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Signal Processing

Winter semester 2018/2019

Lab 3 – Sampling Theorem

Analyzing sampling effect on a rotating stage

Consider the set-up displayed in the Figure below consisting of a camera and a rotation stage. The rotation stage is built from a gear-box, a step-motor and a control unit, which drives the step-motor.

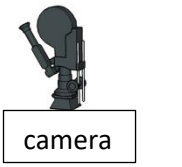
The control unit drives the motor constantly at 3500 steps per second. A full step of the motor results in a rotation of 1.8° of the motor axis. The gear box transforms this rotation at a ratio of 1:52. This means 52 full rotations of the motor result in one full rotation of the stage.

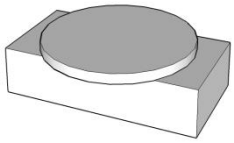
On the rotation stage there is a grating pattern consisting of 32 black bars (Siemens Star). The camera observes the stage from a top view. The frame rate of the camera can be chosen from 0 to 30 Hz. The frame rate can be considered the sampling rate of the continuous optical signal. Depending on the chosen sampling rate, optical artifacts will occur considering the direction of the rotation of the grating pattern.

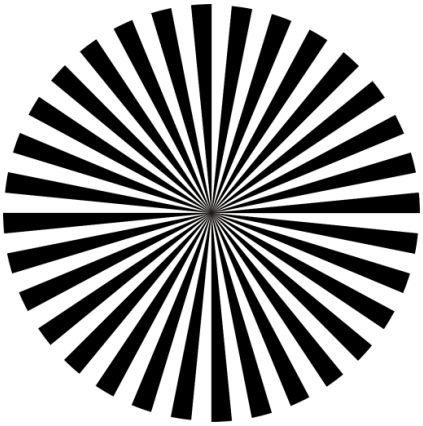
1. Compute three frequencies (see tasks a, b and c), which show the characteristic effects of the altered sampling. Describe the computation for each frequency and give the result in [Hz].

a) Compute the minimal sampling frequency (Nyquist Rate), which fulfills the sampling theorem. We expect no optical artifacts at this frequency.
b) Compute the maximum sampling frequency at which the stage seems to stand still.
c) Compute the sampling frequencies between 3 Hz and 5 Hz at which the stage seems to rotate backwards.

Hint:
First try to compute the number of revolutions of the stage per second. Then consider the symmetry of the pattern. This leads to the frequency of the optical signal. Then apply the sampling theorem.







Sampling theorem in real imagery

2. Select any kind of (digital) image, which contains much of (small, repetitive) information. Resize this image on your computer screen by just using *zoom-in, zoom-out* functions. Carefully look, if and when aliasing happens. Please discuss. Document via screen-shots.

3. *Optional:* Open any kind of image processing tool box (e.g. irfanview, PhotoShop) you normally use on your computer to manipulate your digital images. Have a careful look on their *image resize function*. Try to understand, what this function does, especially when images are reduced in size. Can you select different parameters, which influence the quality of your resized image? Please document different results of resizing and try to explain.

Deadline: Tuesday, 29th January 2019

Please, submit only one report per group. Submission in digital manner as .PDF document). Send report via mail to dominik.laupheimer@ifp.uni-stuttgart.de.
Please, comply with the following naming convention: SigProc-Lab3-SURNAME1-SURNAME2.pdf