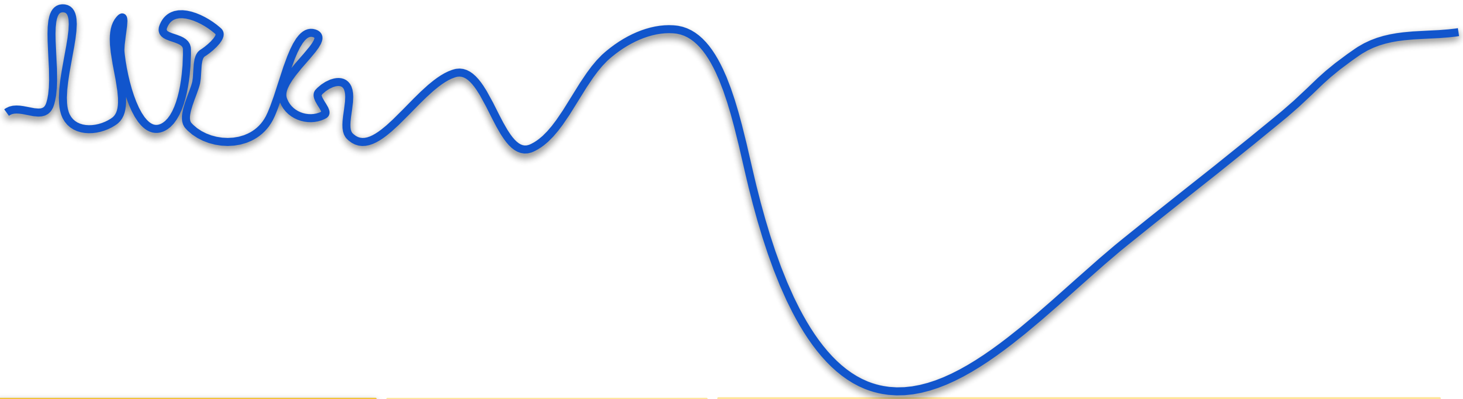
Computing with Signals



DA 623

Jan - May 2024

IIT Guwahati

Instructors: Neeraj Sharma

Lecture-11


Labels
US Weather
Saharanpur
New Delhi
Agra
Jaipur
Kanpur
Gwalior
Gorakhpur
NEPAL
Kathmandu
Xigaze
Lhasa
BHUTAN
Rangpur
Patna
Varanasi
Bhagalpur
Gaya
Kota
Rajshahi
BANGLADESH
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Jabalpur
Jamshedpur
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INDIA
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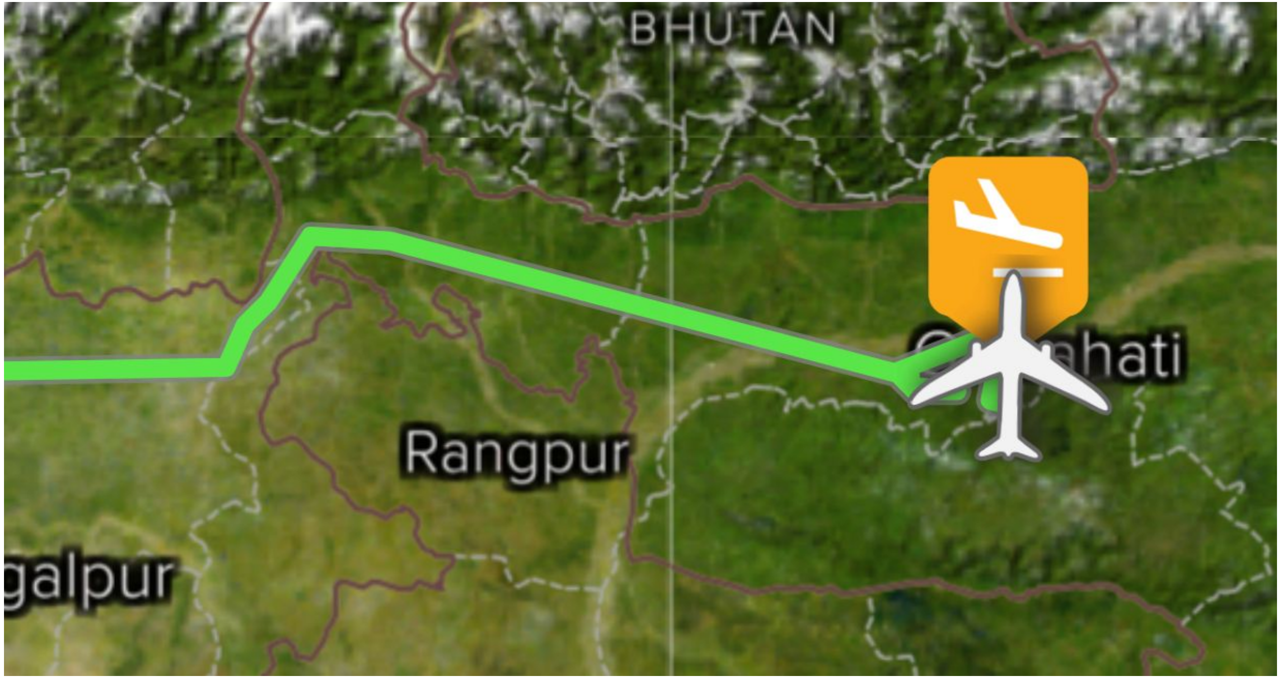
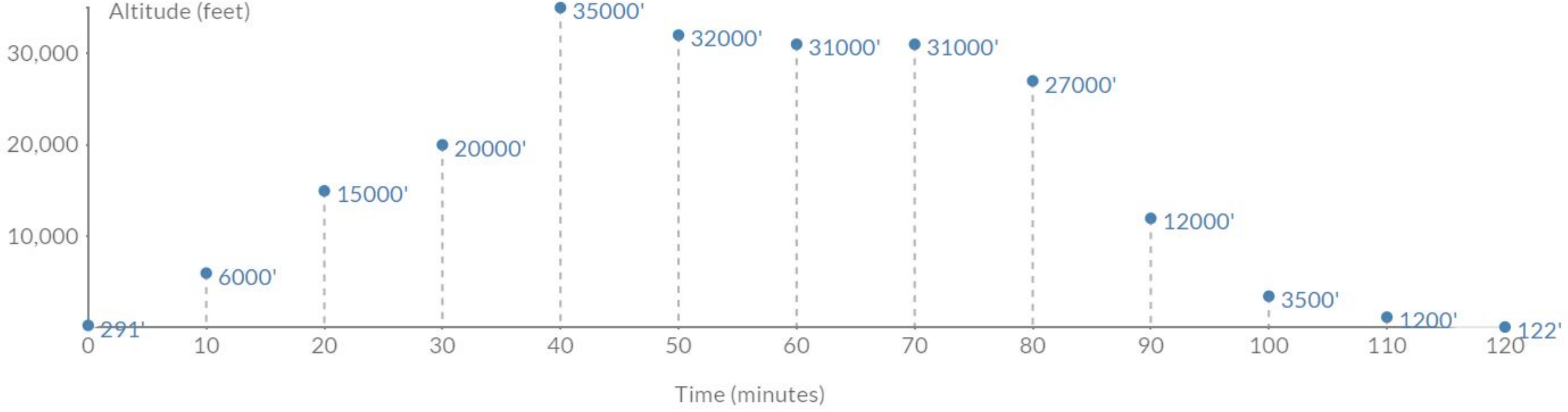

BHUTAN
Rangpur
galpur

A Sampling Story

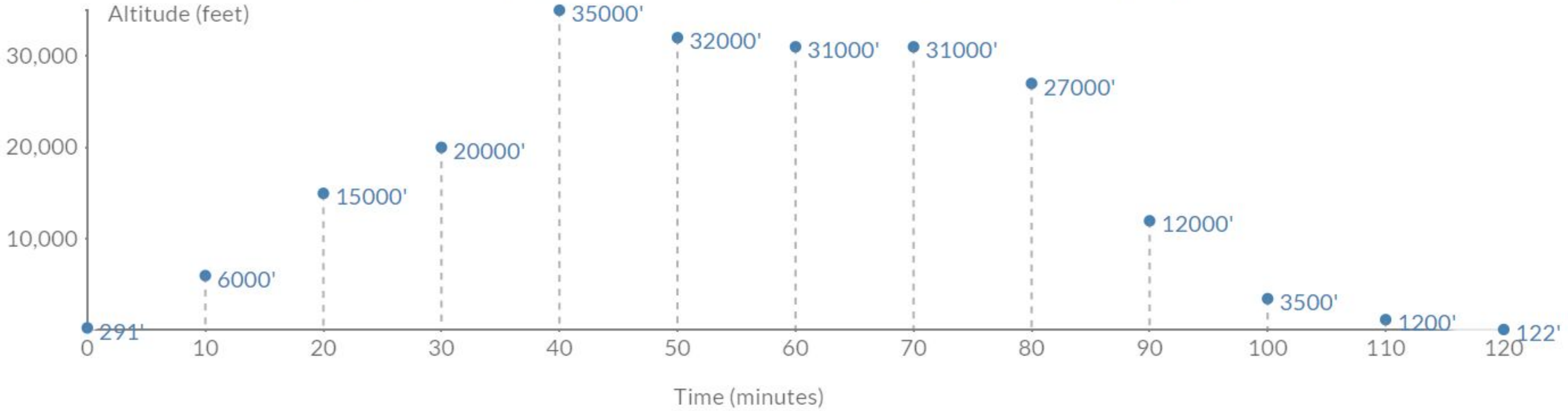
- When you measure the value of some quantity, you're sampling.
- Each one of your measurements is referred to as a sample.
- Discrete signals are simply lists of samples, and are usually generated by sampling real-world continuous signals.
- Example, let's think about the process of sampling the altitude of a plane over the course of a two hour long flight.

Figure 1. Sampling the Altitude of a Plane During a Two Hour Long Flight



Source: https://jackschaedler.github.io/circles-sines-signals

Figure 1. Sampling the Altitude of a Plane During a Two Hour Long Flight



- altitude = [291, 6000, 15000, 20000, 35000, 32000, 31000, 31000, 27000, 12000, 3500, 1200, 122]
- For example, altitude[4] is 35,000 and altitude[8] is 27,000.
- Note that the indexes start from zero.
- The first sample is at index 0, the second sample is at index 1, the third at index 2, and so on.

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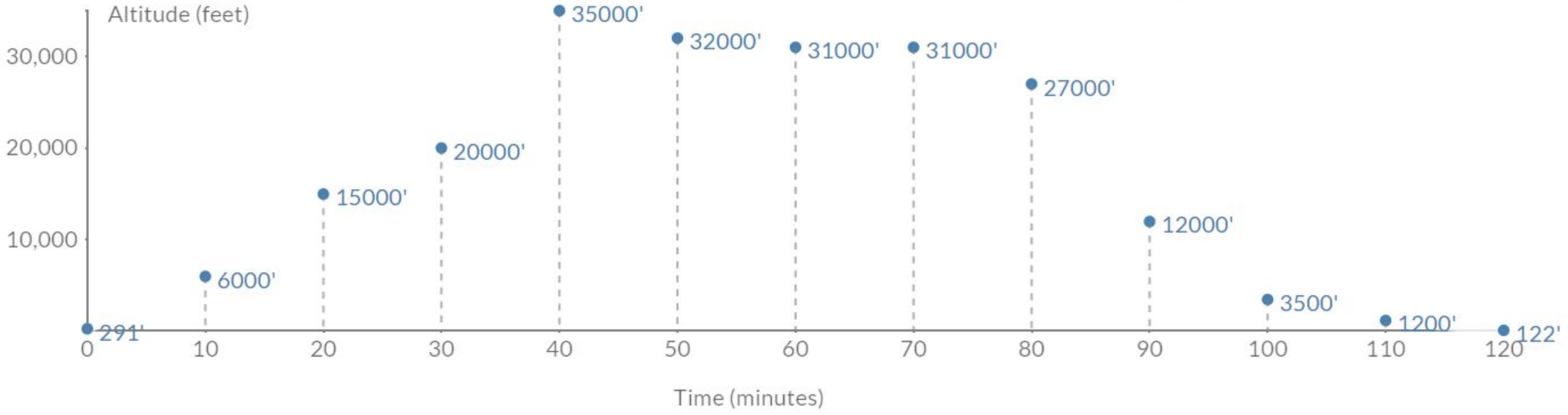

- If we want to know when a particular sample was taken, we need an extra bit of information known as the sampling period.
- The sampling period is the duration in-between consecutive samples.
- Our samples were created by measuring the plane's altitude every ten minutes.
- This means that our sampling period is 10 minutes.

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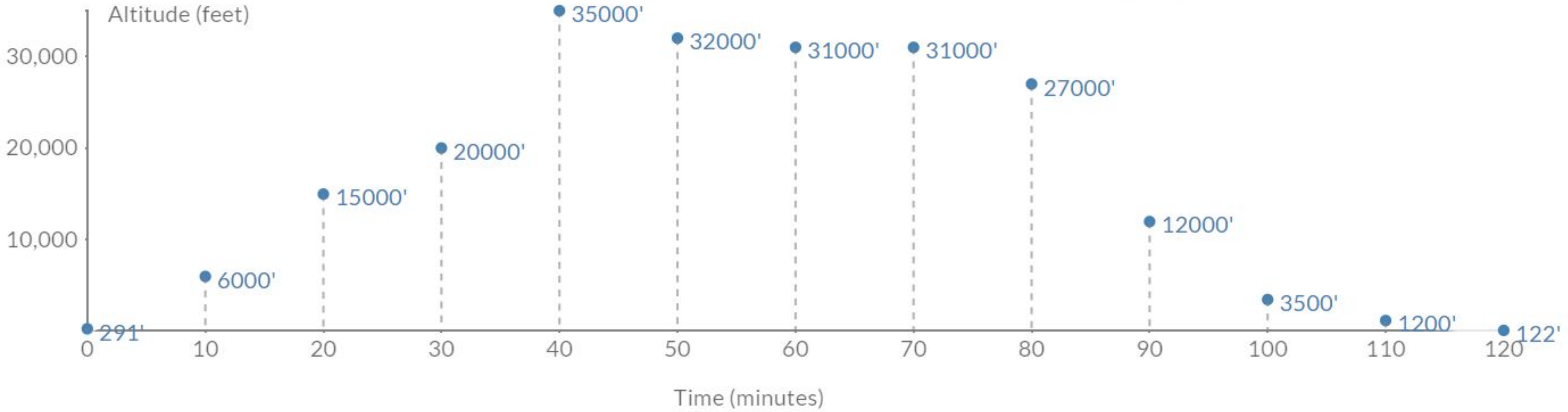

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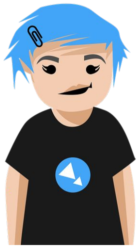
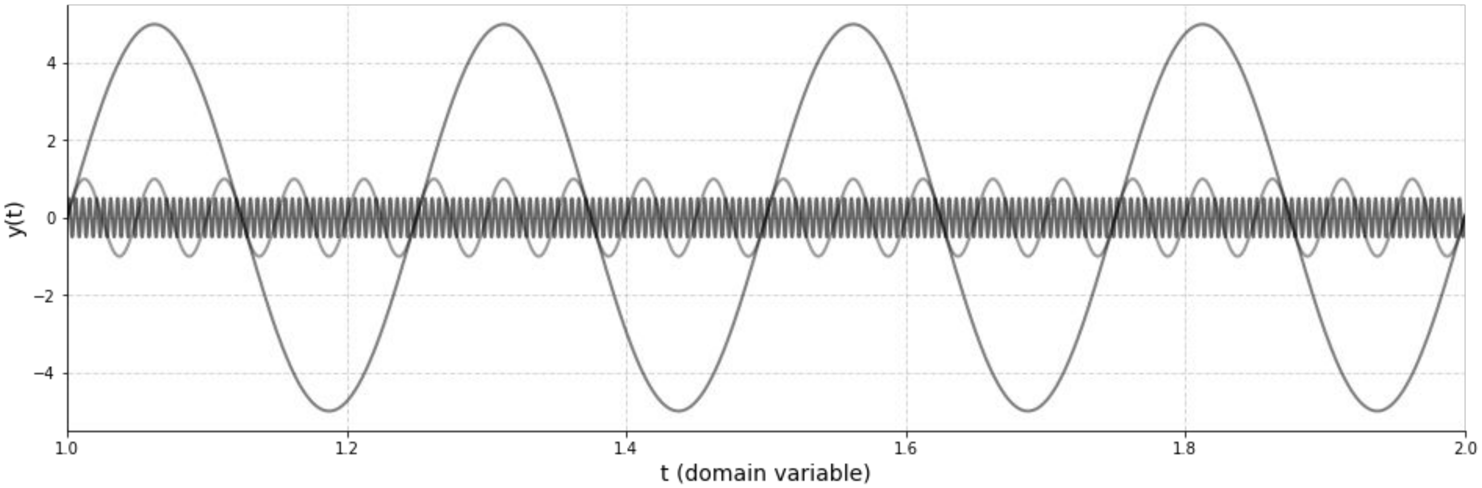
sampling period = 10 minutes / **1** sample

A Sampling Story

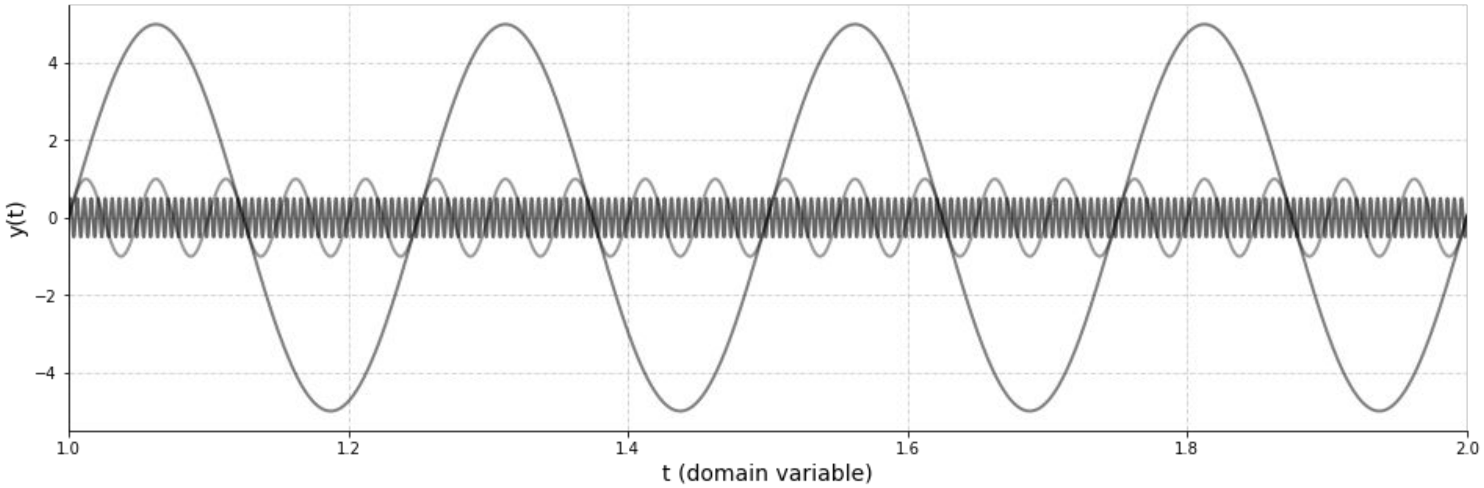


$y_1(t), y_2(t), y_3(t)$

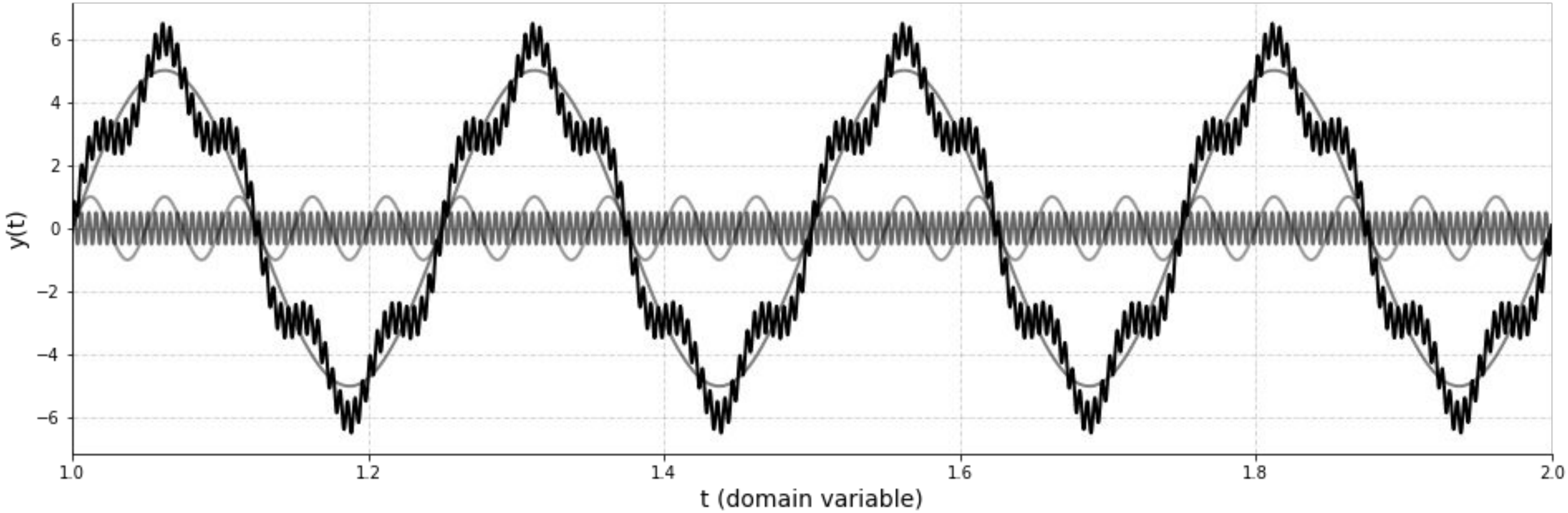


f_1= 4 Hz, f_2= 40 Hz, f_3=400 Hz

$y_1(t)$, $y_2(t)$, $y_3(t)$



$$y(t) = y_1(t) + y_2(t) + y_3(t)$$

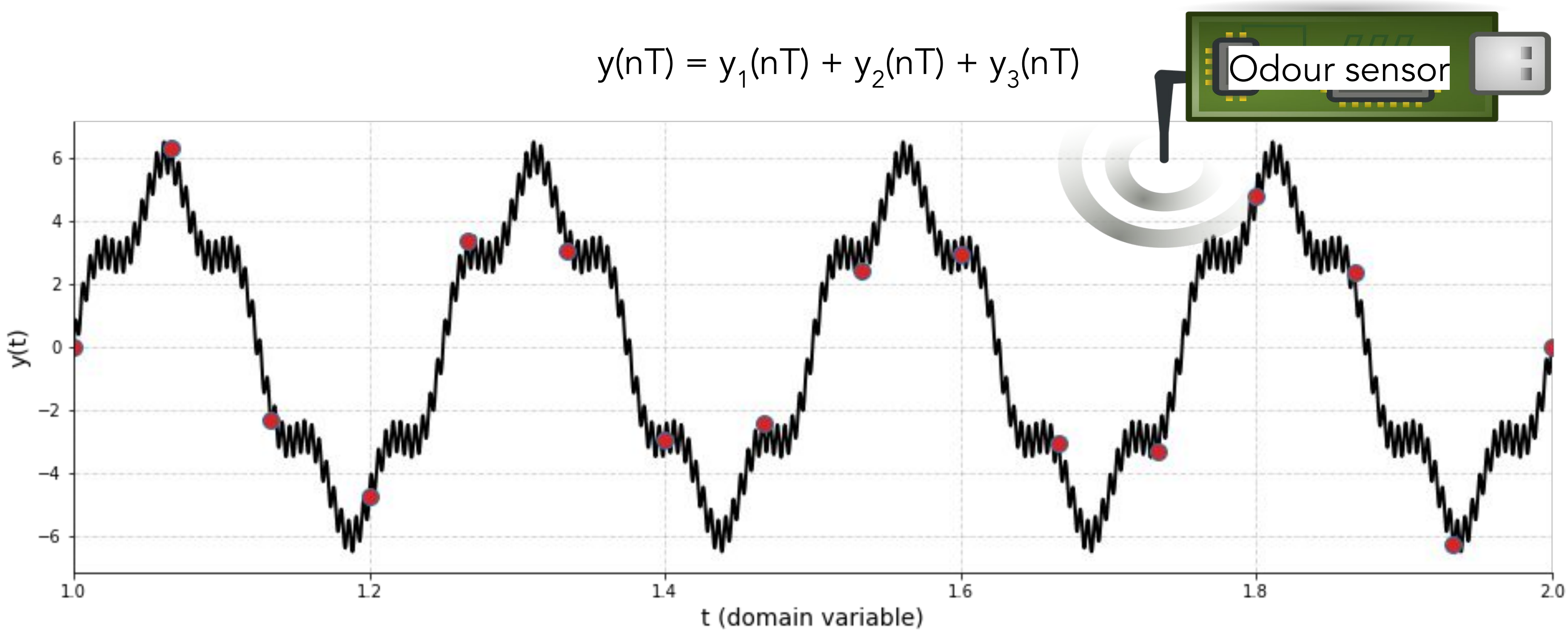



Odour sensor

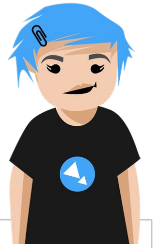
Assuming, T denotes the sampling period and n the sample index, we have:

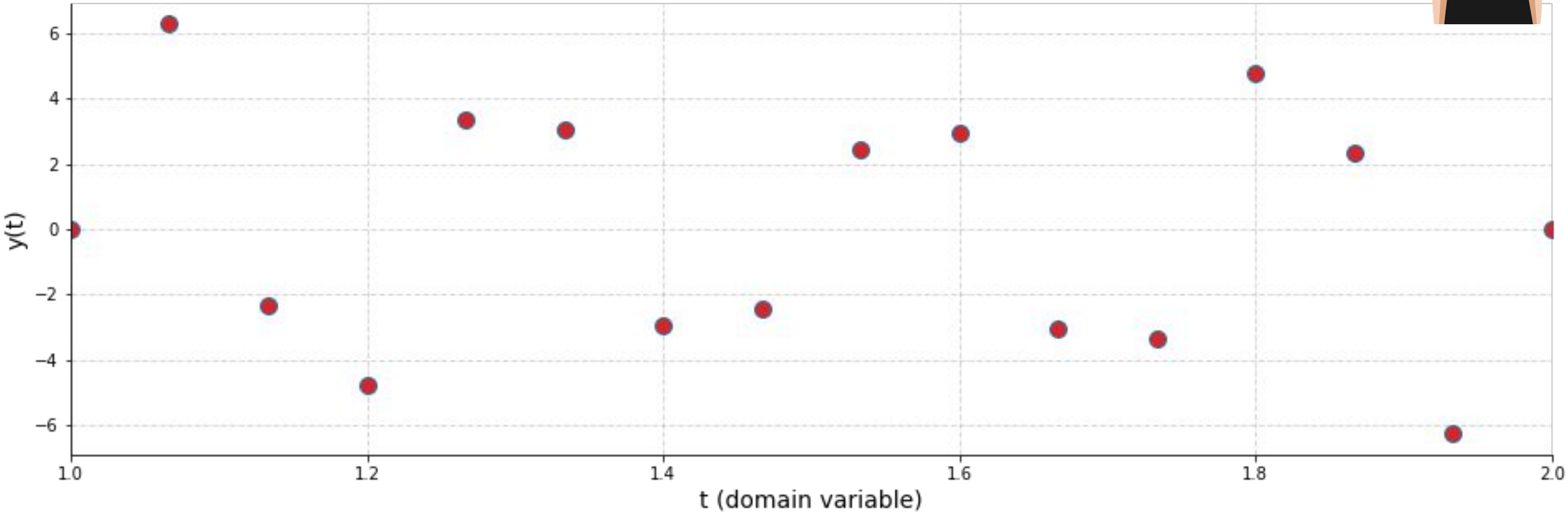
- Hardware parameter: f_s= 15 Hz, that makes, T = $1/f_s$

$$y(nT) = y_1(nT) + y_2(nT) + y_3(nT)$$



In hardware, data is stored as, $y(nT)$ where T is fixed by us in the hardware





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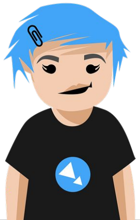
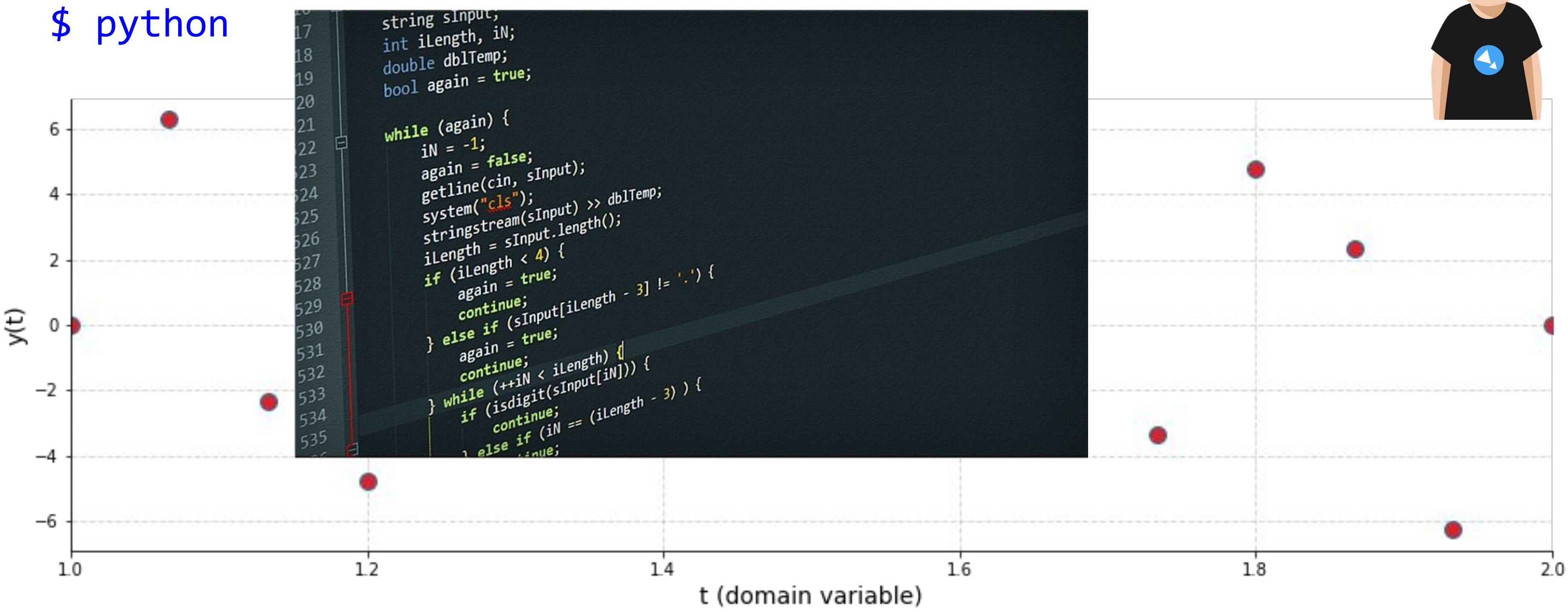


$ python

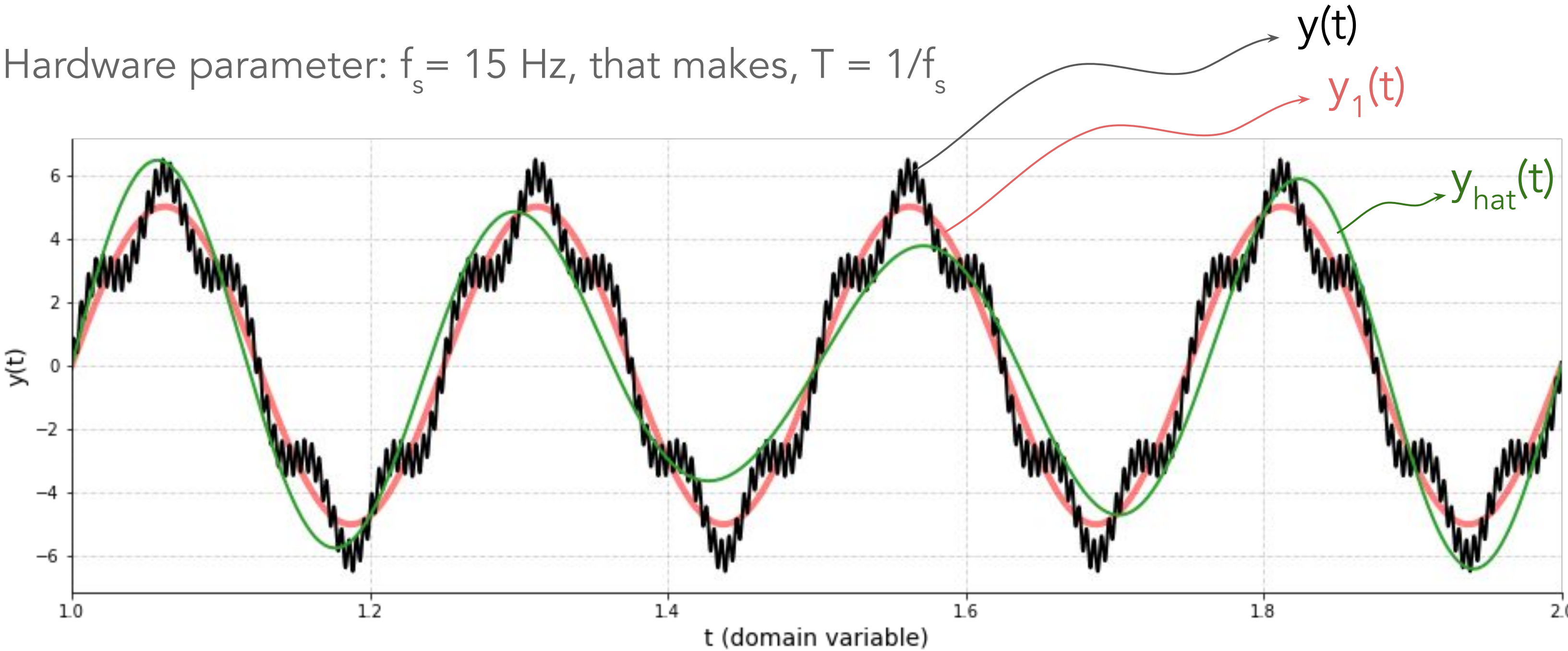


In hardware, data is stored as, $y(nT)$ where T is fixed by us in the hardware

$ python

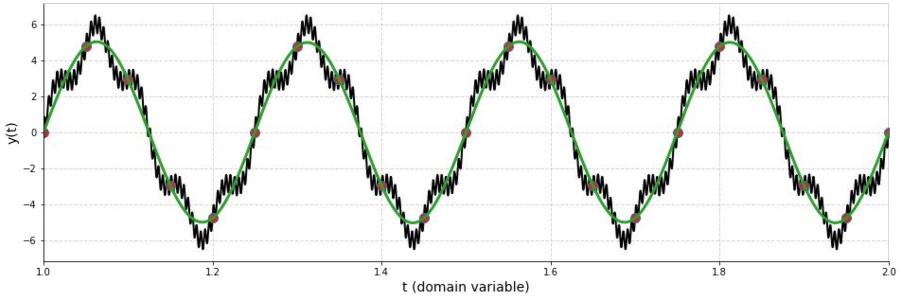
$y_{hat}(t)$ obtained from $y(nT)$ via sinc interpolation

Hardware parameter: $f_s = 15$ Hz, that makes, $T = 1/f_s$

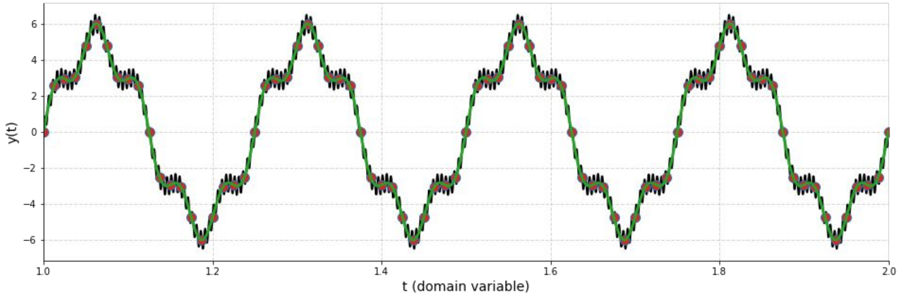


1. Applying Shannon Interpolation to $y[nT]$ results in constructing $y_{hat}(t)$?
2. Is $y_{hat}(t) == y(t)$?
3. If not, why?

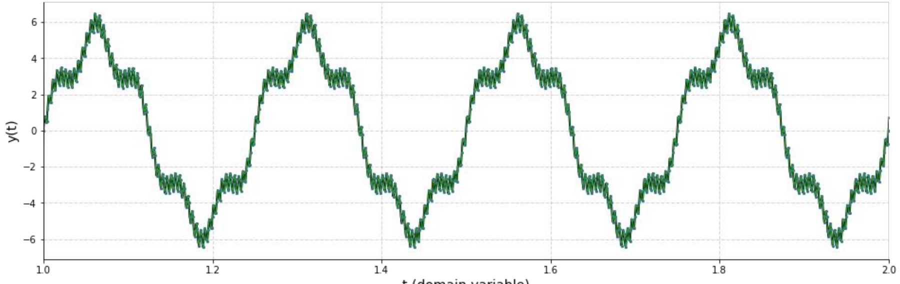
- $f_s = 20$ Hz



- $f_s = 80$ Hz



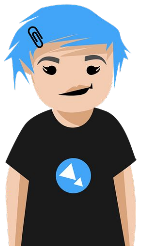
- $f_s = 1000$ Hz



For perfect reconstruction: obey Nyquist rate

$$f_s > 2\, f_{max}$$

A Sampling Story



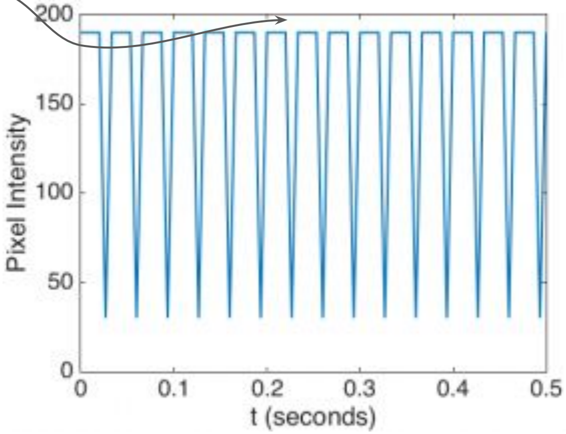
Moral of the story

- nature is continuous
- understand the domain knowledge
- note the choice of sampling rate
- then analyze the data - do DS/ML/AI

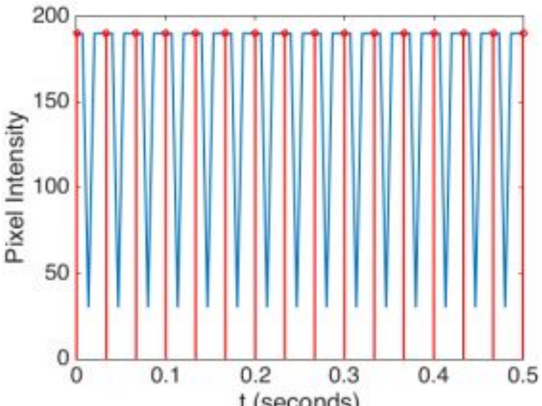
Sampling blunders

How is the helicopter flying without the rotor blades moving?

Note the value of intensity as a function of time on the camera pixel

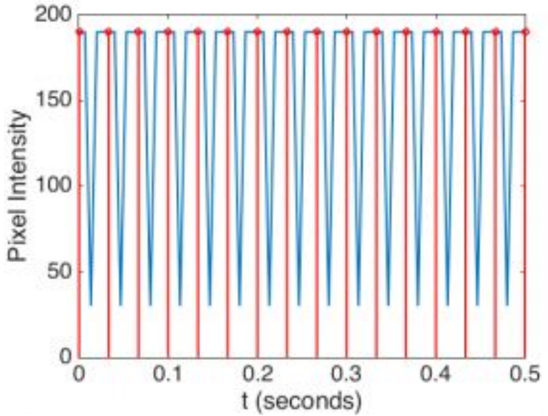


The period of this signal corresponds to the rotor speed.



Courtesy:
https://allsignalprocessing.com/2017/04/03/aliasing-movies-levitating-helicopters/

Note the value of intensity as a function of time on the camera pixel



- The period of this signal corresponds to the rotor speed.
- The camera samples this signal at a particular frame rate.

Sampling blunders

Note the different rotation speed of the spokes in the wheel vs Mercedes logo