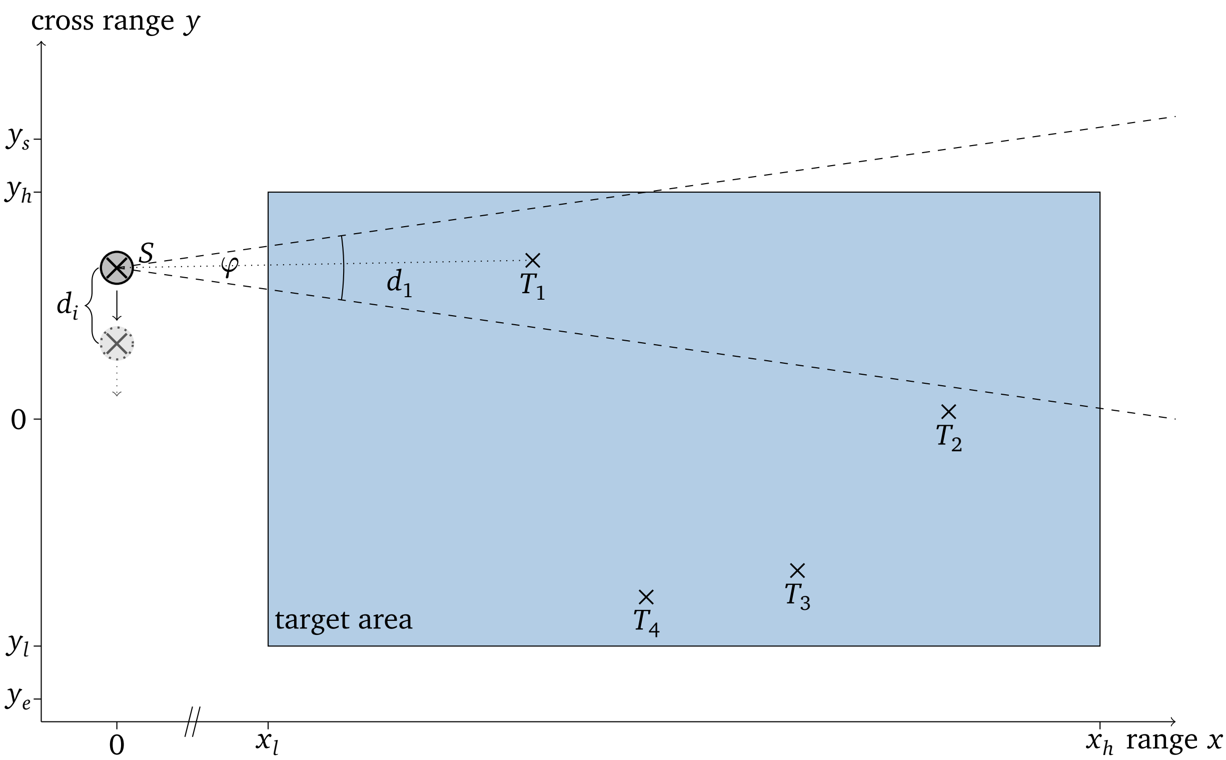
Advanced Digital Signal Processing: Imaging and Image Processing

TECHNISCHE UNIVERSITÄT DARMSTADT

Exercise 3: Image Formation **Due date: 15.06.2015**

Problem 1 – Generating the scene

Based on problem 2 in exercise 2, a simulator for sonar imaging is implemented in this task. The positions of the targets are denoted by T_n with $1 \le n \le N$ and the position of the sensor by S. The sensor is monostatic, i.e. it is transmitting and receiving at the same position. The beam width of the sensor is given by φ.



a) The sensor is moving along-track in negative y-direction (slow time axis). Where does it have to start (y_s) and end (y_e) given the beam width φ to cover the complete target area $(x_l, y_l), (x_h, y_h)$?

Now look at the MATLAB script **problem01.m** and complete the missing parts as follows:

b) Given the inter-element spacing d_i and the start and end point y_s, y_e, respectively, compute how many measurements (pings) N_p are performed. Suppose that one measurement is taken after each distance d_i.

c) Define a vector **sensor.u** ranging from y_s to y_e with a spacing of d_i. Check the number of elements which should be equal to N_p.

d) For each target and sensor position, compute the difference d_x and d_y between the x coordinates and the y coordinates (similar to the range detection in Exercise 2). Use this information to compute the distance and time delay.

e) Next, compute the reflected signal

$$ee_l(t) = \sum_{n=1}^{N} \frac{1}{d_{l,n}} r_t p(t - t_{l,d,n}).$$

of all N targets where l denotes the l-th ping. The target reflectivity $r_t = 0.1$ is constant for all targets.

f) In order to simulate a noisy environment, add some Gaussian zero-mean noise to the real and imaginary part of the signals with variances σ_r^2 and σ_i^2 so that the SNR is 3dB. The power of the noise P_N and all signals P_S (derived from the root-mean-square (RMS) amplitude) is given by

$$P_N = \sigma_r^2 + \sigma_i^2 \qquad P_S = \frac{1}{T} \sum_{t=0}^{T} \frac{1}{N_p} \sum_{l=1}^{N_p} |ee_l(t)|^2$$

where T denotes the duration of the signal $ee_l(t)$. For convenience, assume $\sigma_r^2 = \sigma_i^2$.

g) Next, compute the demodulated signal $ee_{l,b}(t)$ and perform pulse compression in the base band to obtain $ss_{l,b}(t)$.

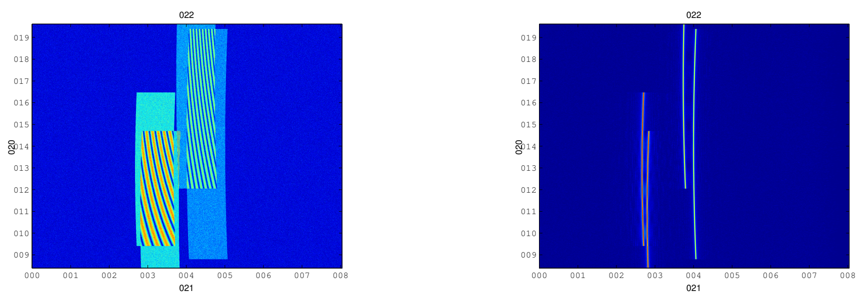


Figure 1: Reflected signal before (left) and after pulse compression (right).