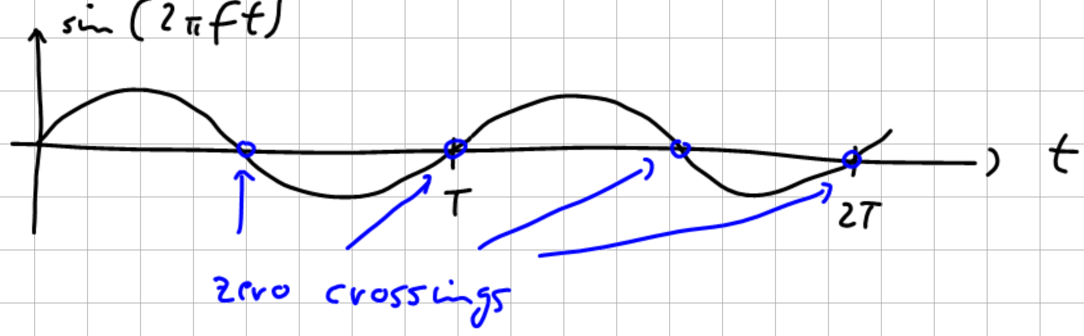
1)



Obviously one period T of a sinus has 2 zero crossings.

$\Rightarrow$ $f = 1234$ Hz $\Rightarrow$ zcr $= 2468$ per second

2) Each feature form one dimension of the so called „feature space":

The louder a signal, the higher the probability, that speech is active.

The lower the zero crossing rate, the higher the probability that speech is active.

o Assumed features for noisy frames

x Assumed features for speech frames

In the shown feature space, noise- and speech-frames can be separated by the dashed line.

The proposed linear separator can be described by two points marked with X:

$(L = -30 \text{ dB FS} \mid zcr = 0)$

$(L = -7 \text{ dB FS} \mid zcr = 1)$

From this the linear separator can be described by the following equation:

$$zcr = m \cdot L + n$$

$$m = \frac{1 - 0}{-7 - (-30)} = \frac{1}{23}$$

$$0 = \frac{1}{23} \cdot (-30) + n \Rightarrow n = \frac{30}{23}$$

$$\Rightarrow zcr = \frac{1}{23} \cdot L + \frac{30}{23}$$

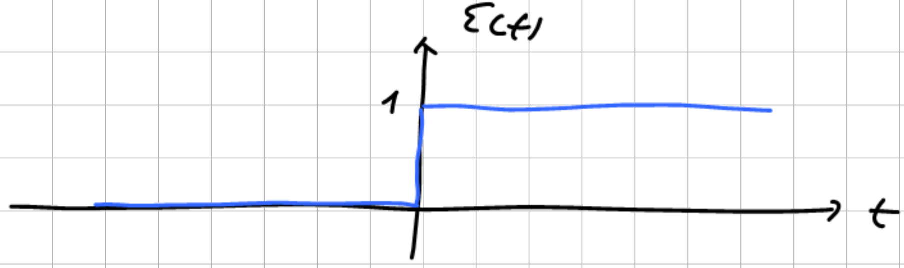
A noisy frame lies above this linear separator:

Is Noise : $zcr \geq \frac{1}{23} L + \frac{30}{23}$

A speech frame lies below this linear separator:

Is Speech : $zcr < \frac{1}{23} L + \frac{30}{23}$

3)



linearity: $\varepsilon(a x_1 + b x_2) = a \cdot \varepsilon(x_1) + b \cdot \varepsilon(x_2)$

In order to prove non-linearity, one counter example for the above given equation is sufficient:

$a = 1 \qquad x_1 = 2$
$b = -1 \qquad x_2 = 1$

$$\varepsilon(1 \cdot 2 + (-1) \cdot 1) = 1 \cdot \varepsilon(2) - 1 \cdot \varepsilon(1)$$

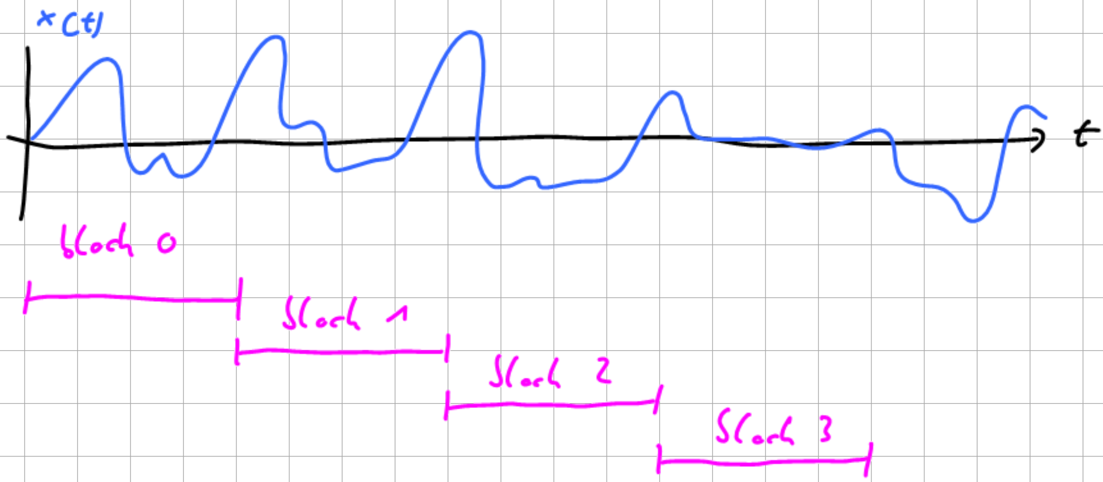
$$\varepsilon(1) = 1 - 1$$

$$1 = 0 \qquad \lightning$$

non-linearity is proven!

4) numpy.arange (5) $\hat{=}$ [0 1 2 3 4]

Assuming a signal x(t) and blocks of a given length in milliseconds:



The features are assumed to be valid for the whole block.

In order to align the signal x(n) and the features properly, the feature is assumed to be located in the middle of the block.

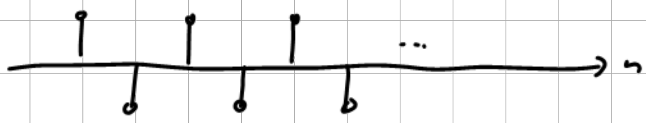
The middle of the block n is:

$$(n + 0{,}5) \cdot T$$ with T corresponding to the blocksize in seconds.

5) smallest possible ZCR: no zero crossings in the observed block:

$\underline{\underline{ZCR = 0}}$

highest possible ZCR: each sample changes the sign:



$\Rightarrow \quad \underline{\underline{ZCR = 1}}$