Project 1: Time-Delay estimation in GNSS

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1 Idea and Motivation

Global Navigation Satellite Systems (GNSS), such as GPS or Galileo are used for different applications such as positioning or tracking of objects or time synchronization of networks. These services have in common that they use an estimate of the propagation delay τ of the signal received from the satellites. From this delay they can calculate their distance to the transmit satellite. Using the distance to at least four satellites and the position of the satellites, the position of an object can be determined by triangulation.
Let us assume a discrete-time received signal with sampling rate f_s and N samples

$$\boldsymbol{y} = \gamma \boldsymbol{c}(\tau) + \boldsymbol{n} \tag{1}$$

where γ is the signal attenuation, $\boldsymbol{c} \in \mathbb{R}^N$ is the signal transmitted by the satellite and $\boldsymbol{n}$ is assumed to be white Gaussian noise. For this signal the optimum estimate for τ in the maximum-likelihood (ML) sence is given by

$$\hat{\tau}_{\text{ML}} = \arg\max_{\tau} \left| \boldsymbol{y}^T \boldsymbol{c}(\tau) \right|, \tag{2}$$

i.e. the maximum of a correlation of the received signal $\boldsymbol{y}$ with the transmit signal $\boldsymbol{c}$ which is known at the receiver.

2 Task: Determining the propagation delay of a received signal

We have provided a matlab function *gnss_signal* which generates the transmit-signal $\boldsymbol{c}(\tau)$ and the corresponding sampling points for a given delay τ. Further there is a *proj_1_sample.mat*-file which provides a vector $\boldsymbol{y} \in \mathbb{N}$ with a noisy received signal $\boldsymbol{y}$. It is your task to develop a code which realizes (2) and allows you to determine the time-delay τ of the signal. We have provided a template file *Proj_1_template.mat*.
You are supposed to write a short report (1-2 pages) in which you explain your proceeding.

2.1 Hints

- Calculate the approximate delay as a multiple of the sampling rate $f_s = 1.023\text{MHz}$.
- Negative delays are not possible
- Use your knowledge on how to efficiently express correlation