Compressed Sensing as a tool for Video Analysis

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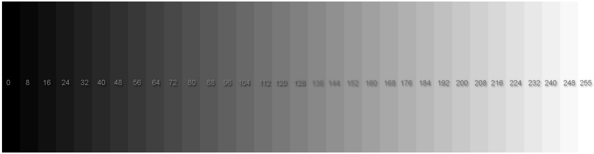
Topics of interest

- Detection and tracking of foreground in video
- Automatic detection of anomalous behaviour
- The sensing and compressing of signals

Analysing images mathmatically

- An image is a matrix of pixels, with each pixel being represented by a number.
- This number is the grayscale intensity or luminance.



$$X_t = \begin{pmatrix} 54 & 106 & 69 \\ 220 & 7 & 3 \\ 6 & 45 & 101 \end{pmatrix}$$

$$X_t = [54, 106, 69, 220, 7, 3, 6, 45, 101] \quad t = 1 : T$$

Example

Imagine you take a high quality picture and you wish to share this on the internet. If you used the full image uploading and viewing would take a long time.
JPEG2000 compresses the image and but still retains the essential features of your image.

(a) Original image

(b) JPEG2000 compression

Spasity and wavelet transformation

Achievable resolution is dependant on the information content of the image. If an image has low information content it is said to be sparse and can be perfectly recostructed from a small number of measurements. **Nearly all real world images exhibit this sparsity property when transformed using a wavelet basis.**

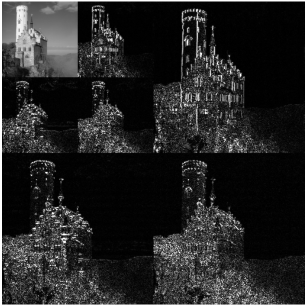


Figure: Wavelet transform

Sparsity and CS

Let a signal be represented by x, of length N and assume that the signal is K- sparse.

$$y = \phi x \tag{1}$$

Take a sample y of size M of the signal according to some measurement matrix ϕ. ($M << N$.) We can use this y to transmit the signal (e.g over the internet) or use it to perform video analysis such as determining if the pixel belongs to the foreground of a video.
How do we get back to x?

Reconstruction

Linear algebra tells us that equation 2 is an underdetermined system and that there is exists no unique solution. But, if we know that x is K-sparse we can reconstuct the signal well.

$$y = \phi x \tag{2}$$

Possible methods include l_1 minimization and basis pursuit.
What effects do different reconstruction algorithms have on the computation time and final quality of the reconstruction?

Figure: Astrophotography

Figure: MRI

Figure: Analysing CCTV footage