

1 An image I has been stretched vertically by a factor of two.

- How does the stretching affect its frequency content in the vertical and horizontal directions?
- We are given a version of the same image, I' , that was smoothed with a 3×3 box filter before stretching. We want to apply a filter to I to obtain the same image as in I' . What filter would do the task?

2 A shifted impulse filter shifts a signal without modifying it otherwise.

- What property of the filtered signal is affected?
- How would you construct a single filter that introduces an echo delayed 5 units, with half the amplitude of the original signal? In other words, the output should be the original signal plus its half-amplitude, 5 unit delayed echo.
- How would you modify the previous filter to produce an echo only of the high frequency components of the signal?

3 Why is it said that a Gaussian filter is a better low-pass filter than a box filter?

4 Causal systems

- A causal system is a system with output and internal states that depends only on the current and previous input values. A filter that reproduces its input plus a shifted copy of it (echo) can be causal or not depending on that shift. Can you explain under what circumstances is it causal?
- Is the echo of your voice in a cavern the result of a causal or a non-causal filter?

5 Doppler radar

- A Doppler radar emits a signal and receives it back after it bounces on a moving target. Then, comparing the two signals, the speed of the target is estimated. What property in the received signal should be measured to estimate the speed with which the target moves with respect to the radar?
- Can you briefly outline a design of such system?
- What signal processing operation is fundamental in this system? What is it used for?
- Can you describe under what circumstances the accuracy of this radar would diminish?