# SNS COLLEGE OF TECHNOLOGY

**Coimbatore-35**
**An Autonomous Institution**

Accredited by NBA – AICTE and Accredited by NAAC – UGC with 'A+' Grade
Approved by AICTE, New Delhi & Affiliated to Anna University, Chennai

# DEPARTMENT OF ELECTRONICS & COMMUNICATION ENGINEERING

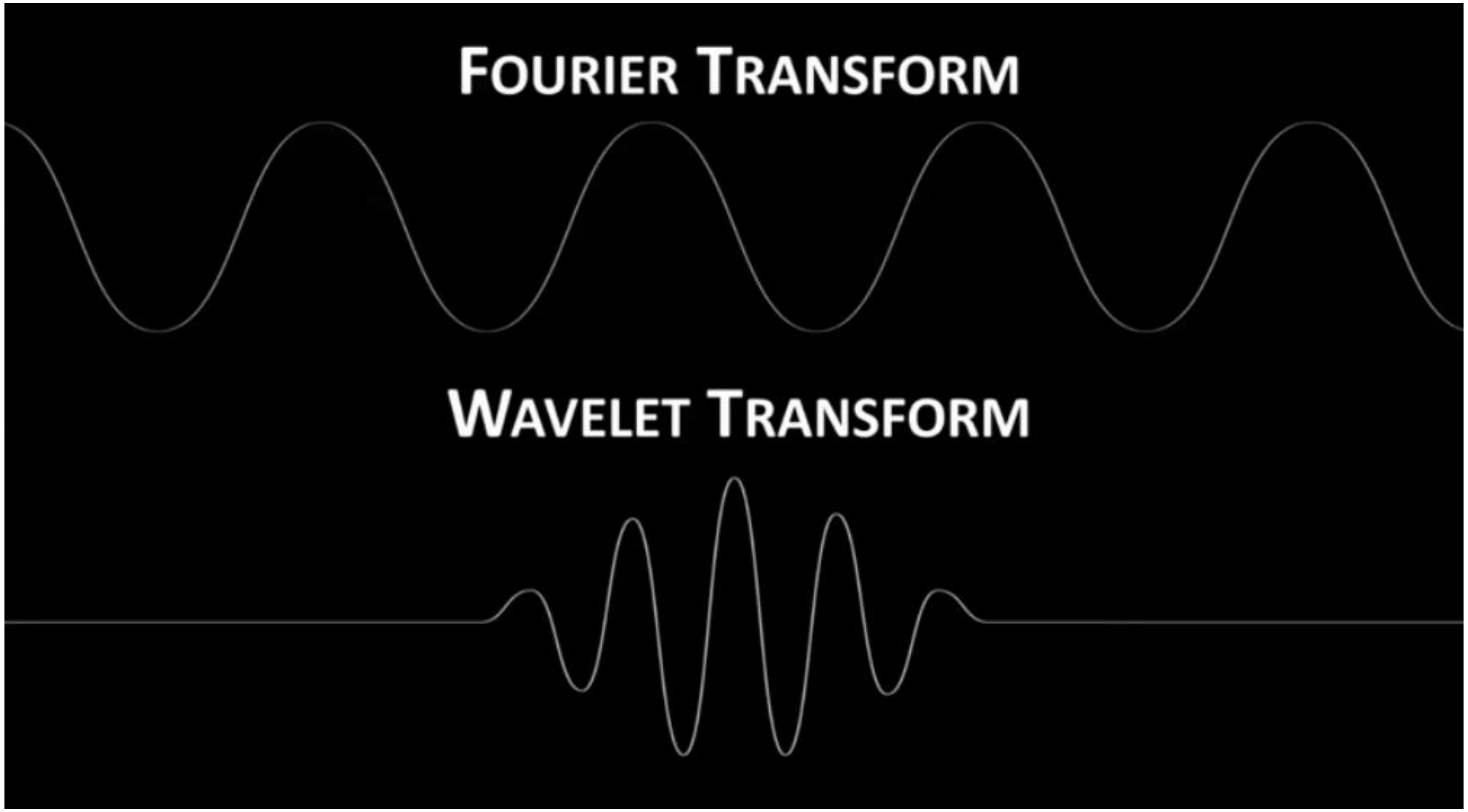
## 19ECE351 – IMAGE PROCESSING AND COMPUTER VISION

III B.E. ECE / V SEMESTER

UNIT 1 – DIGITAL IMAGE FUNDAMENTALS AND TRANSFORMS

TOPIC – WAVELET TRANSFORM

# WAVELET TRANSFORM



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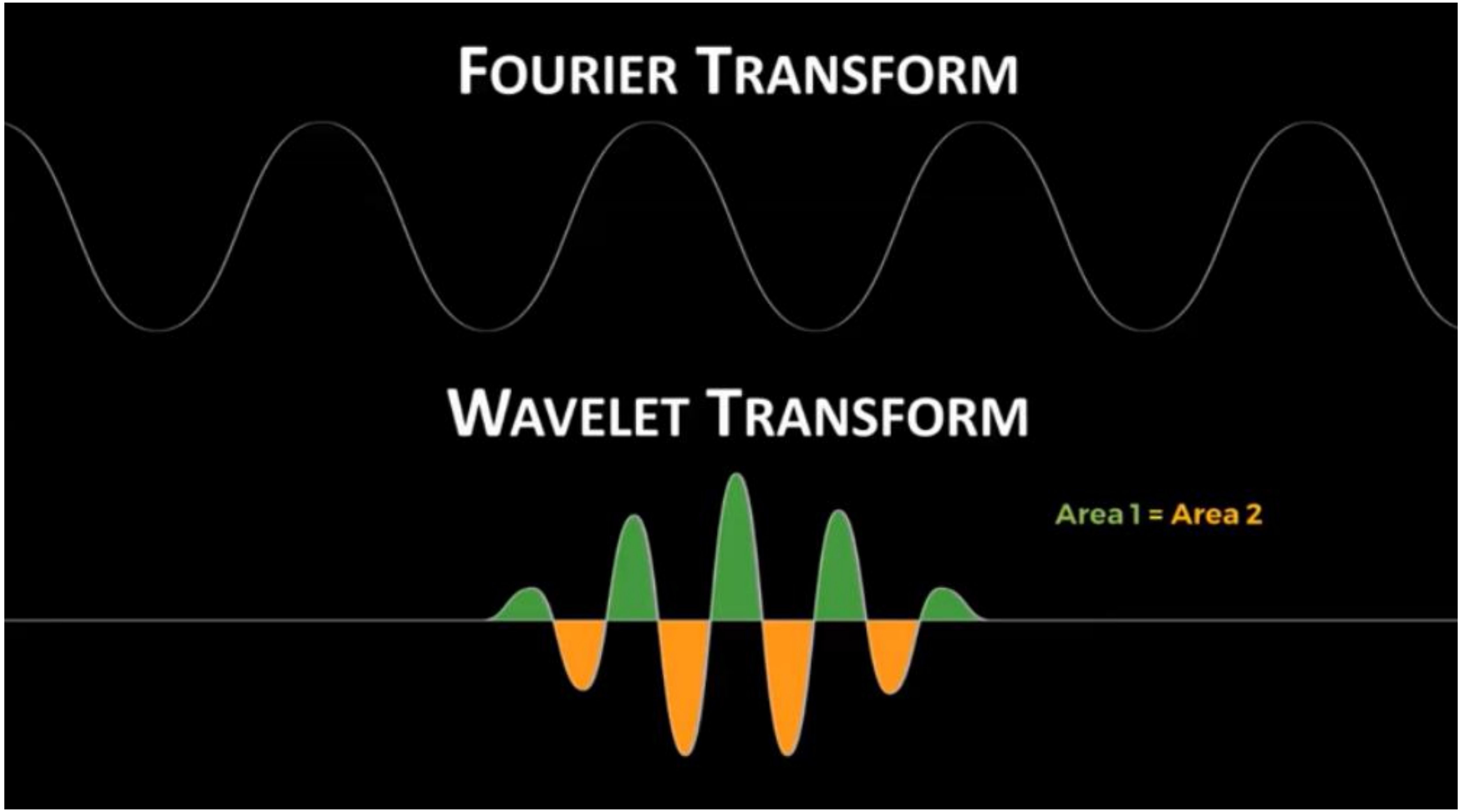

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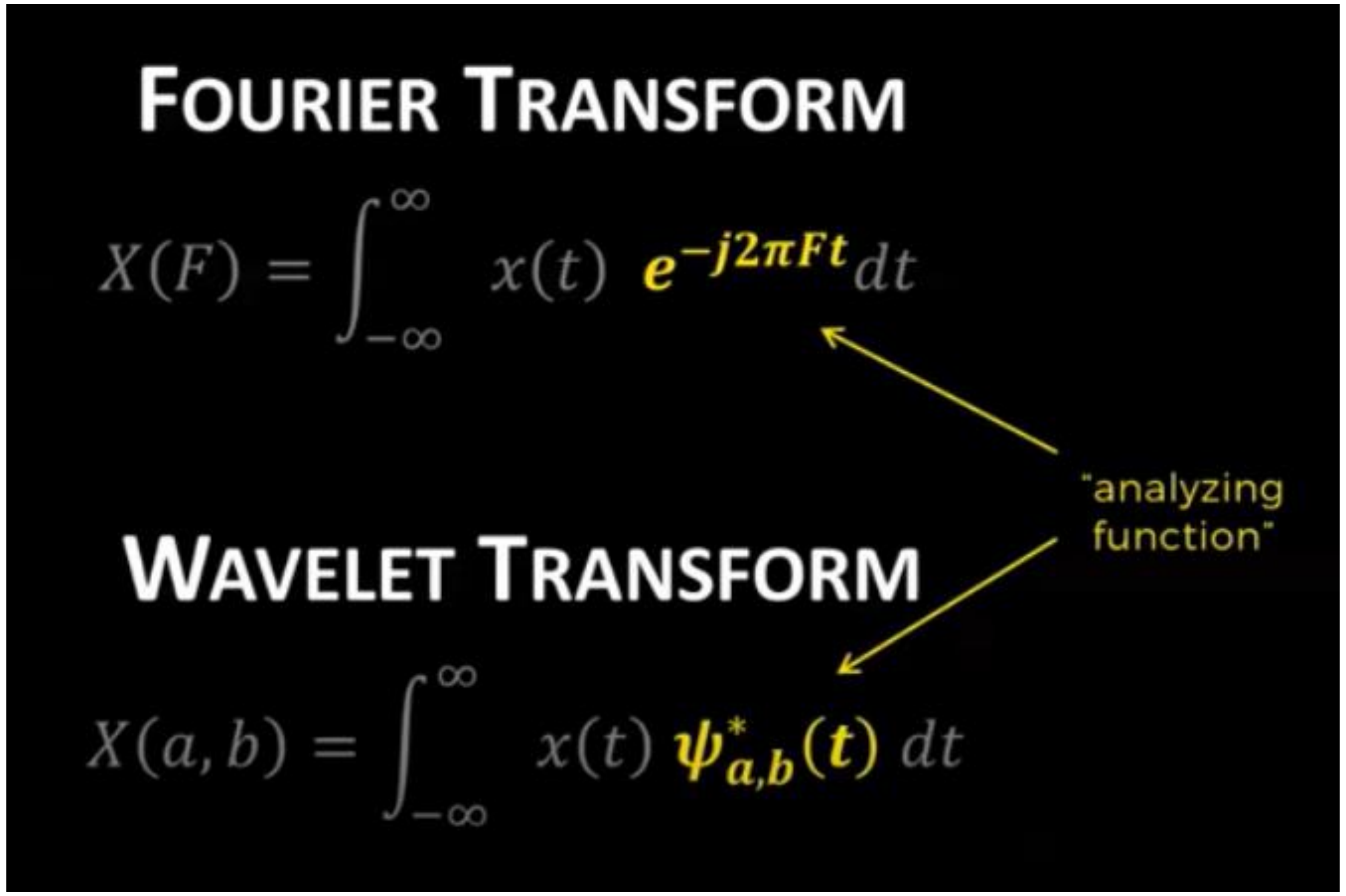


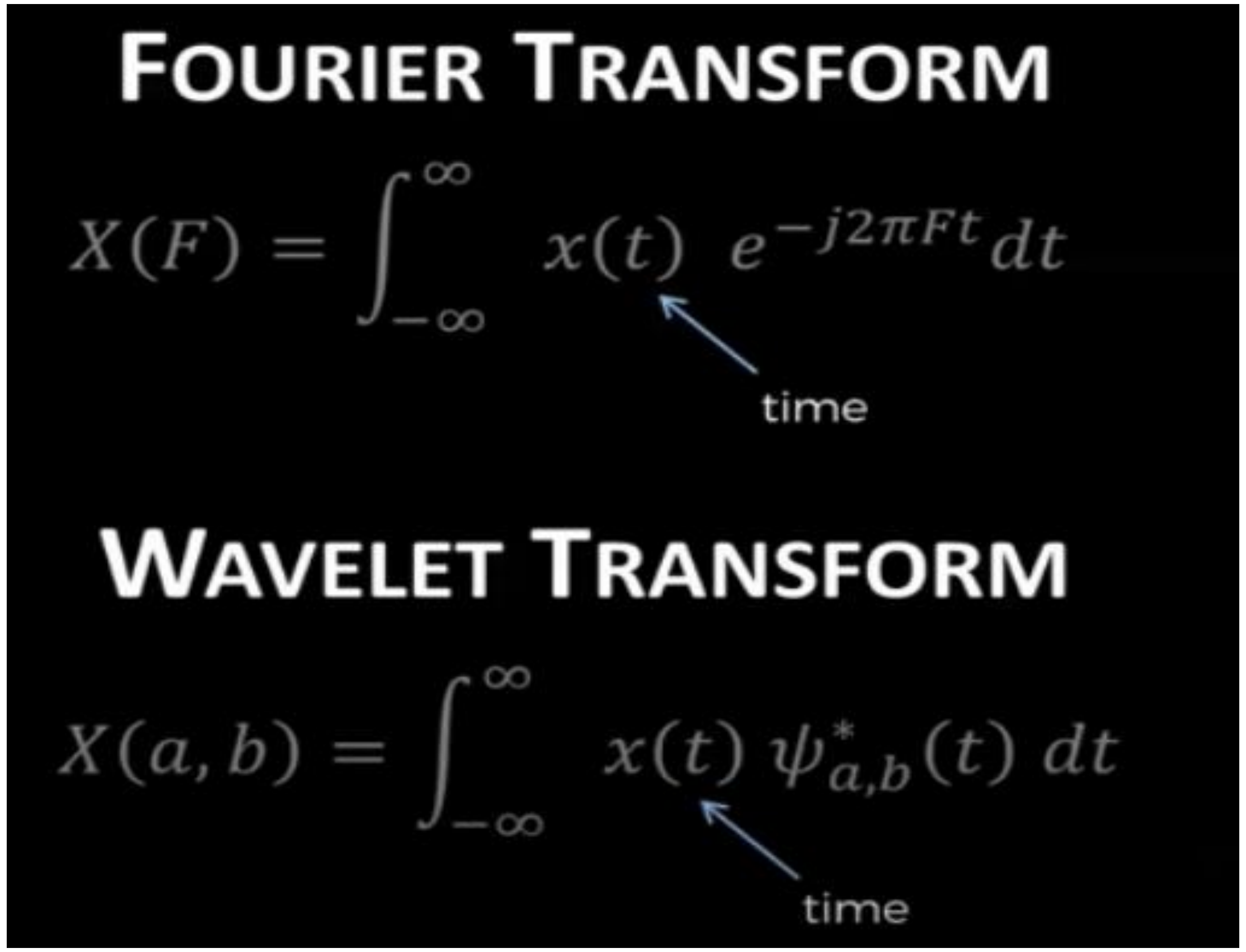

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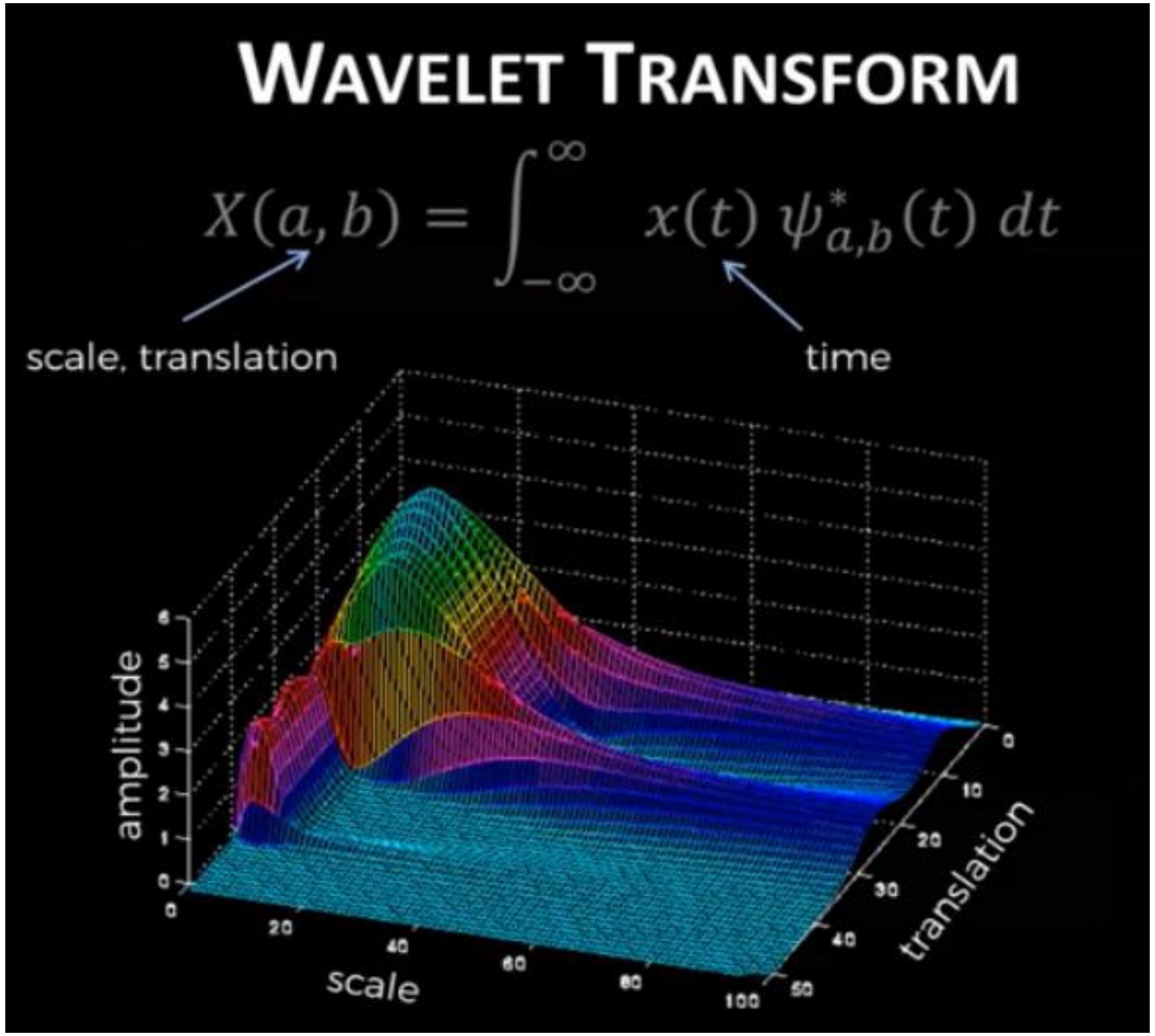

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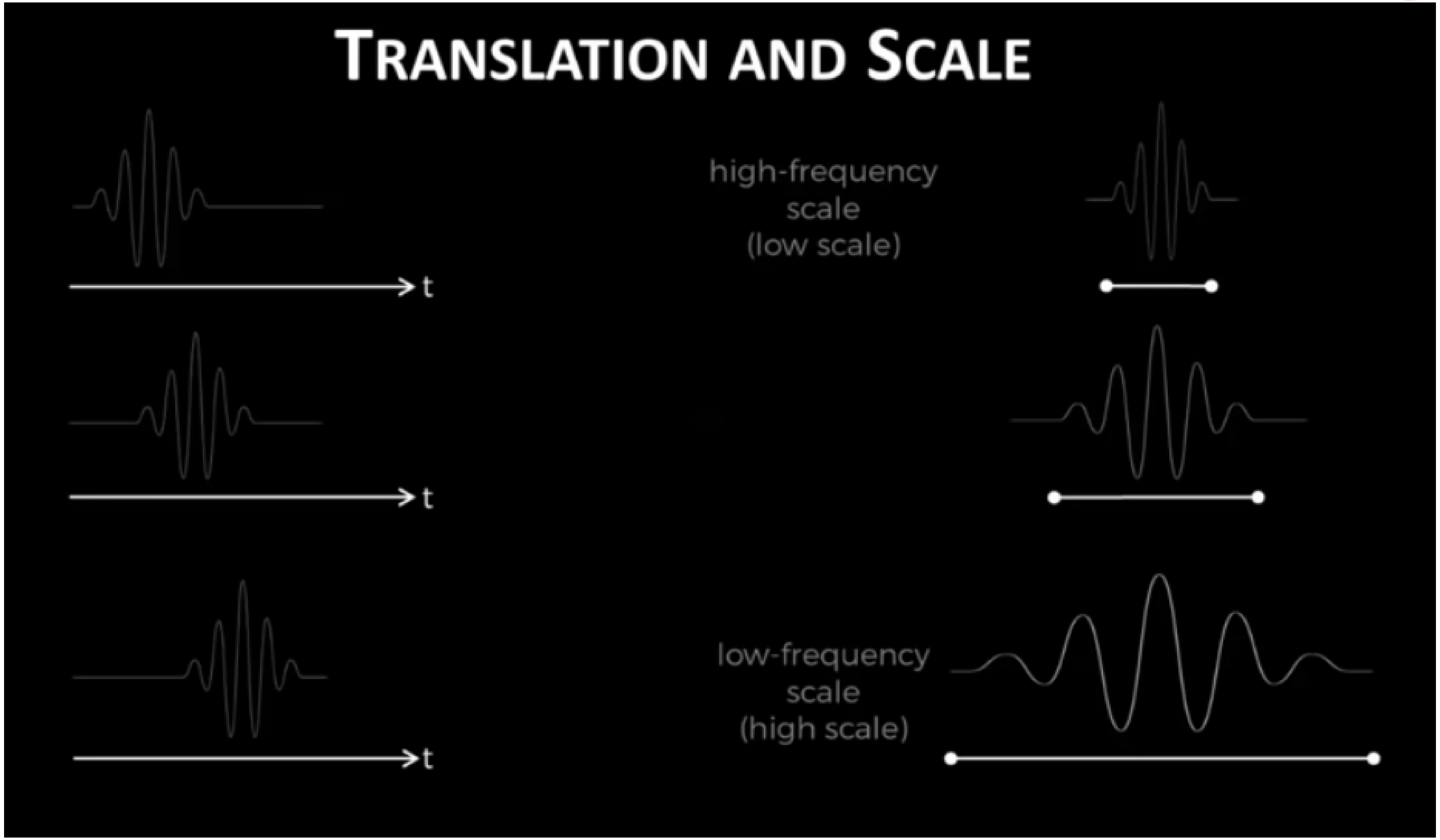

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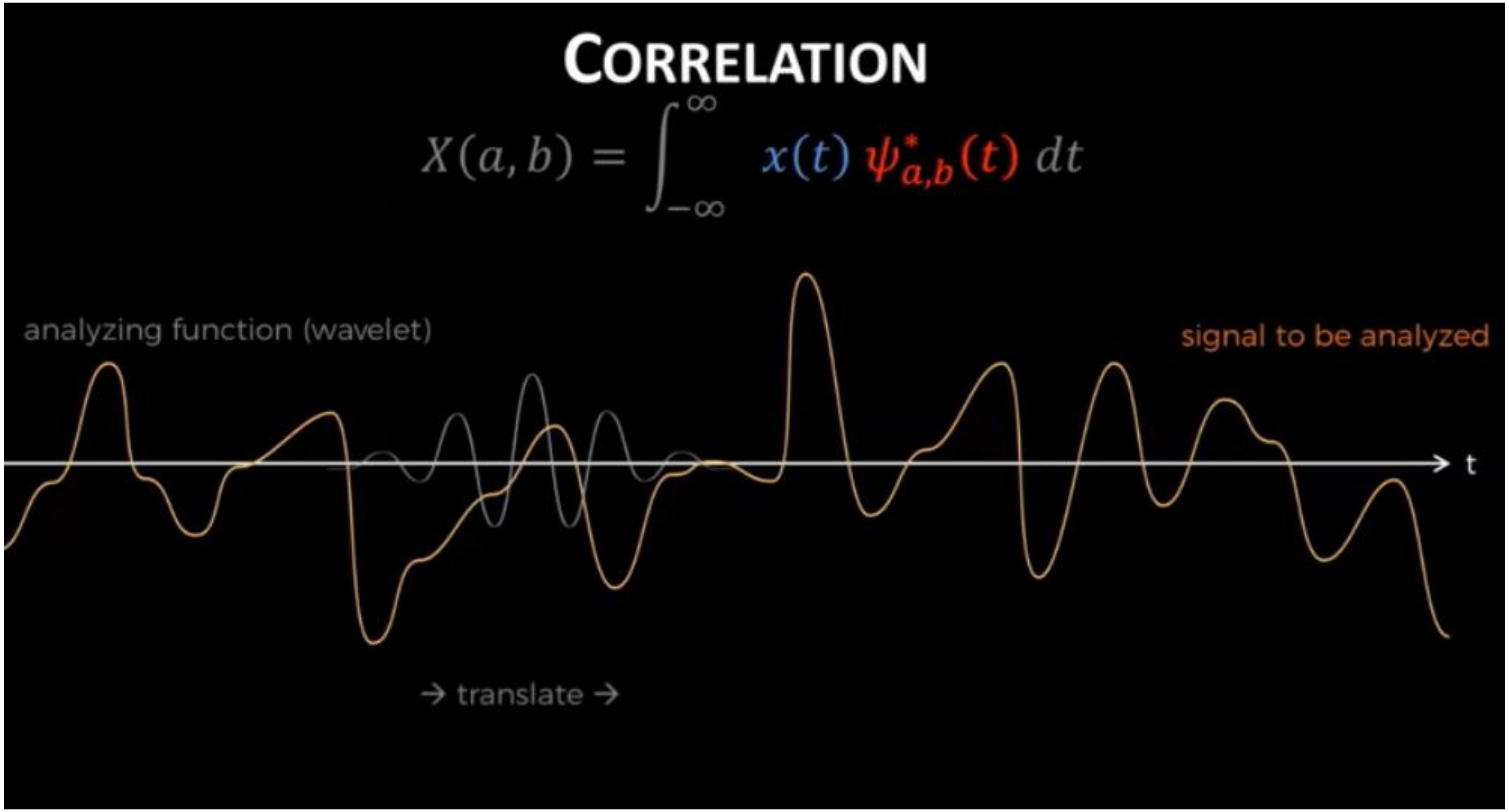
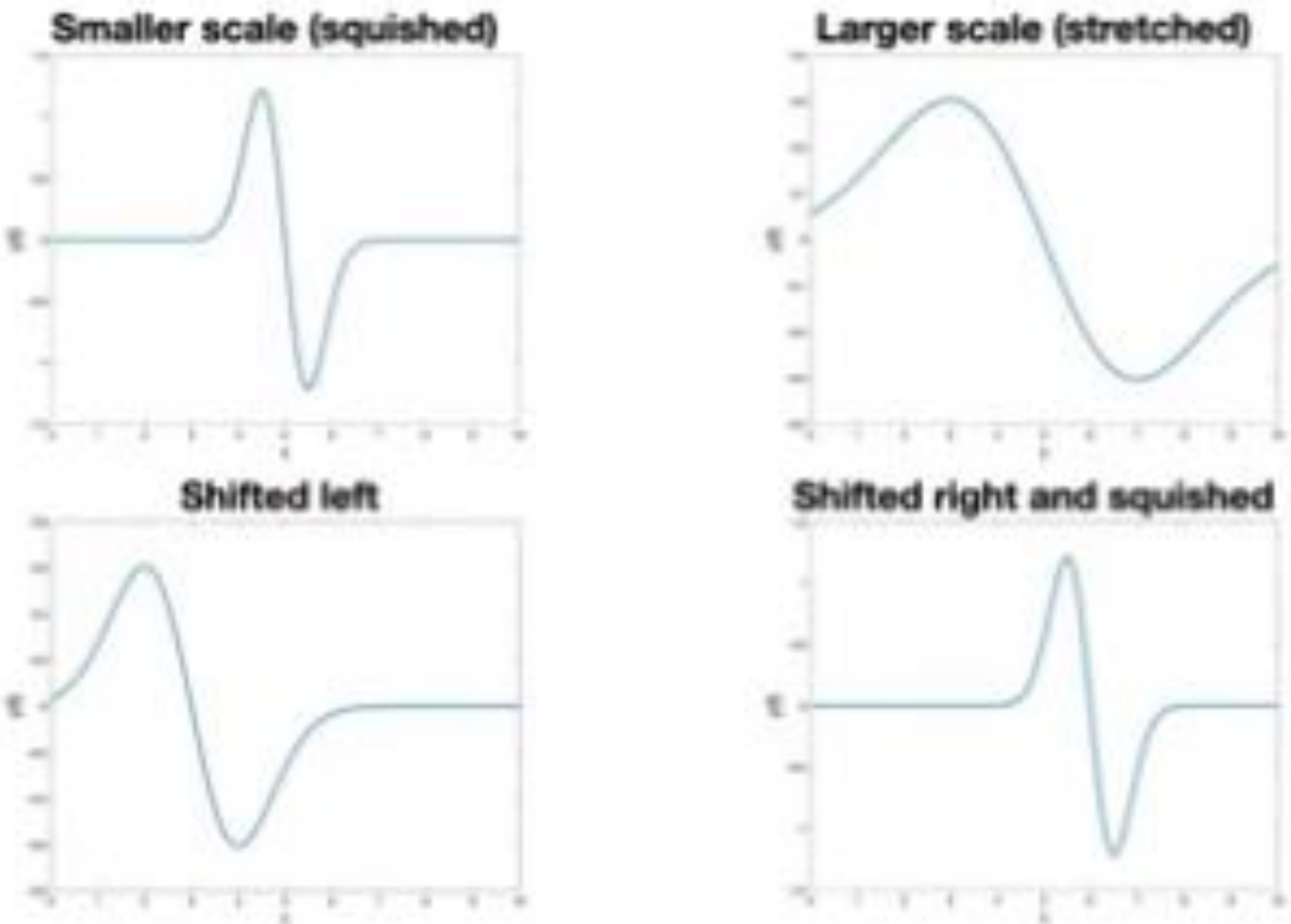


# WAVELET TRANSFORM

**[1] Two basic properties:**

- **Scale (dilation)** - how "stretched" or "squished" wavelet is (related to frequency)

- **Location** - where wavelet is positioned in time




*a*

*b*

# Wavelet Transform

## Two methods

### Continuous Wavelet Transform (CWT)

"Mother" (basis) wavelets are defined everywhere

$$\psi = \psi(t)$$

Transform must be discretized for implementation

$$T(a,b) = \frac{1}{\sqrt{a}} \int_{-\infty}^{\infty} x(t)\, \psi^* \frac{(t-b)}{a} dt$$

$T(a,b)$ may have redundant information since same feature may be *captured* by multiple scales

### Discrete Wavelet Transform (DWT)

"Mother" (basis) wavelets are **only defined** on discrete grid

$$\psi = \psi_{m,n}(t)$$

Transform is already discrete!

$$T_{m,n} = \int_{-\infty}^{\infty} x(t)\, \psi_{m,n}(t)\, dt$$

Coefficients ($T_{m,n}$) do not have redundant information since discretized wavelets can be defined to be orthonormal

$$\int_{-\infty}^{\infty} \psi_{m,n}(t)\psi_{m',n'}(t)\, dt = \begin{cases} 1 & \text{if} \quad m = m' \text{ and } n = n' \\ 0 & \text{otherwise.} \end{cases}$$

# WAVELET TRANSFORM

- Wavelets for 2-D Signals (Images)

- Wavelet Analysis and Synthesis of images using Filer Banks

## Wavelets for 2-D signals

- Images are obviously two dimensional data [i.e. $f(x, y)$].
- To transform images, we need two dimensional wavelets [i.e. $\psi(x, y)$].

# WAVELET TRANSFORM

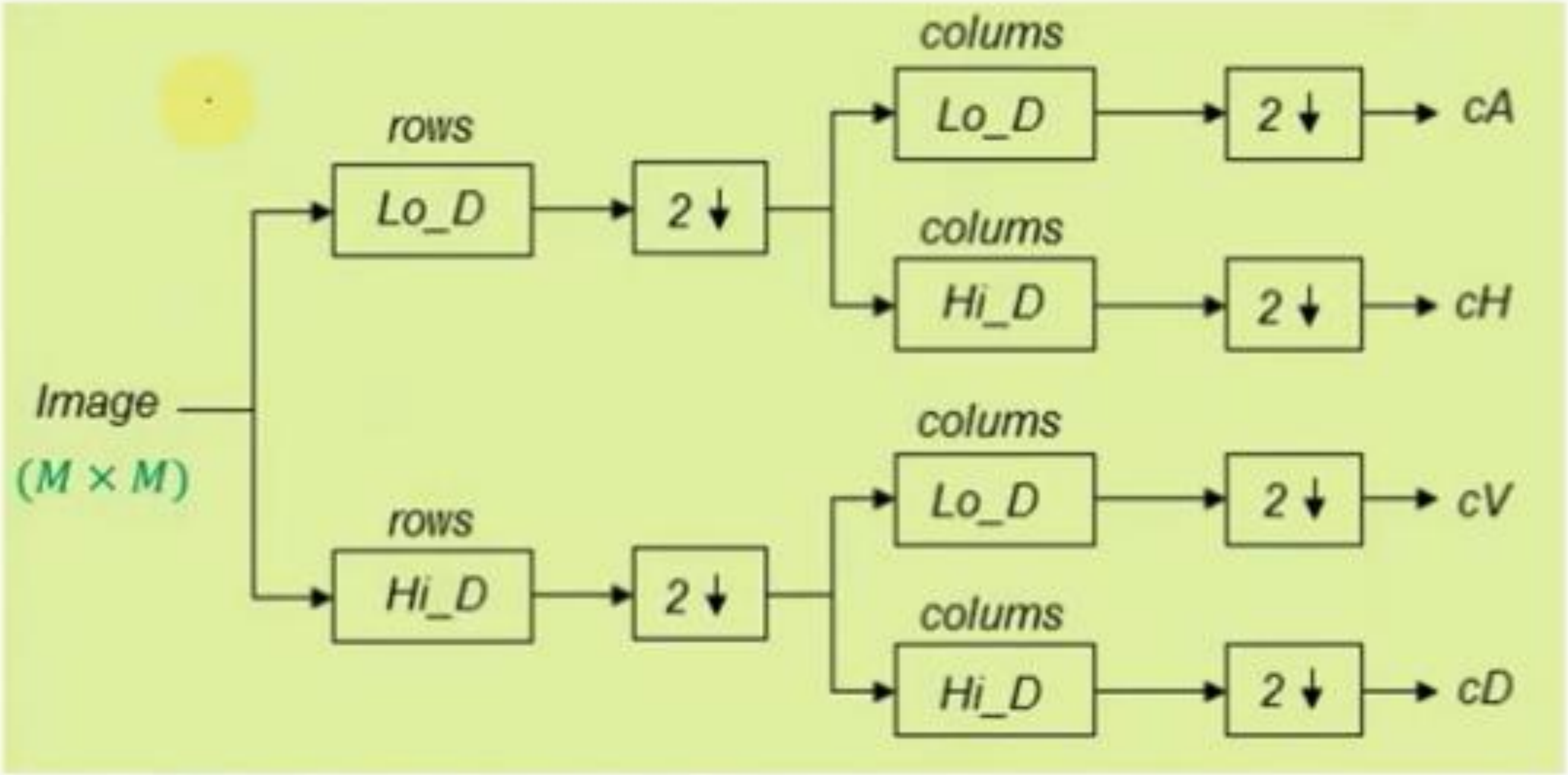
- We can apply the one dimensional transform to the rows and columns of the image successively as separable two dimensional transform.

- In most of the applications, where wavelets are used for image processing, this approach is preferred because of the low computational complexity of separable transforms.

# WAVELET TRANSFORM

## Filter Bank Theory (Wavelet Decomposition)

Filter based approach based on row and column wise operation is shown below.




Approximation Coefficients

$\left(\frac{M}{2} \times \frac{M}{2}\right)$

Horizontal Detailed Coefficients

$\left(\frac{M}{2} \times \frac{M}{2}\right)$

Vertical Detailed Coefficients

$\left(\frac{M}{2} \times \frac{M}{2}\right)$

Diagonal Detailed Coefficients

$\left(\frac{M}{2} \times \frac{M}{2}\right)$

Lo_D: Low Pass Wavelet Decomposition Filter
Hi_D: High Pass Wavelet Decomposition Filter
2 ↓: Down Sampled by 2.

# WAVELET TRANSFORM

## Filter Bank Theory (Wavelet Reconstruction)

Approximation Coefficients

$\left(\frac{M}{2} \times \frac{M}{2}\right)$

Horizontal Detailed Coefficients

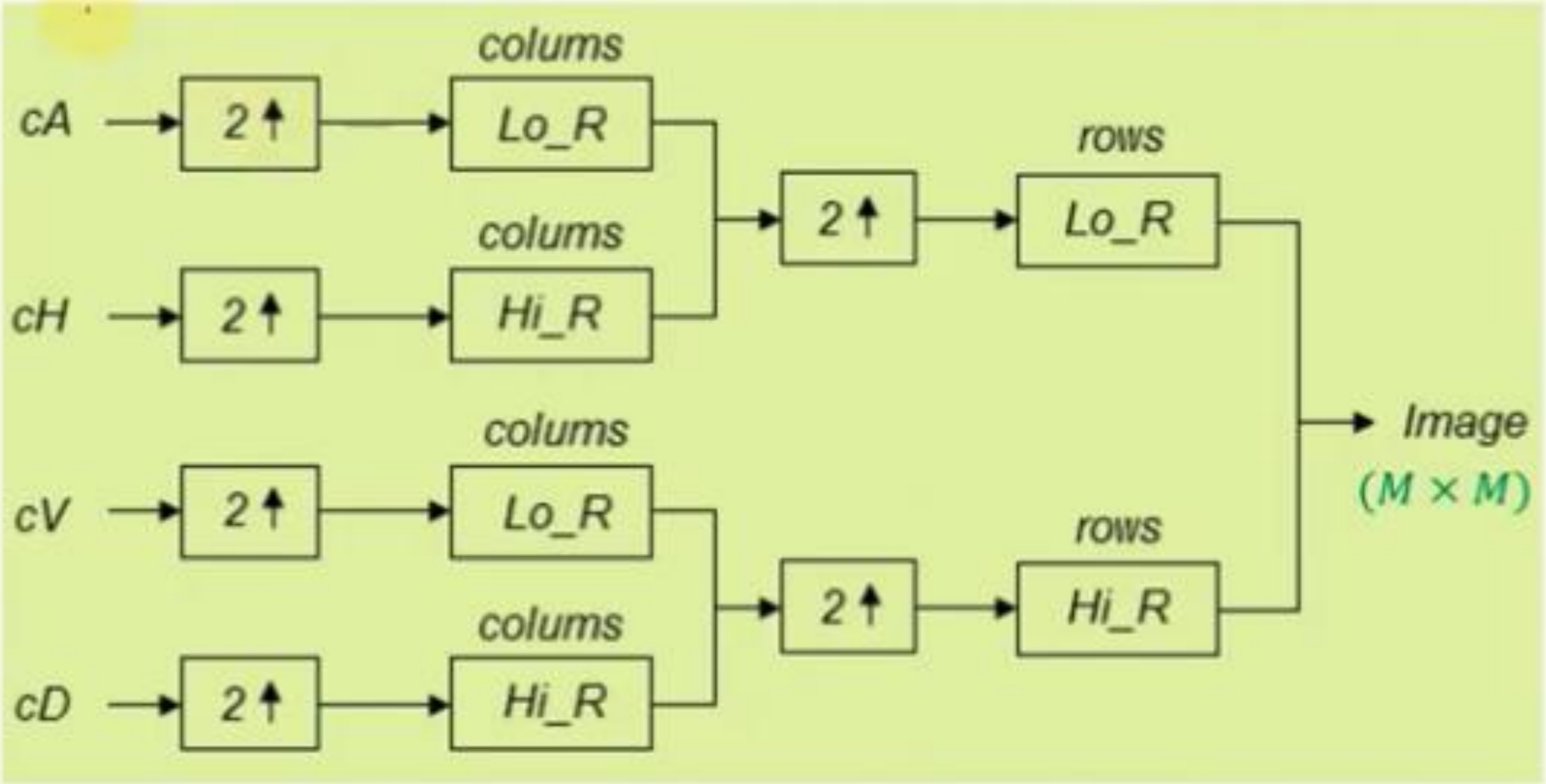
$\left(\frac{M}{2} \times \frac{M}{2}\right)$

Vertical Detailed Coefficients

$\left(\frac{M}{2} \times \frac{M}{2}\right)$

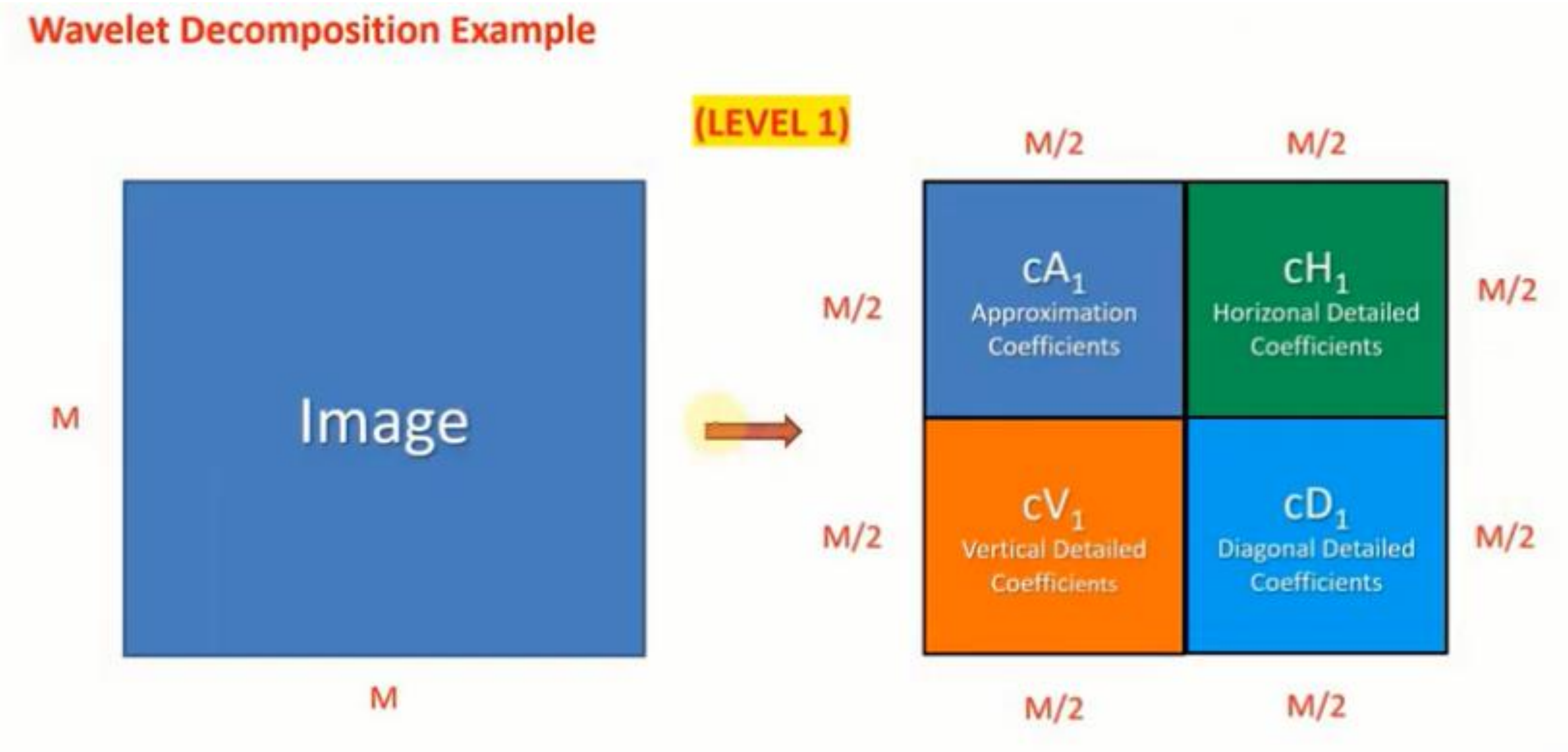
Diagonal Detailed Coefficients

$\left(\frac{M}{2} \times \frac{M}{2}\right)$




Lo_R: Low Pass Wavelet Re-construction Filter
Hi_R: High Pass Wavelet Re-construction Filter
2 ↑: Up Sampled by 2.

# WAVELET TRANSFORM



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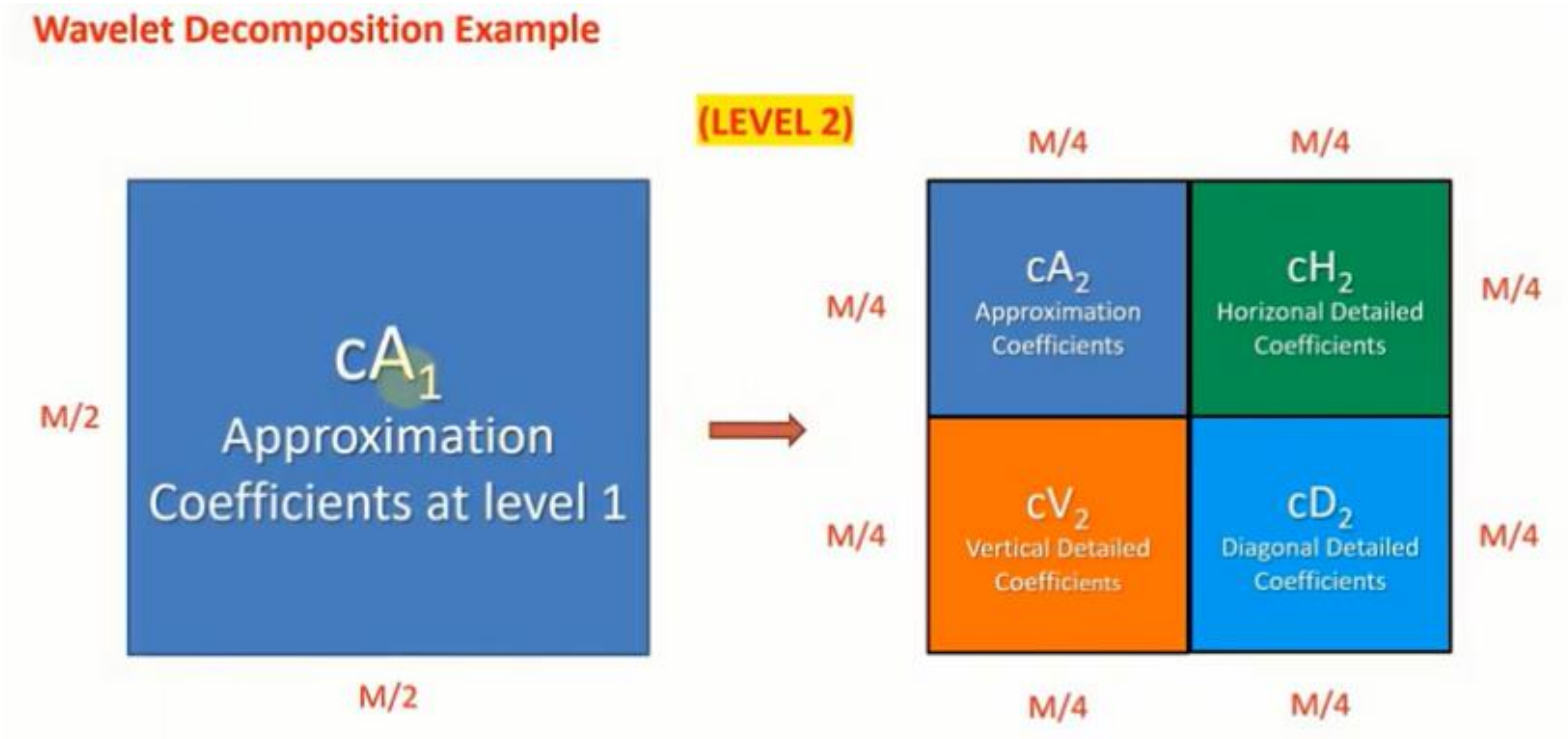

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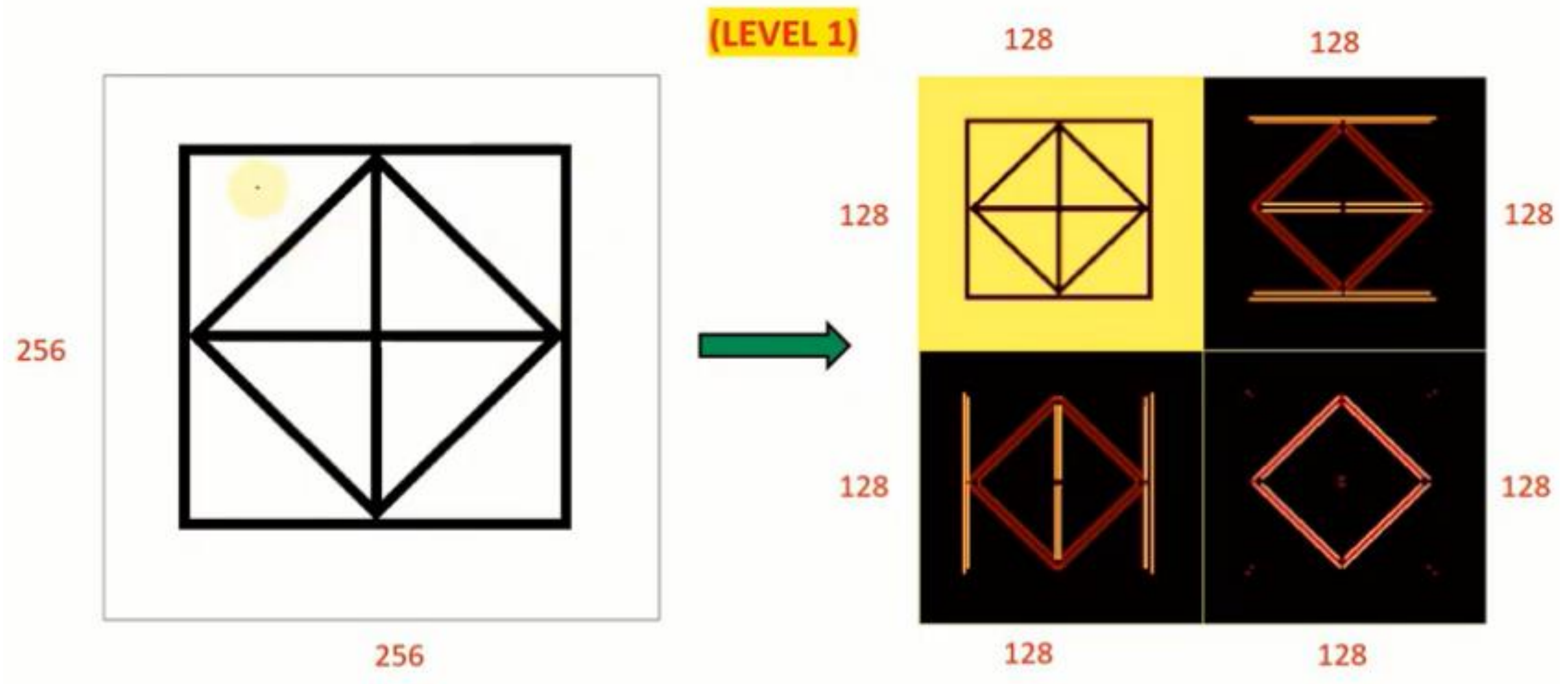

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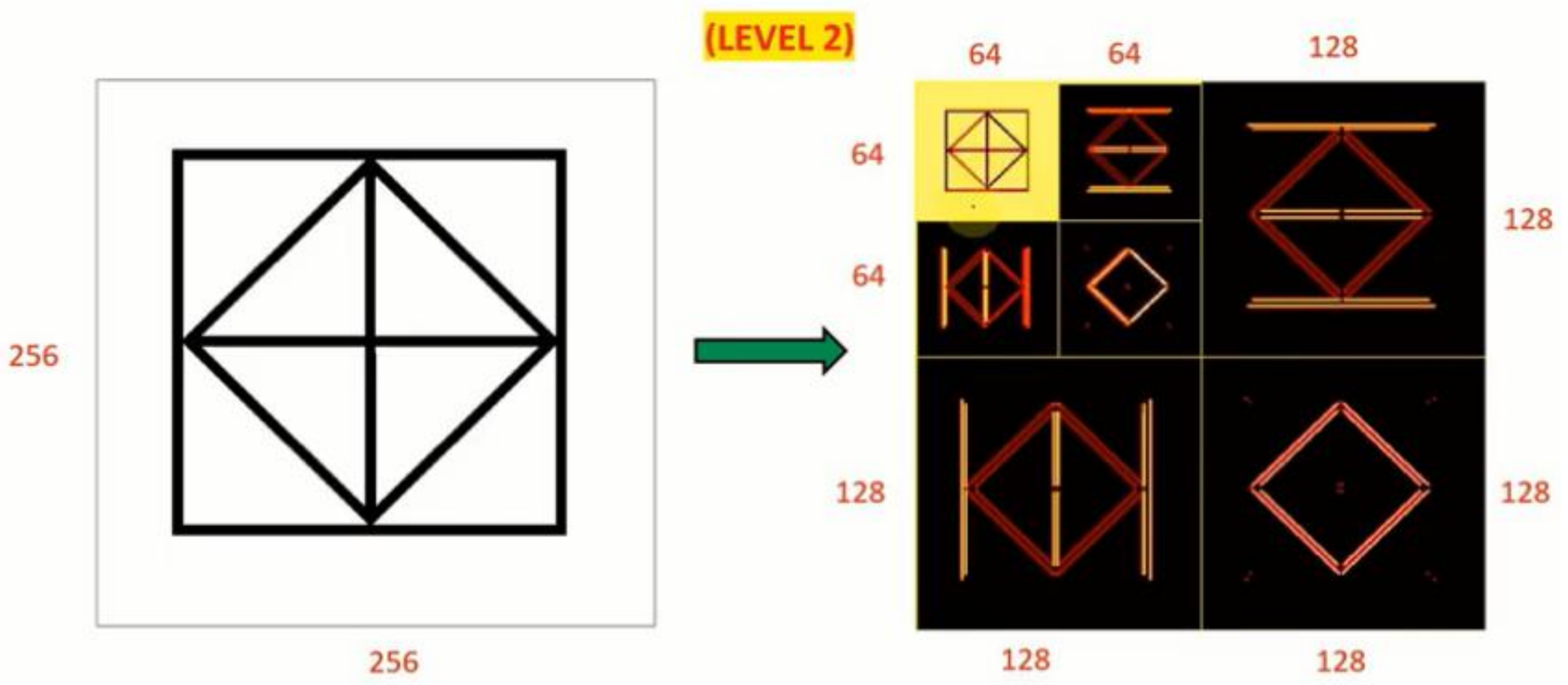

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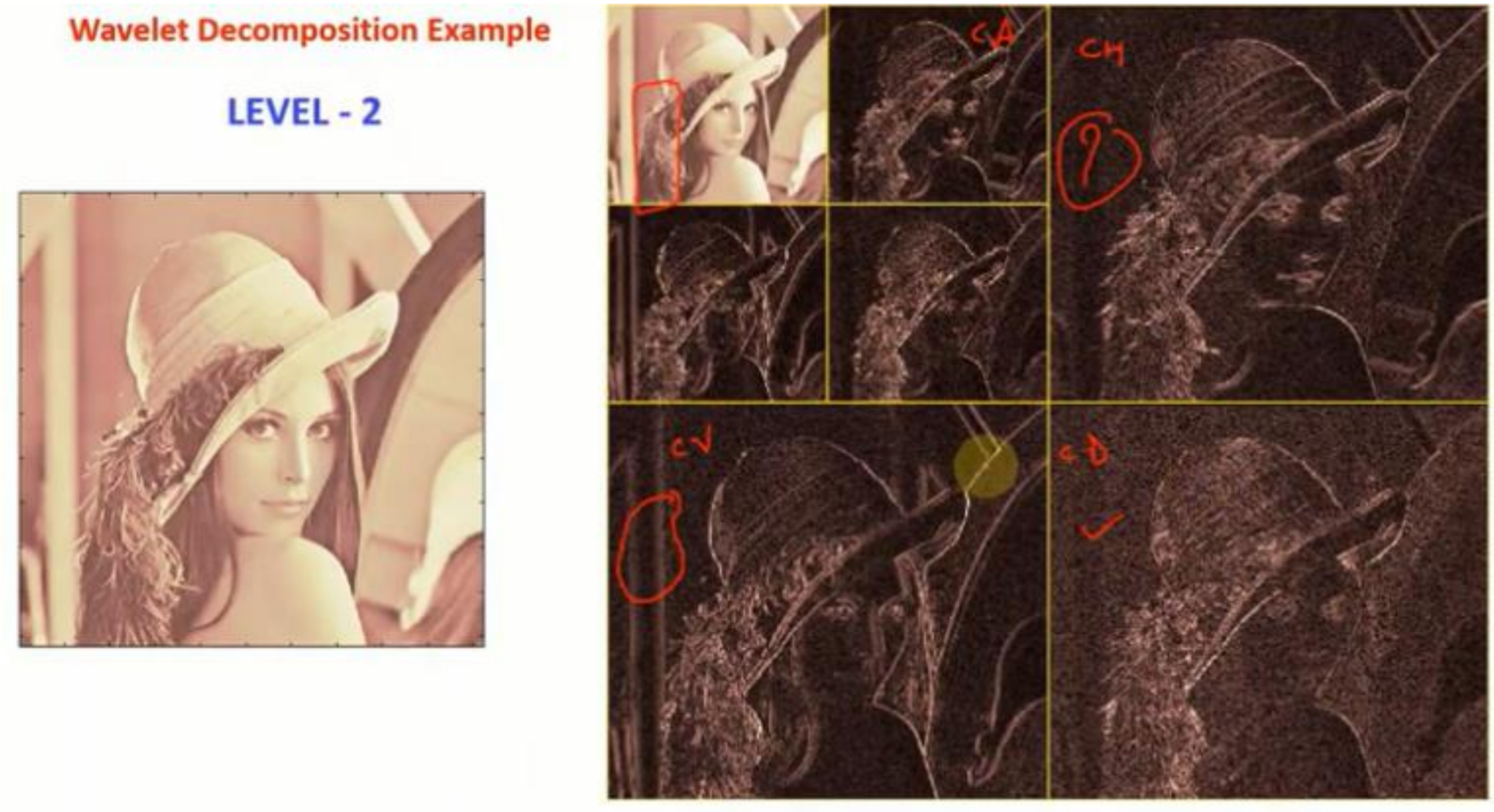

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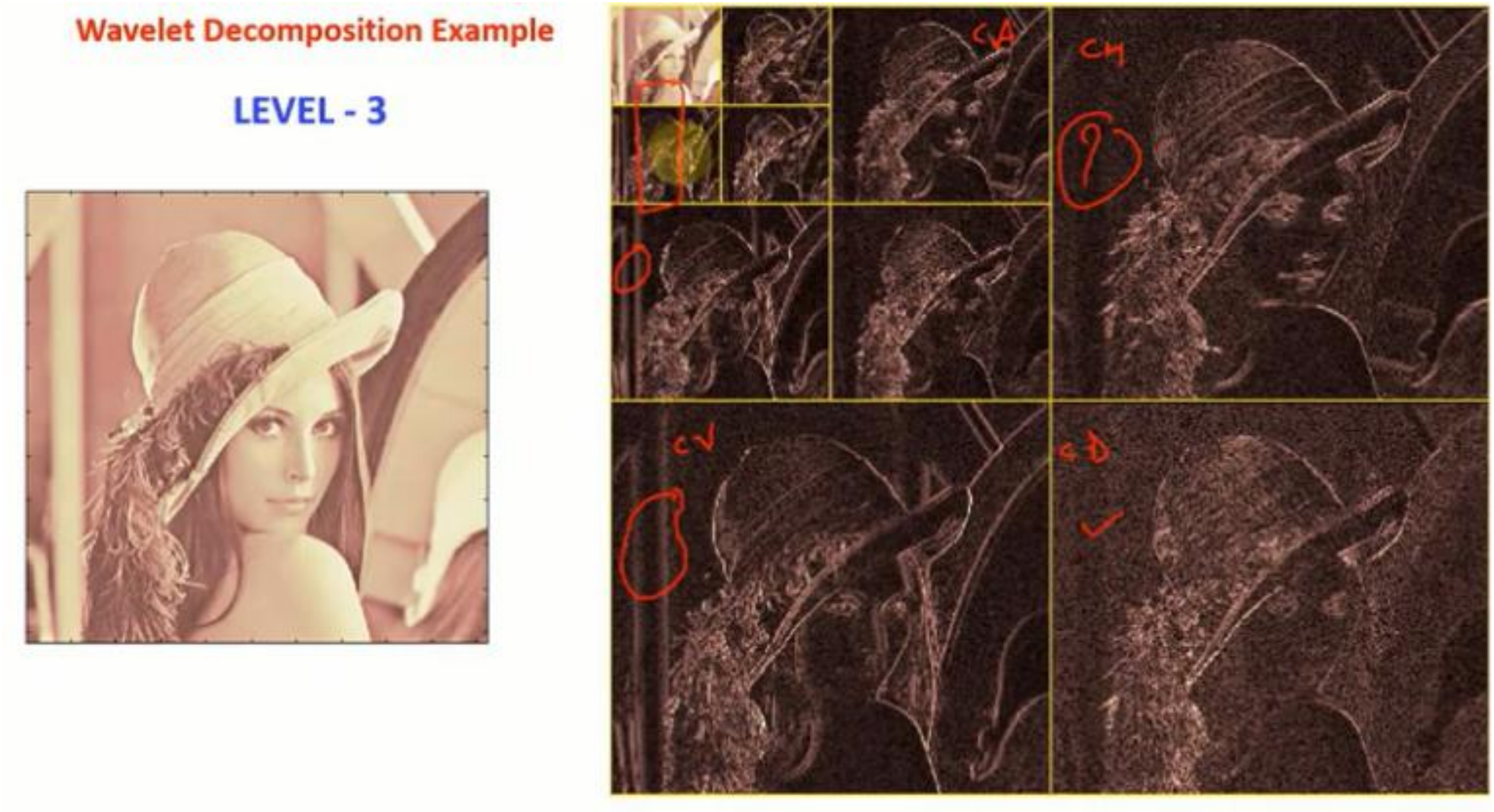

Thank you!