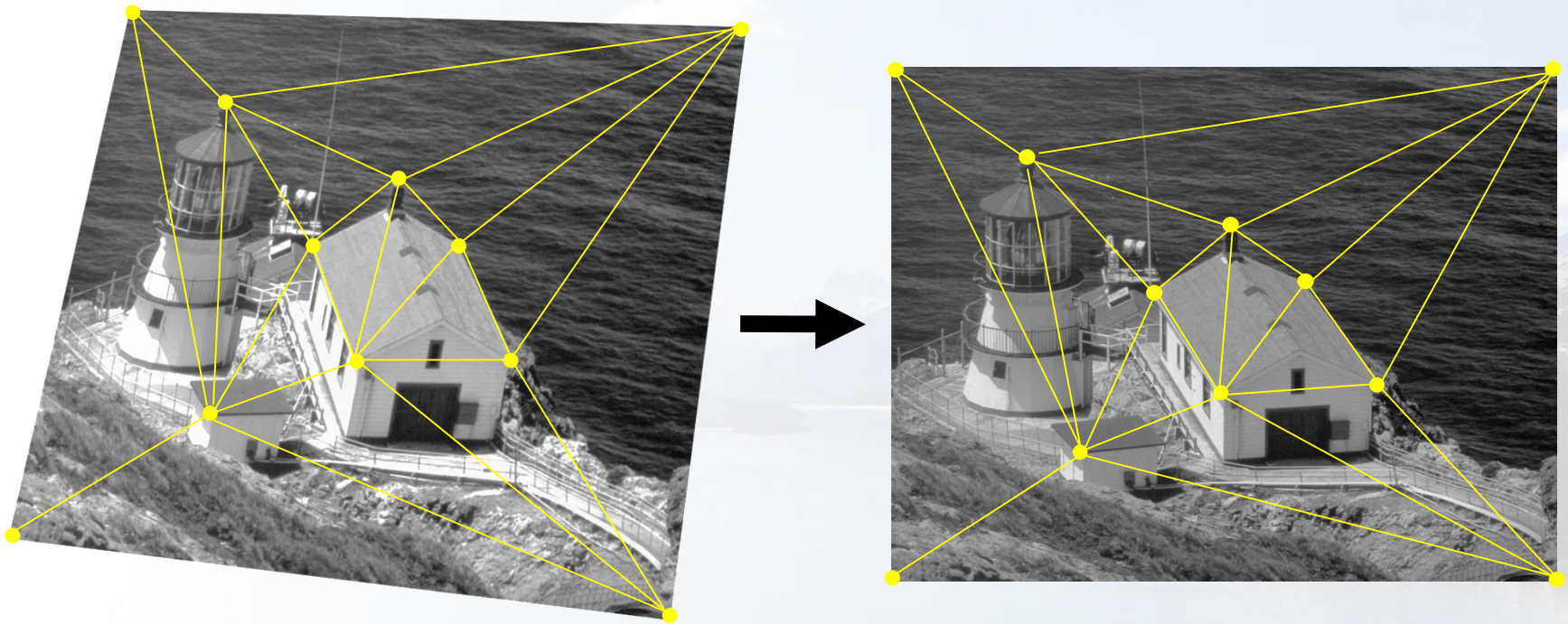


Rotations, distortions and scale differences may decrease the quality of the enhancement because the images must be brought into alignment first using warping/morphing techniques.

# Colour Images



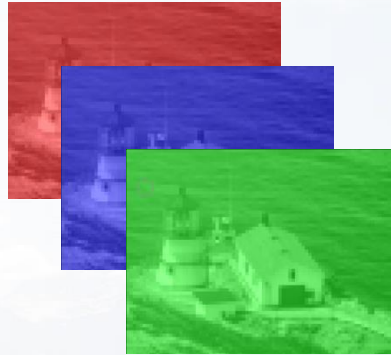Colour images are first split into their RGB (Red, Green and Blue components). Each component is enhanced separately and the results are then merged.

Low-resolution colour images

# Traffic Surveillance



The car of interest in the red box and its trajectory. (a) an enlarged low-resolution view of the vehicle as per original video footage and (b) the enhanced image of the car.
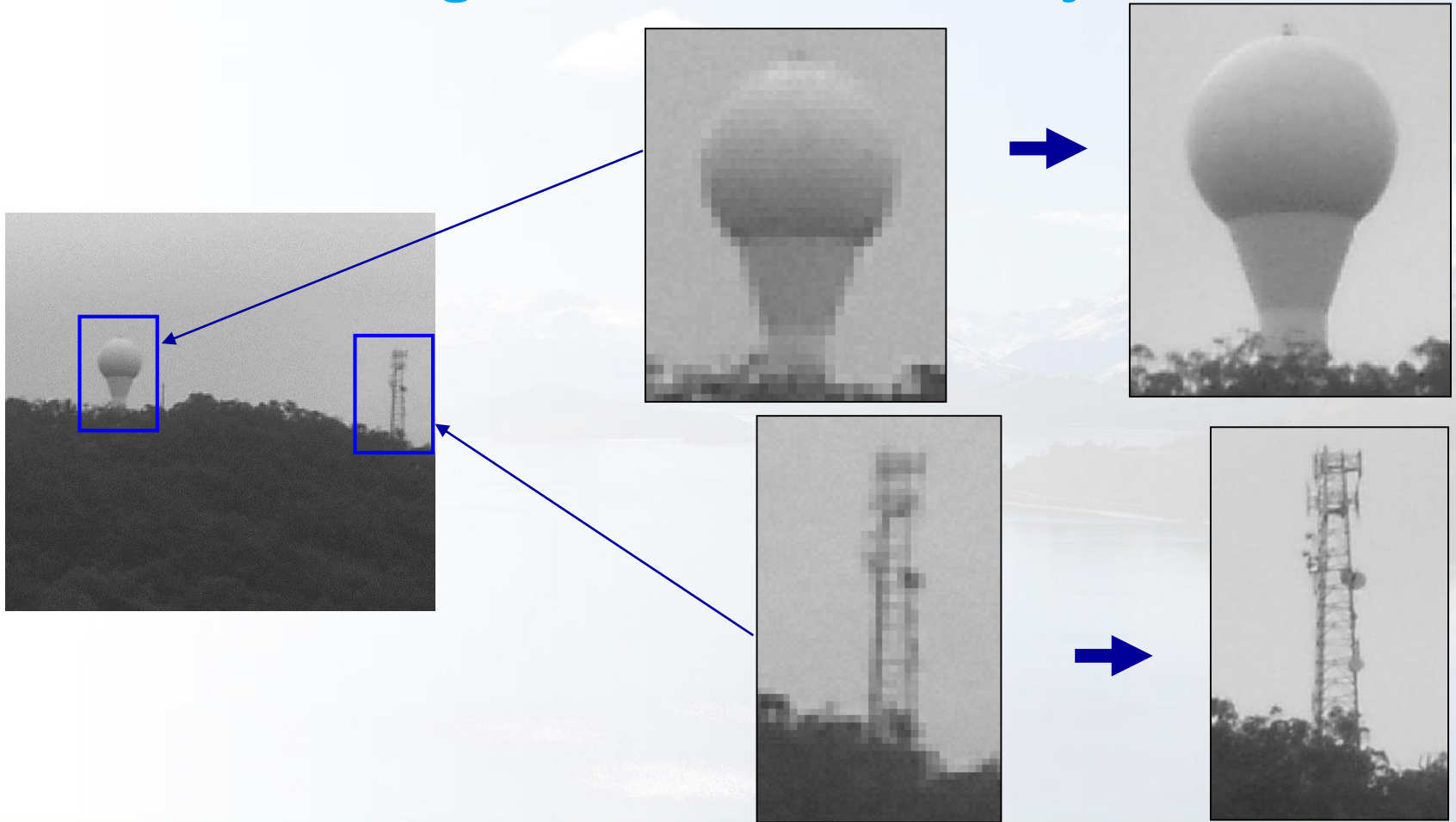
## Long Distance Static Object

# Forensics



A composite was made from a set of in-taxi images; this led to an admission by the suspect of being in the taxi, but the suspect was acquitted of the robbery charge.

Higher resolution composite

# Conclusions

Multi-Frame image enhancement processes are a highly effective way to improve the quality/ resolution of video and still images.

In principle, the quality of the images as enhanced by the proposed method depends on the amount of noise present in the low-resolution images, (b) the number of low-resolution input images and (c) the magnification factor required to meet resolution requirements and (d) atmospheric distortions.

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