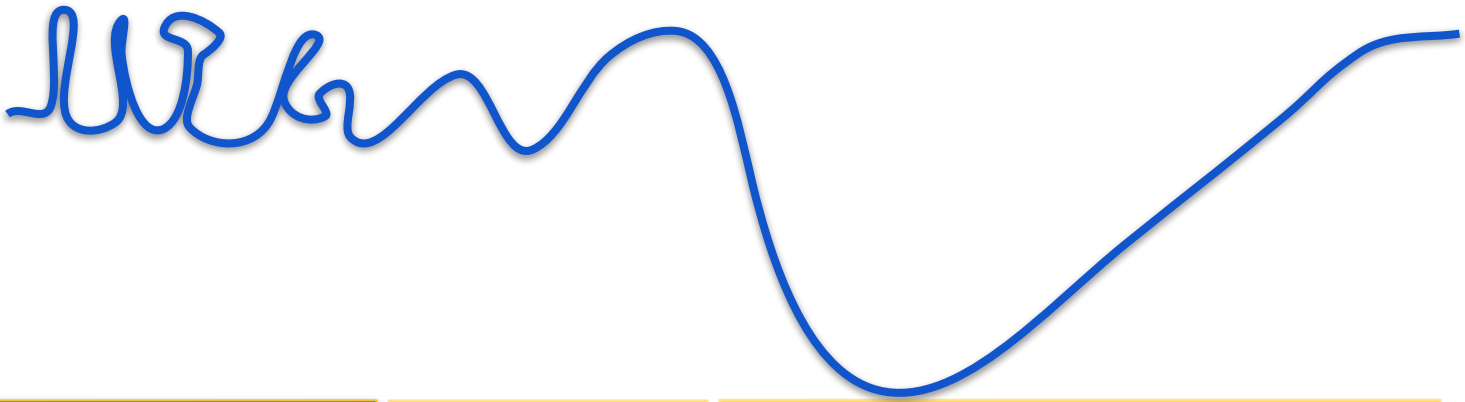
Computing with Signals



DA 623

Jan - May 2023

IIT Guwahati

Instructors: Neeraj Sharma

Lecture-11-[01-Feb]

Signal

or

function

$f(t)$

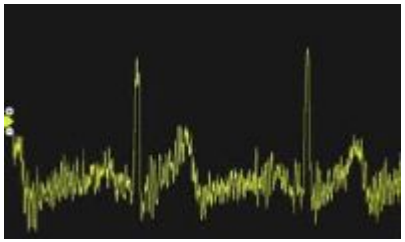
Signals are all around us!

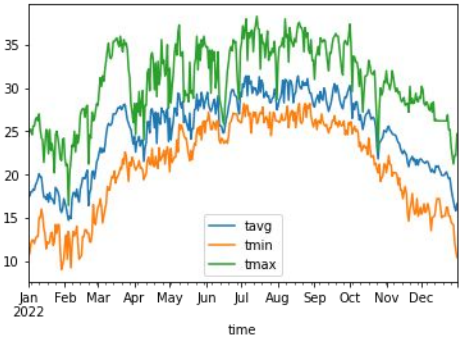
Signal

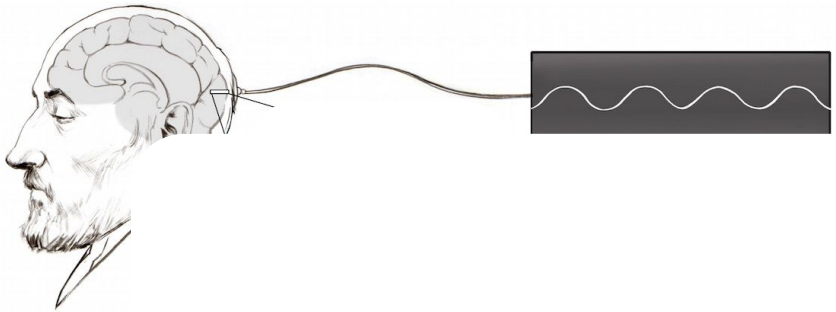
or

function

$f(t)$







“An experiment is a question which science poses to nature,

a measurement is the recording of nature’s answer.”

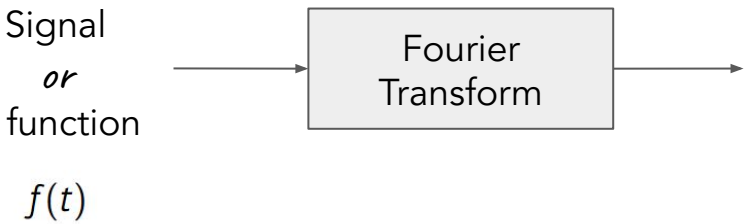
Max Planck
(German Theoretical Physicist)

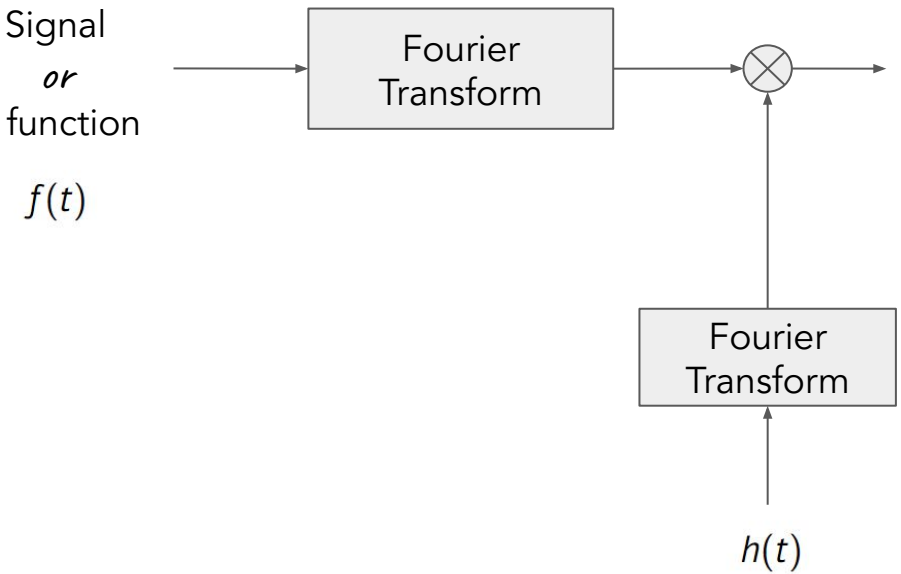
Signal

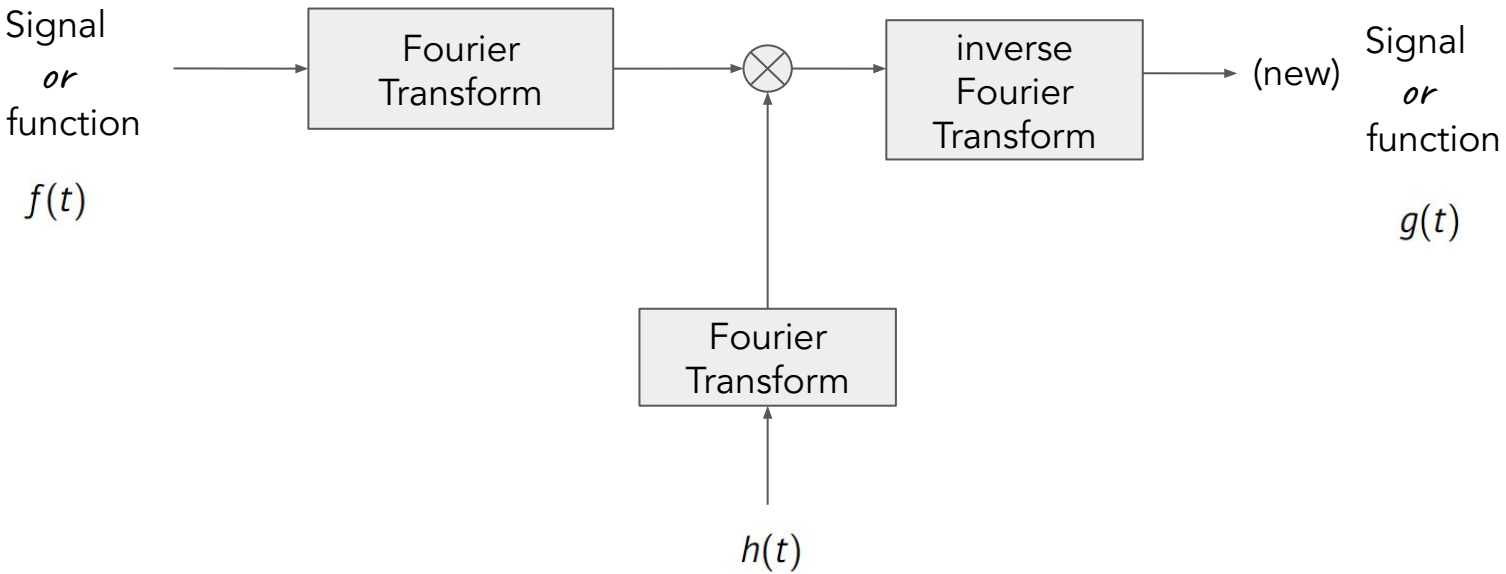
or

function

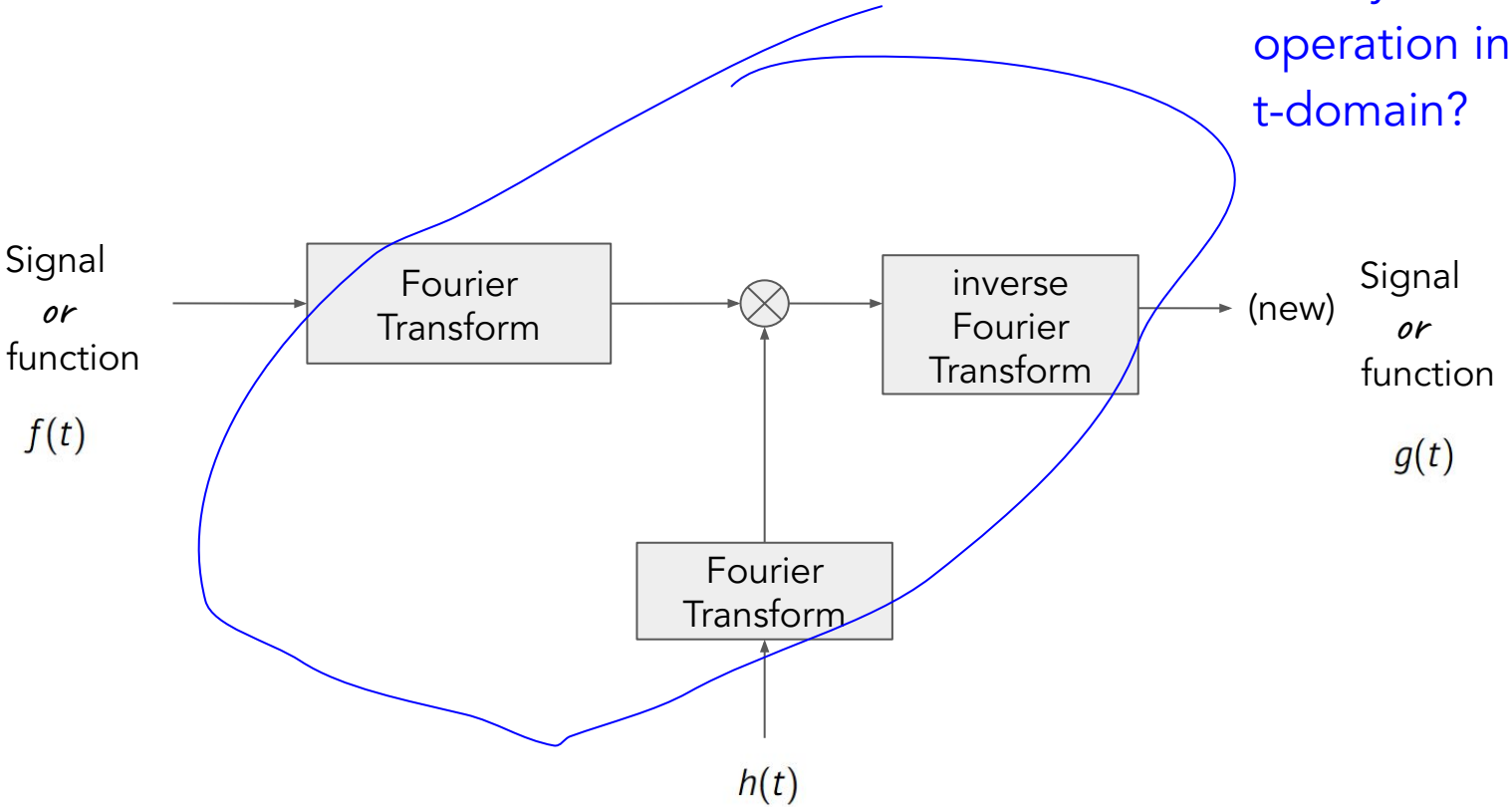
$f(t)$

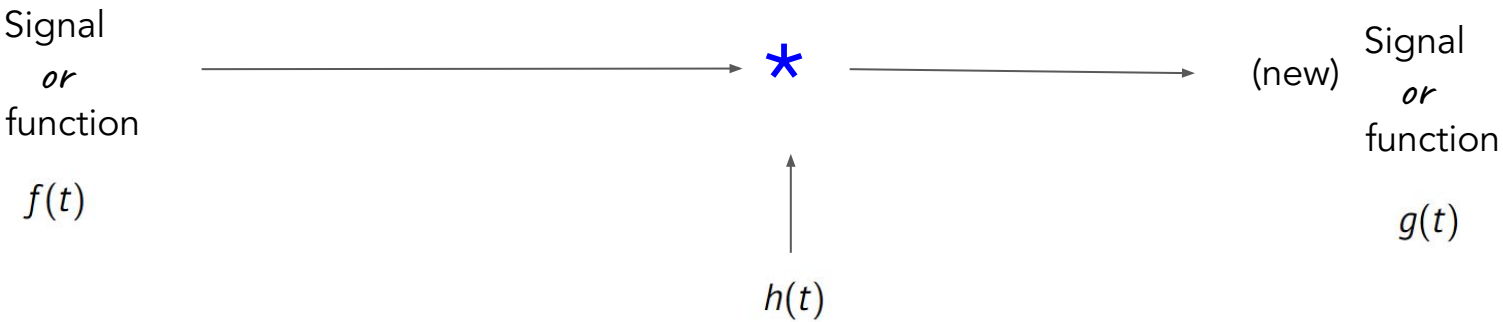

Signal
or
function
$f(t)$
Fourier
Transform

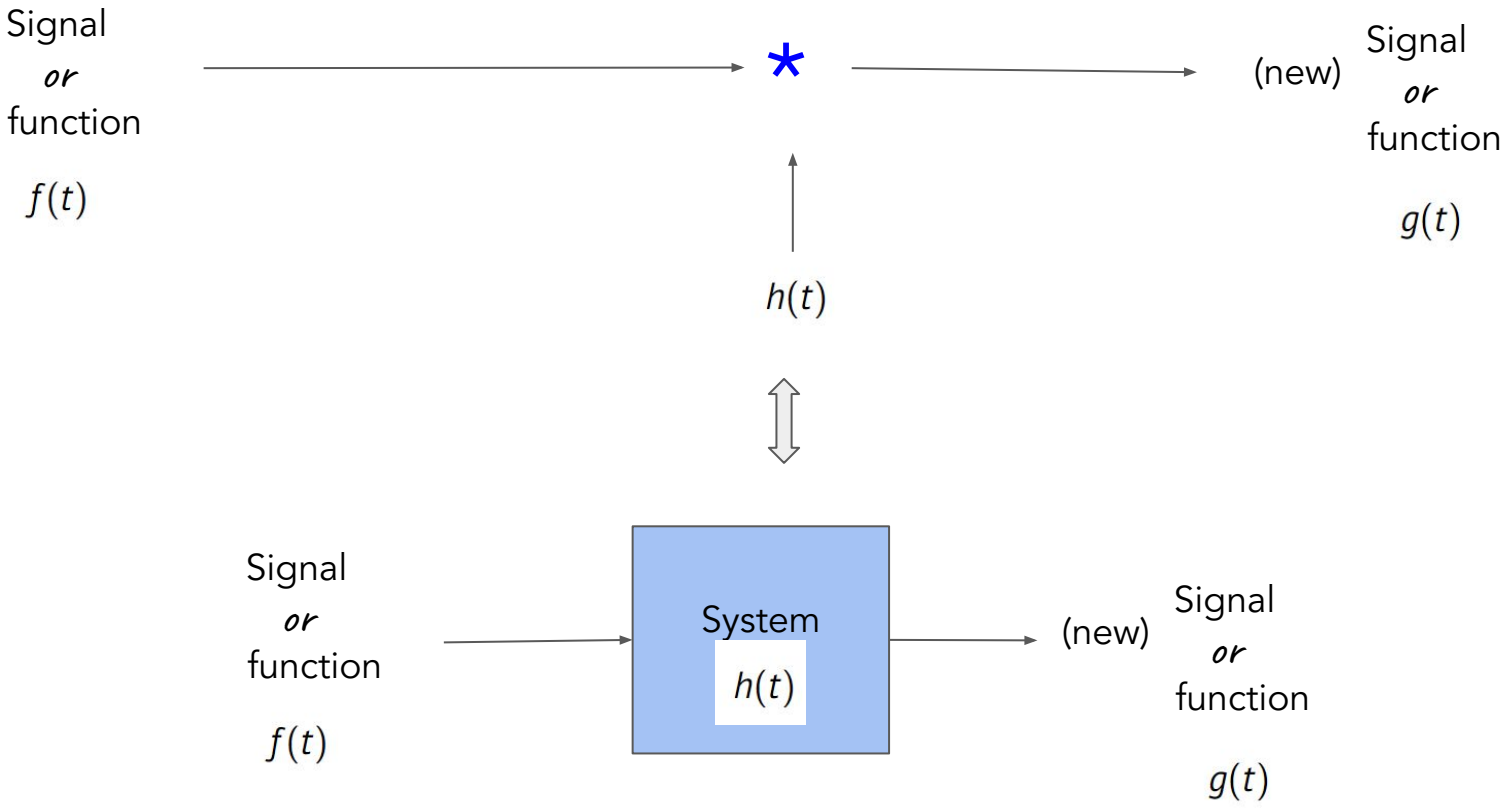

Signal
or
function
$f(t)$
Fourier Transform
Fourier Transform
$h(t)$


Signal
or
function
$f(t)$
Fourier Transform
inverse Fourier Transform
(new)
Signal
or
function
$g(t)$
Fourier Transform
$h(t)$

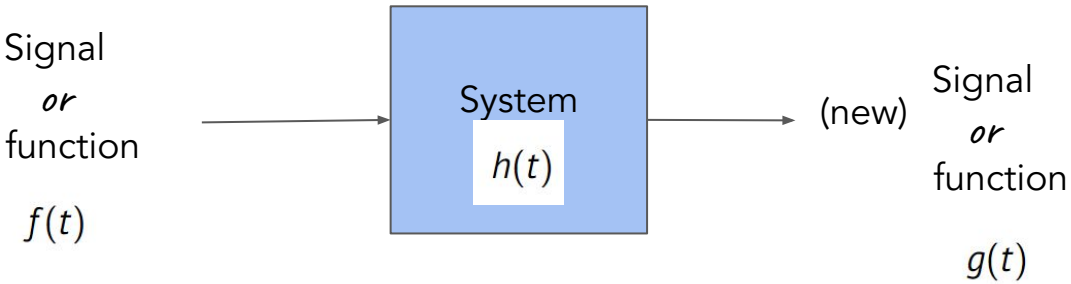
Can we replace this by some operation in t-domain?




Signal
or
function
$f(t)$
*
$h(t)$
(new)
Signal
or
function
$g(t)$



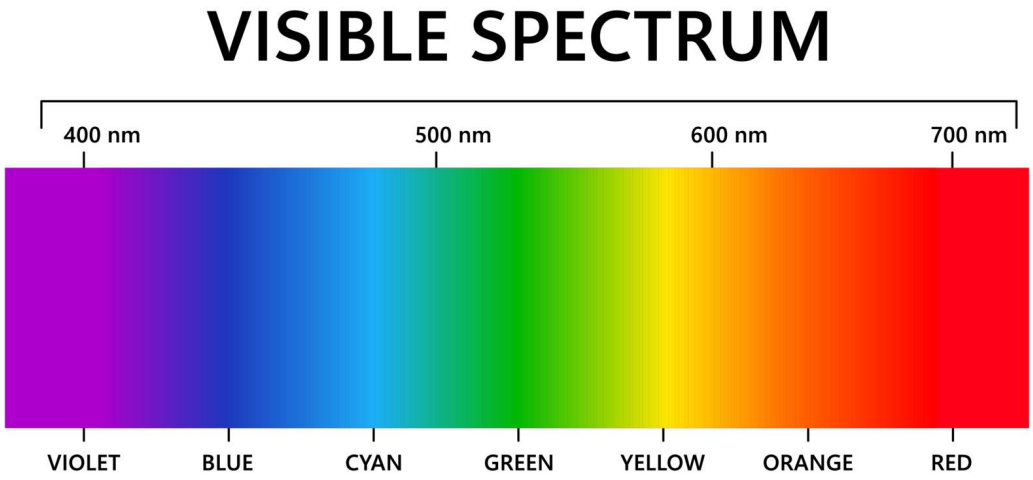
Example: Low pass filter



$$g(t) = h(t) * f(t)$$

$$g(t) = \int_{-\infty}^{\infty} h(t-u)f(u)du$$

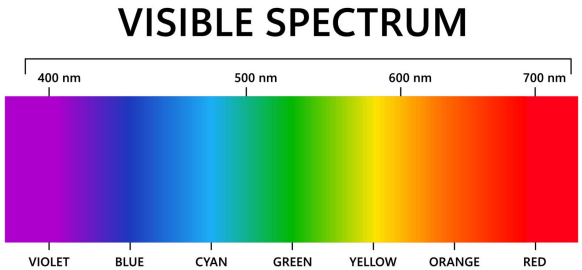
Nature is continuous …



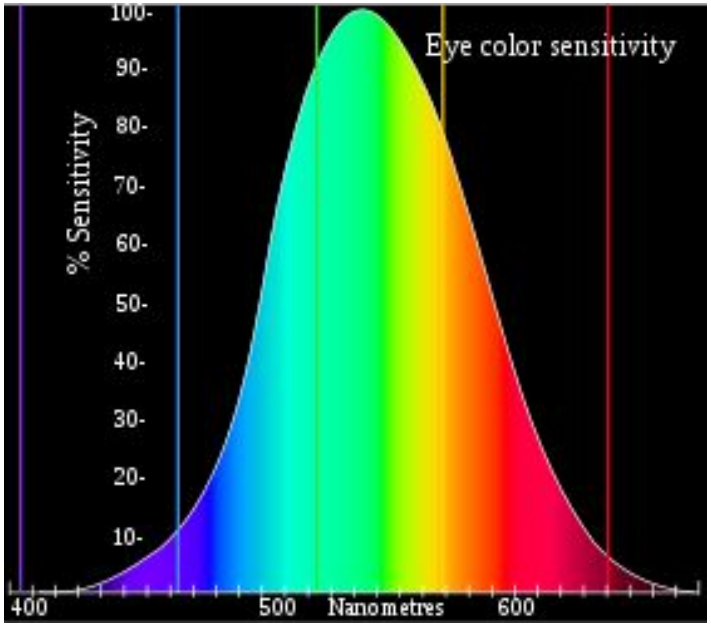
The continuous visible spectrum

Human vision

Cone cells help
to see color



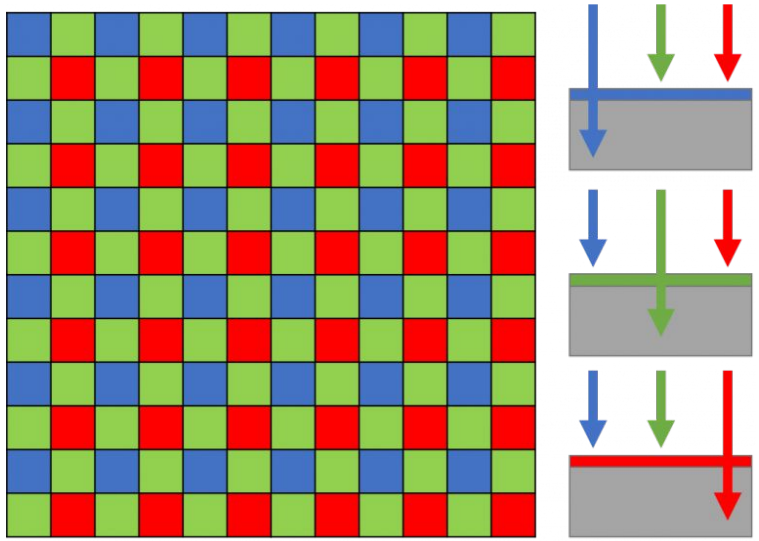
Human color vision has highest sensitivity to green



How does camera capture color?

- cone cells help to see color
- primarily sense red, green, and blue light
- RGB!

Bayer Filter



https://www.photometrics.com/

Combined image

Only R

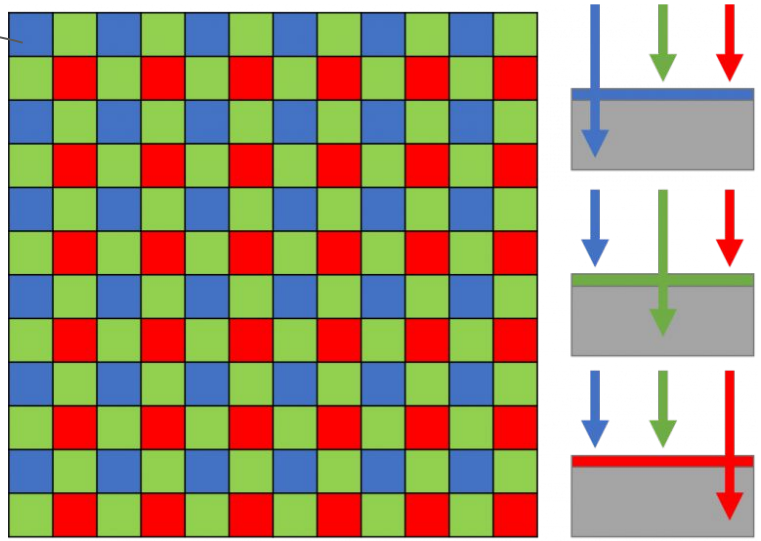
Only G

Only B

https://en.wikipedia.org/wiki/RGB_color_model

How does camera capture color?

Bayer Filter



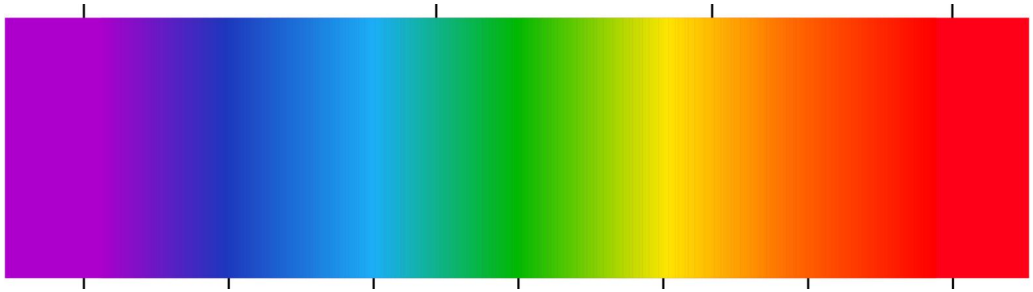
How much blue has been captured?

- Welcome to counting!
- We have to quantify the amount of blue.
- N-bit color depth

… measurements are discrete.

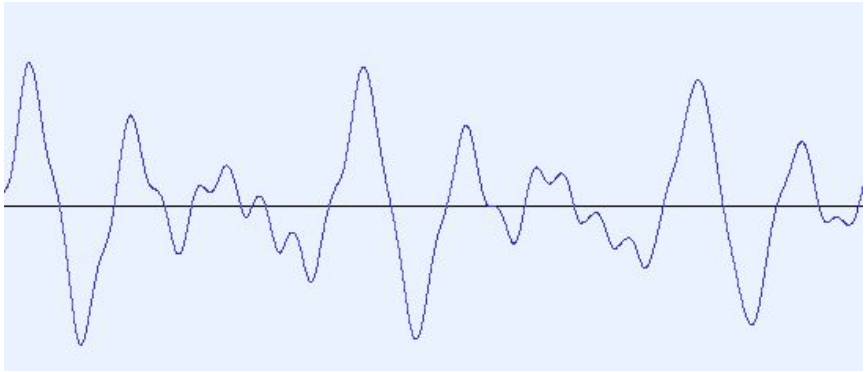
https://www.photometrics.com/

Nature is continuous …

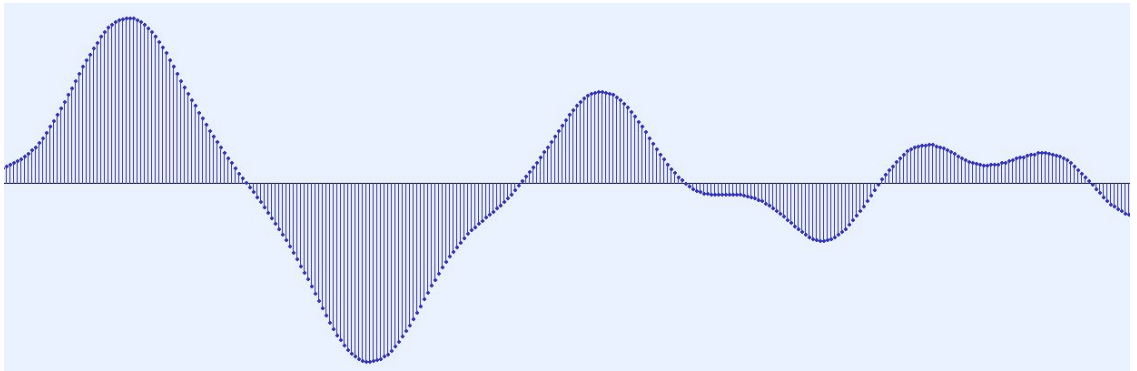


…, measurements are discrete.

Nature is continuous …

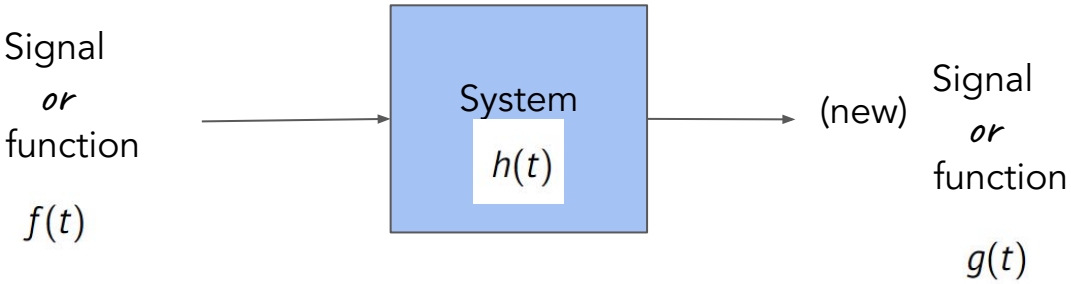


Nature is continuous …



,… measurements are discrete.

Our signal processing model…

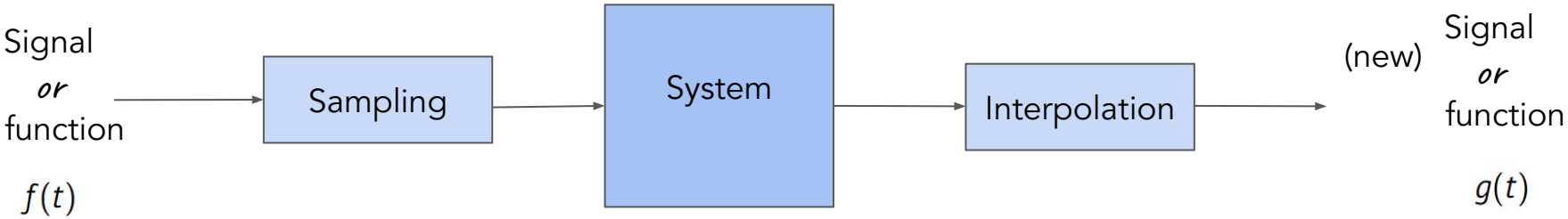


$$g(t) = h(t) * f(t)$$

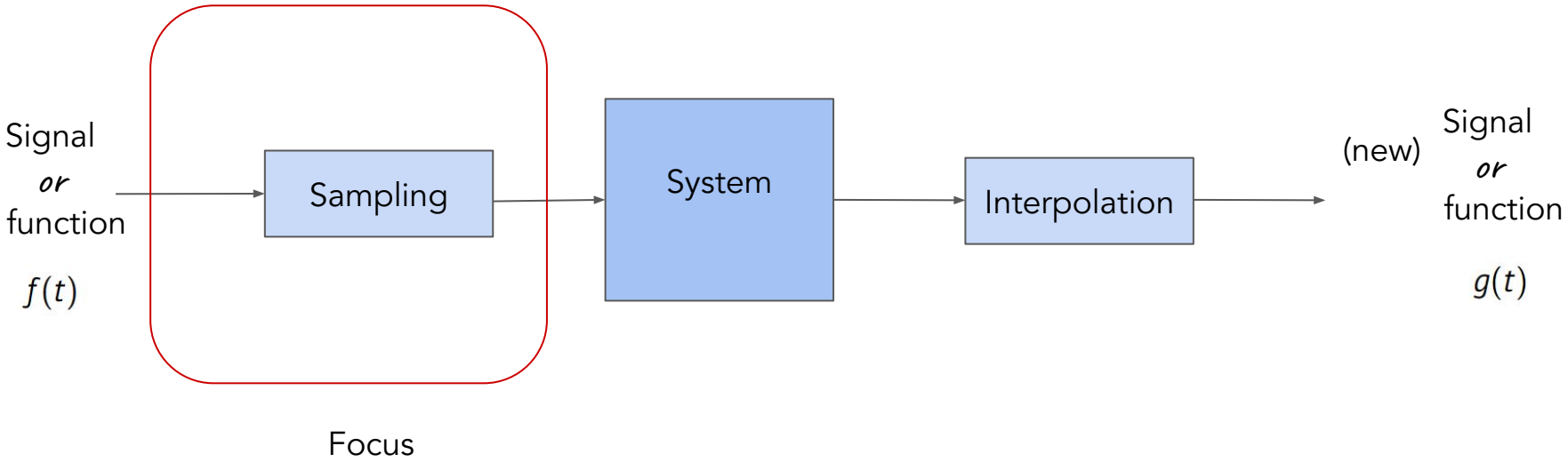
$$g(t) = \int_{-\infty}^{\infty} h(t-u)f(u)du$$

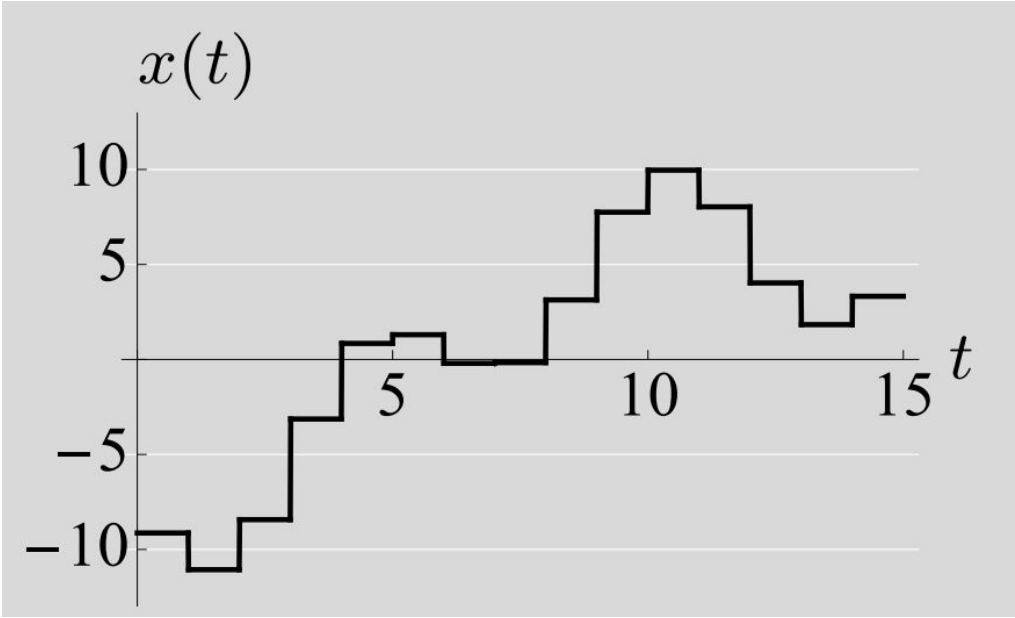
Oops! continuous signals here.

Signal processing model…updated



Signal processing model…updated

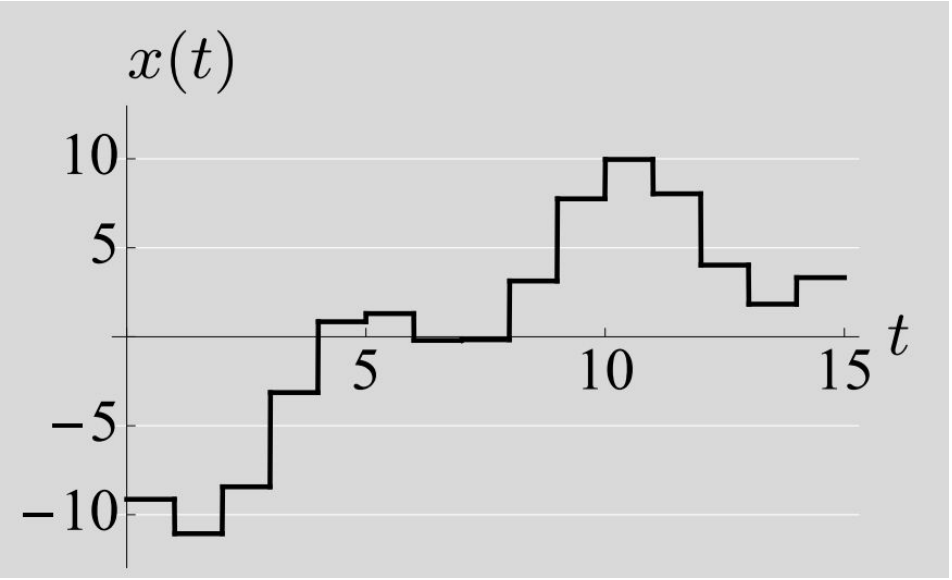



x(t)
10
5
−5
−10
5
10
15
t

Piecewise-constant function

The function is constant over unit-length intervals $[n, n+1),\ n \in \mathbb{Z}$

$$x(t) = x(n) \quad \forall t \in [n, n+1], \quad n \in \mathbb{Z}$$



The set S is a closed subspace, and it is called shift-invariant with respect to integer shifts because, for any x in S and any integer k, the function $x(t-k)$ also belongs to S. Because of (5.1), functions in S are in one-to-one correspondence with sequences. If $g = 1_{[0,1)}$ – the indicator function of the unit interval – the set $\{g(t-k)\}_{k\in\mathbb{Z}}$ is an orthonormal basis for S.

Thank you.