

Course material

Course:

Digital Signal Processing II

Video:

2.1.3.a Filter classification in the time domain

Concepts (extracted from automatically generated subtitles):

Shape of their impulse response. Finite impulse response filters. Typical example of an fir filter. Causal filters. Typical case. Non-causal filters. Moving average filter. Infinite impulse response. Notable exception. Impulse response. Filter. IIR filters. Convolution sum. Batch processing. FIR filters.



[to video sequence search](#)
(within Digital Signal Processing II.)



[to video](#)

Center for Digital Education. More educational support material here:

<https://exoset.epfl.ch/booc/>

Filter types according to impulse response

- ▶ Finite Impulse Response (FIR)
- ▶ Infinite Impulse Response (IIR)
- ▶ causal
- ▶ noncausal

According to the shape of their impulse response, we can already label a filter as belonging to one of the following categories. You have finite impulse response filters, or FIRs for short, infinite impulse response, or IIR, causal filters, and non-causal filters.

notes

summary

0m 0s



FIR

- ▶ impulse response has finite support
- ▶ only a finite number of samples are involved in the computation of each output sample

FIR filters have an impulse response with a finite support. Because of that, and because of how the convolution sum is computed, only a finite number of samples are involved in the computation of each output sample.

notes

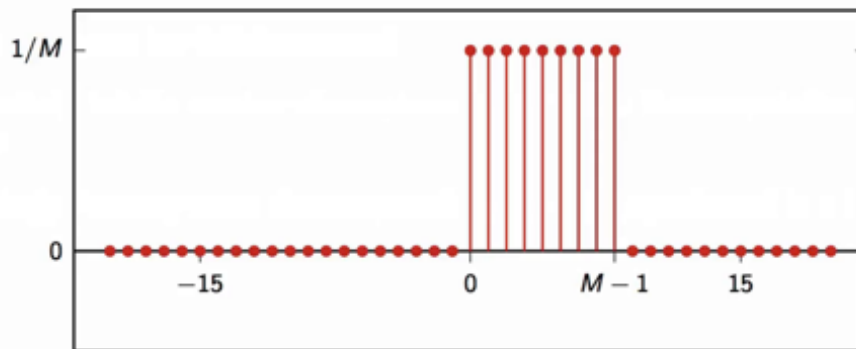
summary

0m 13s



FIR (example)

Moving Average filter



A typical example of an FIR filter is the moving average filter that we've seen before, where only capital M samples are non-zero.

notes

summary

0m 33s



IIR

- ▶ impulse response has infinite support
- ▶ a potentially infinite number of samples are involved in the computation of each output sample
- ▶ surprisingly, in many cases the computation can still be performed in a finite amount of steps

IIR filters, on the other hand, have an infinite support for their impulse response. So potentially, an infinite number of samples are involved in the computation of each output sample. However, perhaps surprisingly, in many cases we can still compute each output sample in a finite amount of time. One notable exception is the class of ideal filters, which we will study shortly.

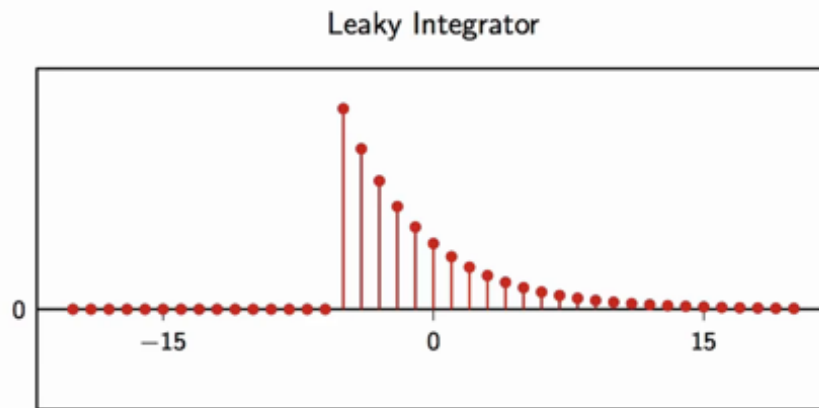
notes

summary

0m 37s



IIR (example)



For instance, the Leaky integrator has an infinite support impulse response, but due to its algorithmic nature, we can compute each output sample with only three operations.

notes

summary

1m 1s



Causal vs Noncausal

► causal:

- impulse response is zero for $n < 0$
- only past samples (with respect to the present) are involved in the computation of each output sample
- causal filters can work "on line" since they only need the past

► noncausal:

- impulse response is nonzero for some (or all) $n < 0$
- can still be implemented in a offline fashion (when all input data is available on storage, e.g. in Image Processing)

A filter is said to be causal if its impulse response is zero for n less than zero. Now if you remember how the convolution sum is computed, the convolution involves a time reversal of the impulse response before multiplication with the input, that means that only past values of the input are involved in the computation of the output.

notes

summary

1m 15s



Causal vs Noncausal

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► noncausal:

- impulse response is nonzero for some (or all) $n < 0$
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So for instance, if your impulse response is like this and this is zero, when you compute the convolution sum, you time-reverse it, and so you will only affect values in the past.

notes

summary

1m 37s



Causal vs Noncausal

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► noncausal:

- impulse response is nonzero for some (or all) $n < 0$
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Causal filter, because of their dependency only on the past, can work online, they can work in real time.

notes

summary

1m 48s



Causal vs Noncausal

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► noncausal:

- impulse response is nonzero for some (or all) $n < 0$
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A non-causal filter, on the other hand, is a filter whose impulse response is non-zero for at least some negative values of the index. In other words, non-causal filters will need samples from the future in order to be able to compute their current output value. As such, they can of course not work in real time, but there are applications in which the future is indeed available to a processing system, in particular when you do what is called batch processing, namely processing for which all the data is available in advance.

notes

summary

1m 49s



Causal vs Noncausal

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► noncausal:

- impulse response is nonzero for some (or all) $n < 0$
- can still be implemented in a offline fashion (when all input data is available on storage, e.g. in Image Processing)

'batch'

A typical case in point is image processing, in which the whole picture is available for processing before you start.

notes

summary

2m 25s



Causal vs Noncausal

► causal:

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- causal filters can work "on line" since they only need the past



► noncausal:

- impulse response is nonzero for some (or all) $n < 0$
- can still be implemented in a offline fashion (when all input data is available on storage, e.g. in Image Processing)

'batch'

The moving average filter is again a causal filter. We have developed it in a causal fashion, and indeed its impulse response is non-zero, only for positive or null values of the index.

notes

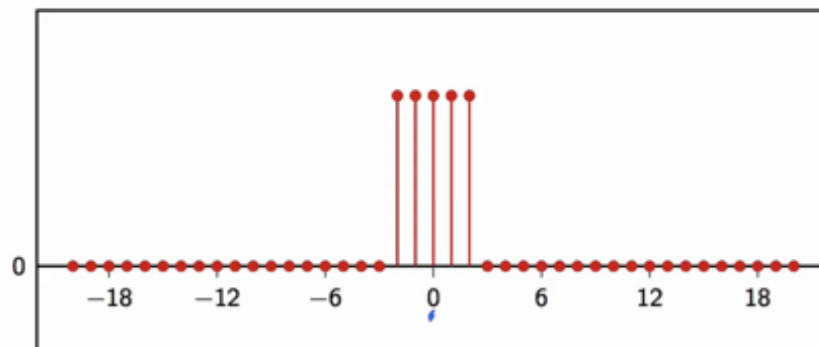
summary

2m 30s



Noncausal example

Zero-centered Moving Average filter



We could develop a non-causal moving average if we center the impulse response in zero. And indeed, if we do so, we would eliminate the delay that you've seen when computing longer and longer averages, because we would compensate the delay by looking at future samples. We could apply this to a set of data that we've already stored in computer memory, for instance.

notes

summary

2m 37s

