BOX AND MEDIAN FILTERS

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DEFINITION OF IMAGE FILTERS:

Image filters are mathematical operators applied to image data for modifying or enhancing visual quality.

PURPOSE IN COMPUTER VISION:

Filters aim to remove noise, improve image clarity, and prepare images for further analysis.

TYPES OF FILTERS:

Common filters include Box Filtering and Median Filtering, used based on image characteristics.

BOX FILTER MECHANISM:

BOX FILTER OPERATION:

A Box filter replaces each pixel value with the average of surrounding pixels. It smooths the image but may blur edges.

KERNEL SIZE IMPACT:

A larger kernel smooths more, reducing detail, while a smaller kernel retains detail but may miss noise reduction. Balance is key.

APPLICATION AREAS:

Box filters are used in real-time video streaming, image compression, and preparing images for edge detection.

BOX FILTER IN ACTION:

Suppose we have this matrix (small image):
Input Image = [
[1, 2, 3],
[4, 5, 6],
[7, 8, 9]
]
We apply a 2×2 box filter.
Box filter rule:
At each step:

- Take a 2×2 patch.
- Sum all the numbers inside the patch.
- Divide by 4 (since 2×2 = 4) to get the average.
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Step 1: Top-left position
Patch: [
[1, 2],
[4, 5]
]
Sum = 1 + 2 + 4 + 5 = 12
Average = 12 ÷ 4 = 3

Step 2: Move right by 1
Patch: [
[2, 3],
[5, 6]
]
Sum = 2 + 3 + 5 + 6 = 16
Average = 16 ÷ 4 = 4

Step 3: Move down by 1
Patch: [
[4, 5],
[7, 8]
]
Sum = 4 + 5 + 7 + 8 = 24
Average = 24 ÷ 4 = 6

Step 4: Move right again

Patch: [
[5, 6],
[8, 9]
]
Sum = 5 + 6 + 8 + 9 = 28
Average = 28 ÷ 4 = 7

Final Output (after applying 2×2 average box filter):
Filtered Output = [
[3, 4],
[6, 7]
]

MEDIAN FILTER MECHANISM:

OPERATION OF MEDIAN FILTERS:

Median filters replace each pixel value with the median of local neighborhood values, making them less affected by outliers

ROBUSTNESS TO NOISE:

Effective in removing salt-and-pepper noise, preserving image structure and enhancing clarity.

FLEXIBILITY IN KERNEL SIZE:

Varying kernel sizes influence performance; larger sizes may smooth important features, while smaller may not address noise well.

MEDIAN FILTER IN ACTION:

Let’s use the same matrix:

Input Image =

[
  [1, 2, 3],
  [4, 5, 6],

[7, 8, 9]
]

Apply a 2×2 median filter.
At each step:

- Take a 2×2 patch.
- List all the numbers inside the patch.
- Sort them.
- Pick the median (middle number)

Step 1: Top-left position
[
[1, 2],
[4, 5]
]

Numbers: 1, 2, 4, 5
Sorted: 1, 2, 4, 5
Middle values: 2 and 4 → Median = (2 + 4) ÷ 2 = **3**
(When even number of values, median = average of middle two.)

Step 2: Move right by 1
[
[2, 3],
[5, 6]
]

Numbers: 2, 3, 5, 6
Sorted: 2, 3, 5, 6
Middle values: 3 and 5 → Median = (3 + 5) ÷ 2 = **4**

Step 3: Move down by 1
[
[4, 5],
[7, 8]
]

Numbers: 4, 5, 7, 8
Sorted: 4, 5, 7, 8

Middle values: 5 and 7 → Median = (5 + 7) ÷ 2 = **6**

Step 4: Move right again

[
  [5, 6],
  [8, 9]
]

Numbers: 5, 6, 8, 9
Sorted: 5, 6, 8, 9
Middle values: 6 and 8 → Median = (6 + 8) ÷ 2 = **7**

Final Output

[
  [3, 4],
  [6, 7]
]

COMPARING BOX AND MEDIAN FILTERS:

PERFORMANCE ANALYSIS:

Box filters are efficient for uniform noise, while Median filters excel in edge preservation for non-uniform noise.

IMPACT ON IMAGE DETAILS:

Box filters blur edges, potentially losing detail, whereas Median filters maintain clarity and precision.

PRACTICAL APPLICATIONS:

Box filters favor speed, while Median filters suit high-importance imagery requiring detail.