Study of Medical Image Segmentation Using Neural Networks

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Image Segmentation

- Segmentation partitions an image into distinct regions containing each pixels with similar attributes.
- Goal is to change image into some which is more meaningful and easier to analyze.

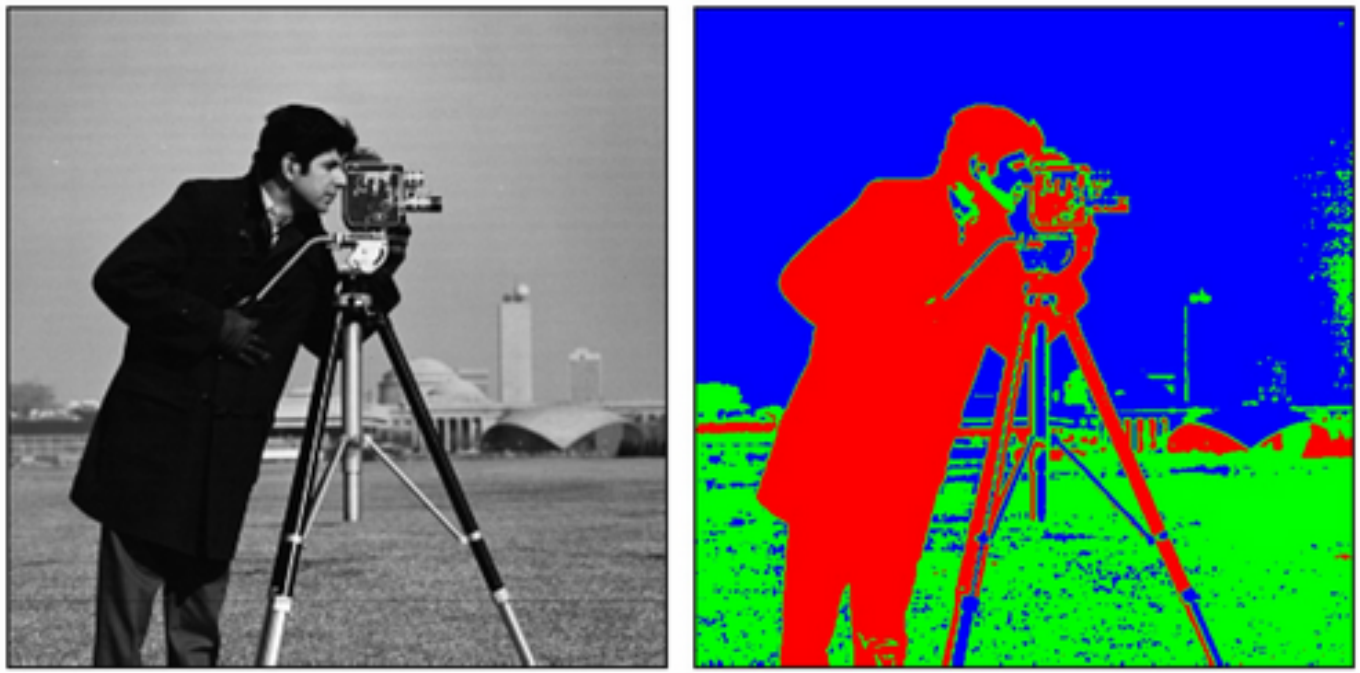


FIGURE – Image Segmentation [1]

1. https ://in.mathworks.com/matlabcentral/mlc-downloads/downloads/submissions/41967/versions/2/screenshot.jpg

- Brain tumor and Hippocampus segmentation is used in Medical image segmentation.
- MRI is used to understand this tumor regions.
- Amount of data created is large.
- Not possible to simulate in reasonable amount of time.
- Accurate segmentation is required to maximize the likelihood of successful treatment.
- Manual segmentation is slow and tedious.
- High demand for computer algorithms that can do this quickly and accurately.

Autoencoder Model

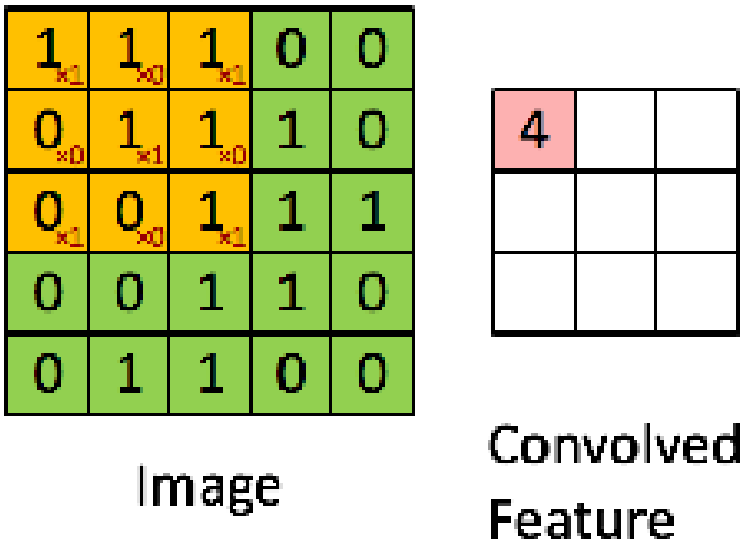
- Used for pixel wise label predictions.
- Consists of two parts : encoding and decoding parts.
- Encoding and decoding parts consists of four layer.
  - Convolution Layer
  - Max pooling Layer
  - ReLU Function
  - UpSampling Layer

Convolution Layer

- Extracts features from the input image.
- Preserves spatial relationships between pixels.
- 3x3 matrix (filter) slides over the image.
- Filters acts as feature detector.
- **Conv2D(filters, kernel_size, strides=(1, 1), padding='valid')**.

Convolution Layer

- Matrix is called as ‘filter’ or ‘feature detector’.
- Different filters are used for different feature selections.



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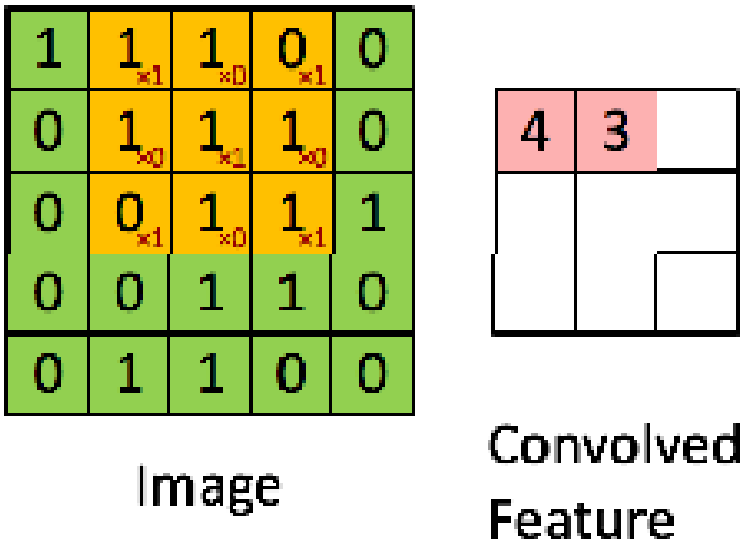

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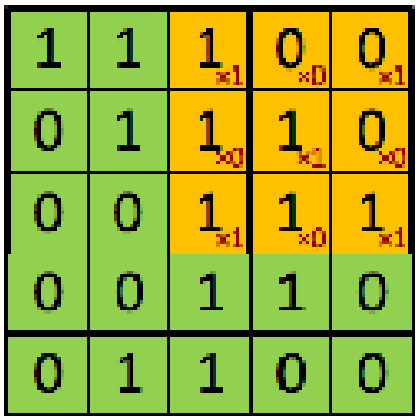

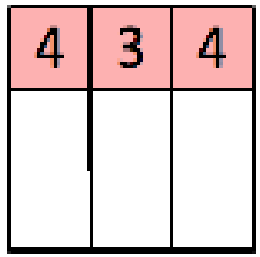

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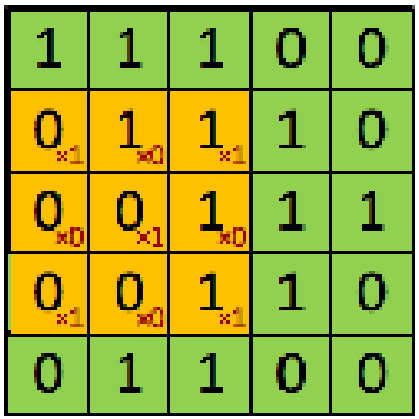
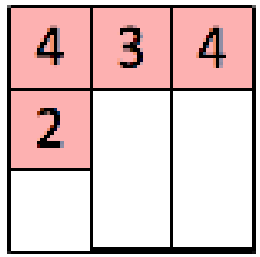


Image



Convolved Feature

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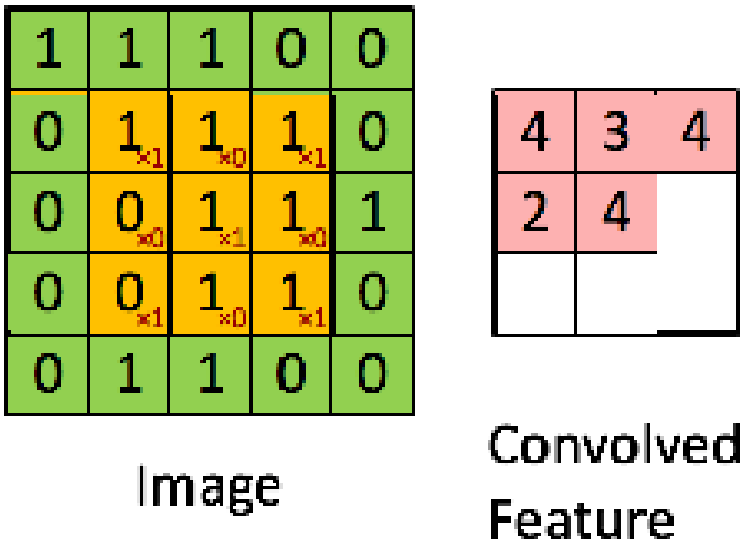

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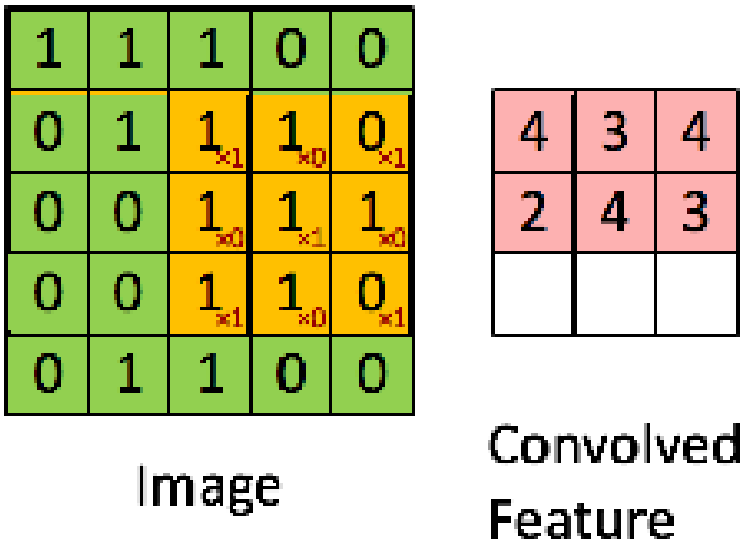

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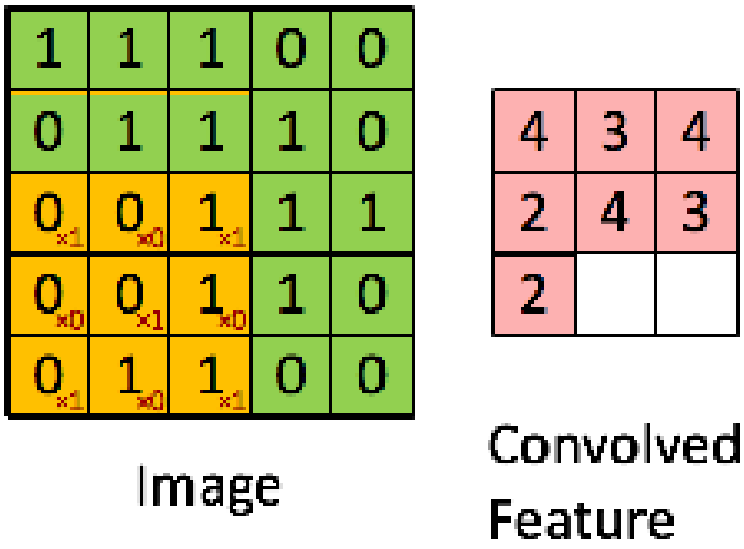

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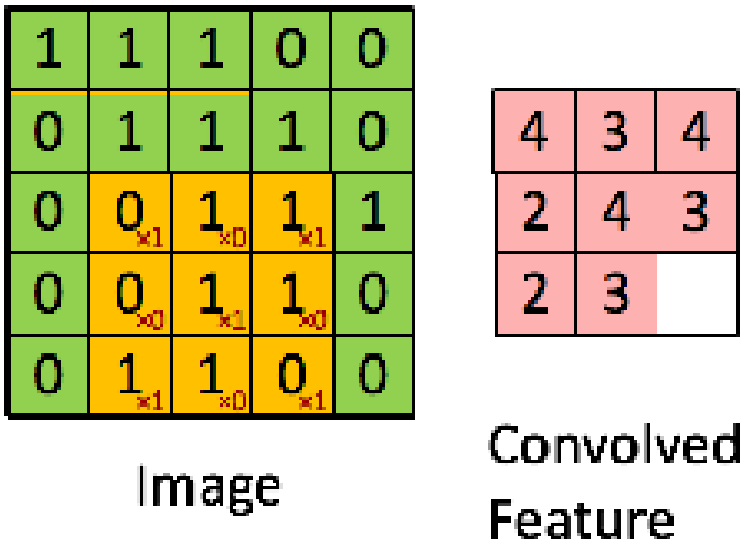

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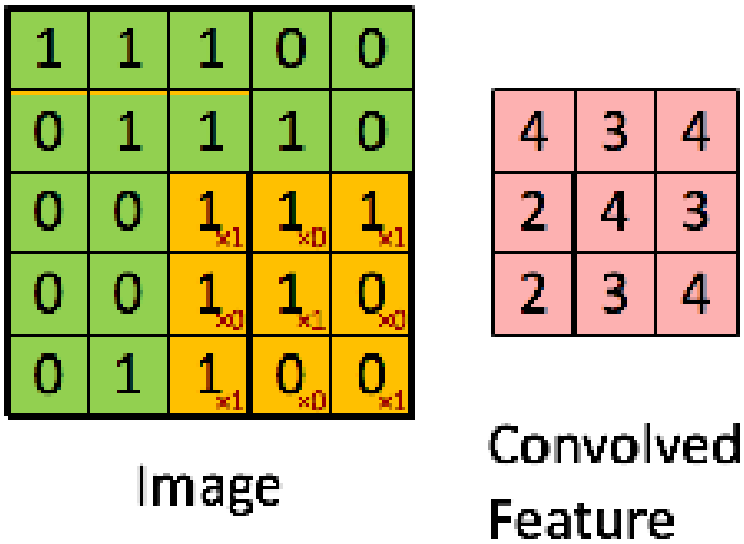

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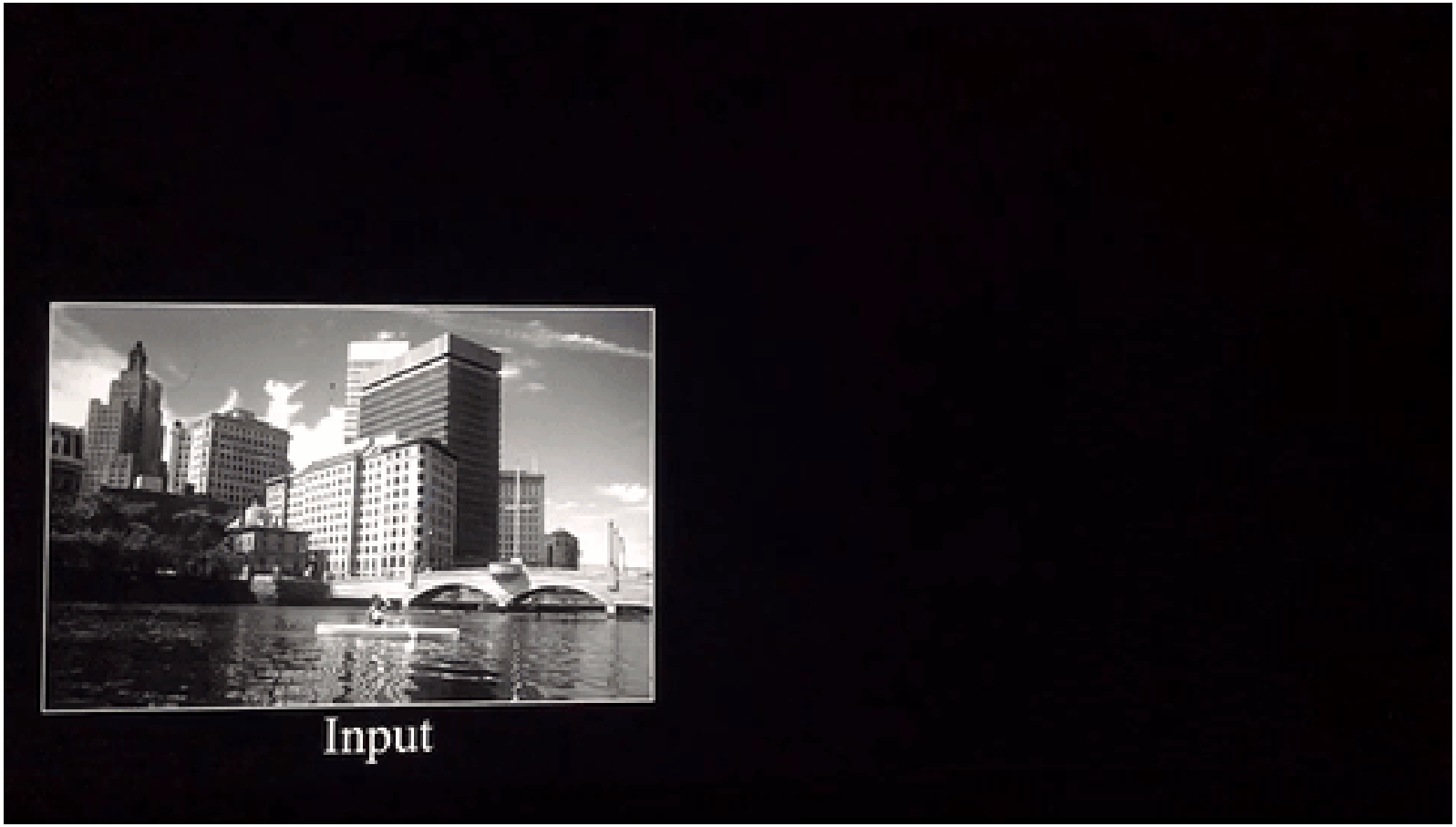

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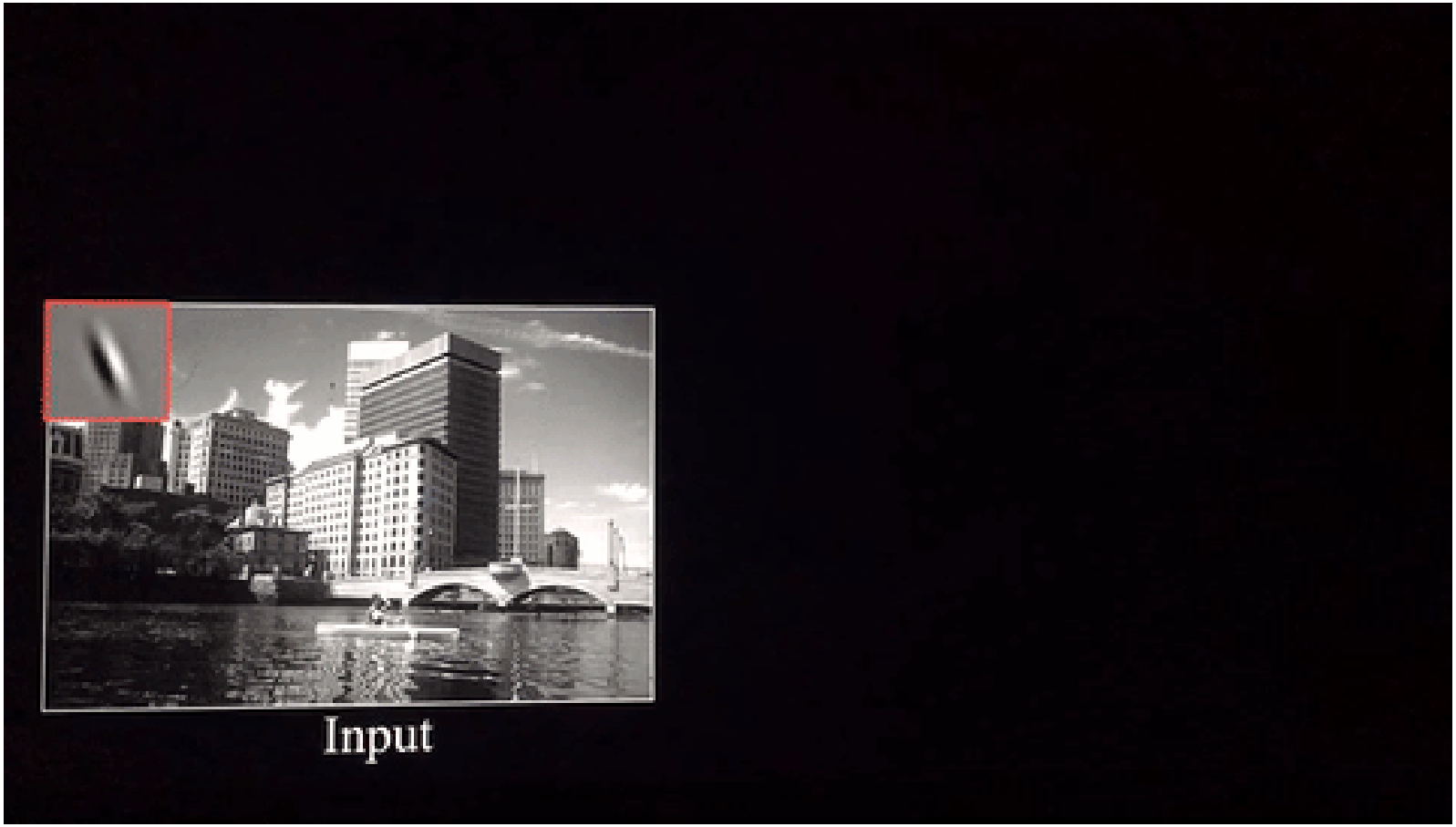

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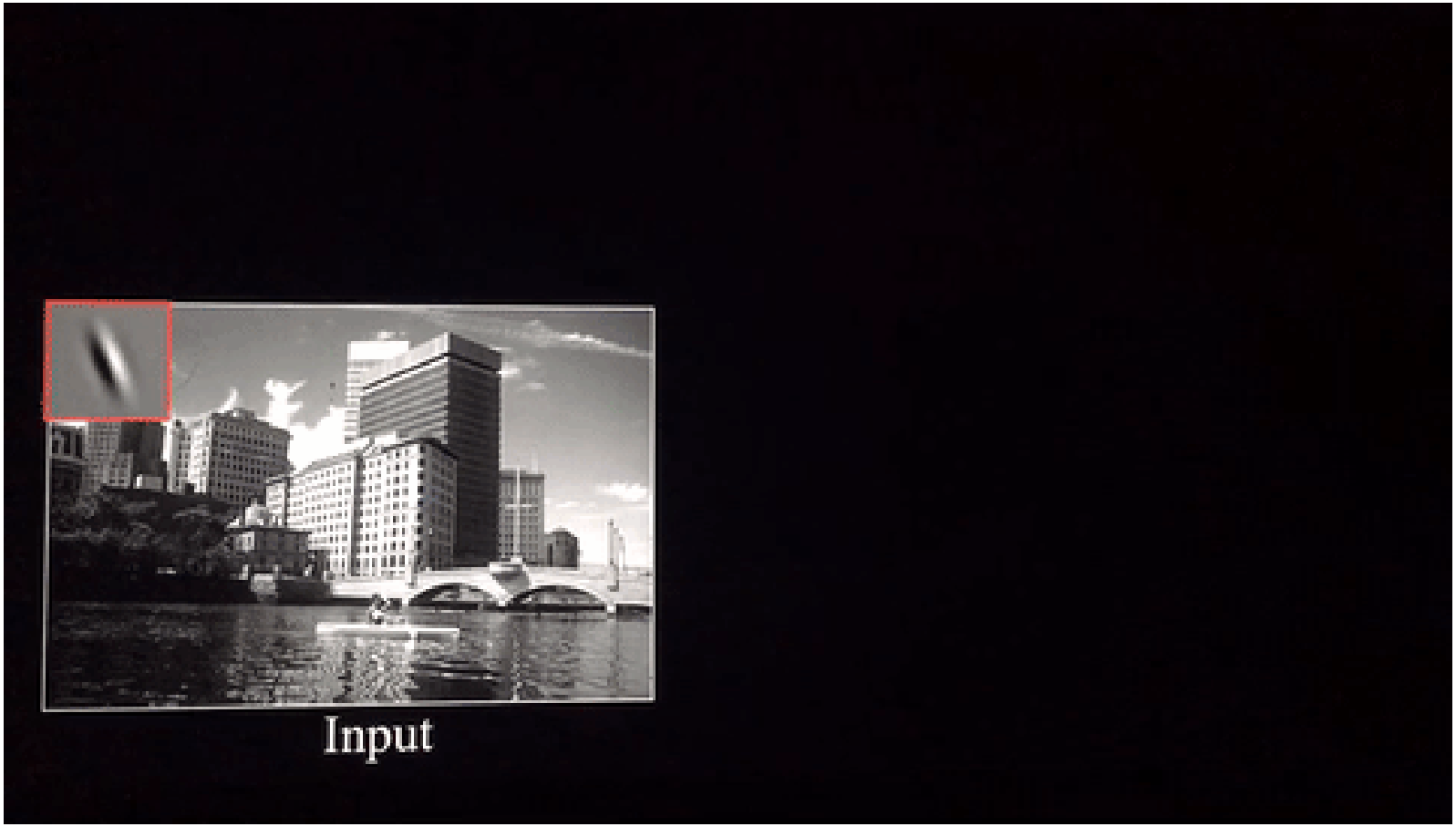

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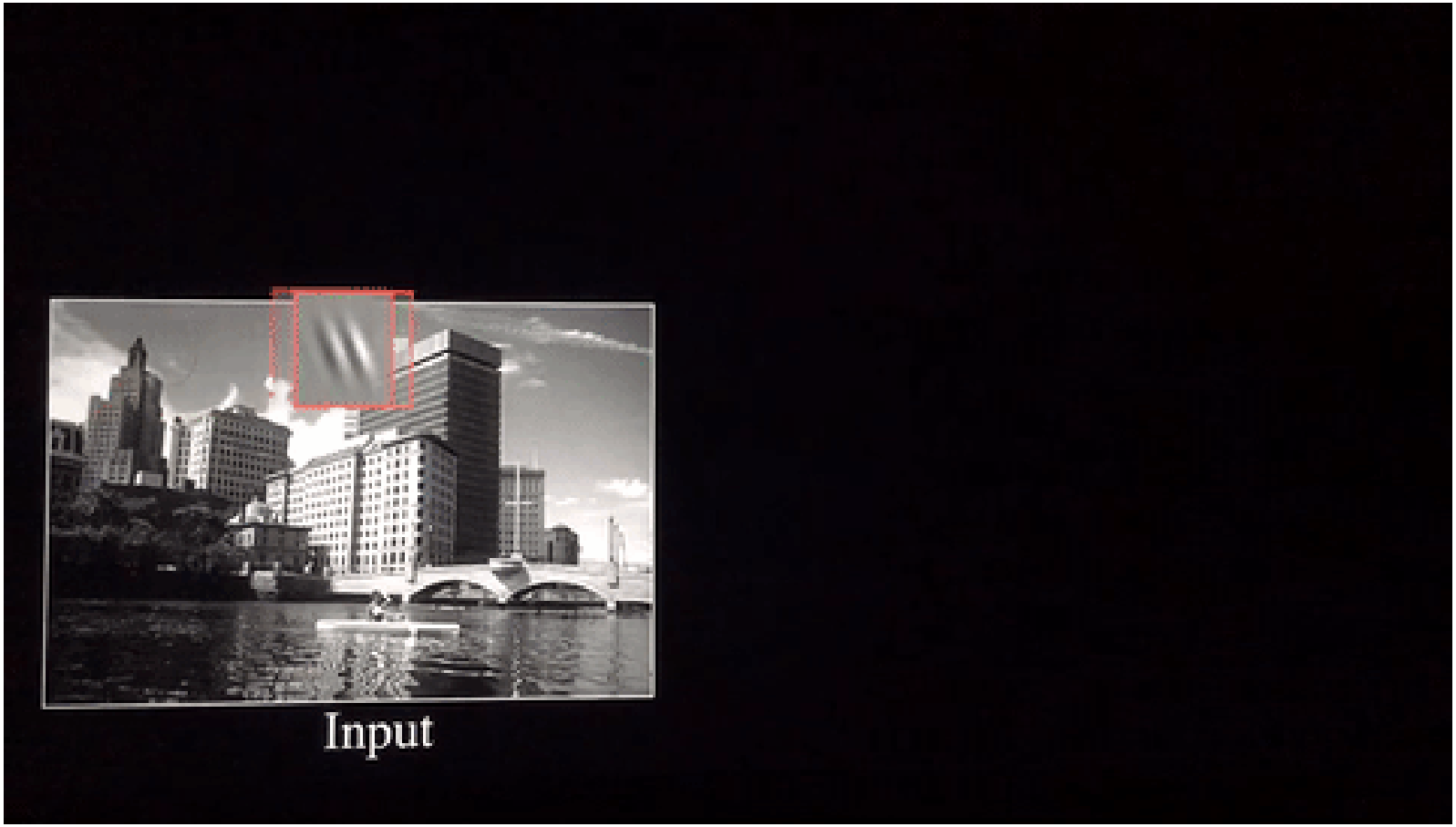

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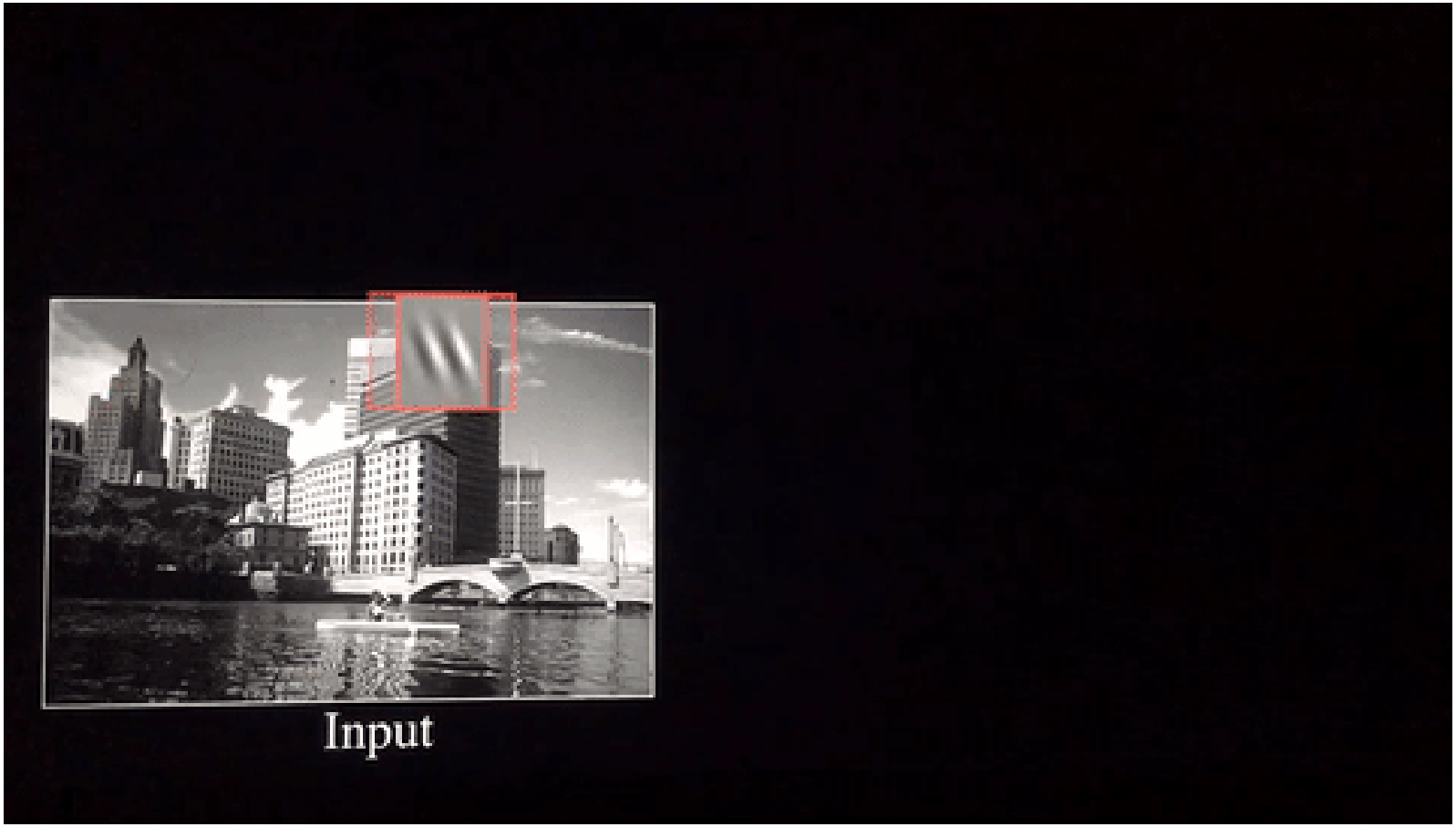

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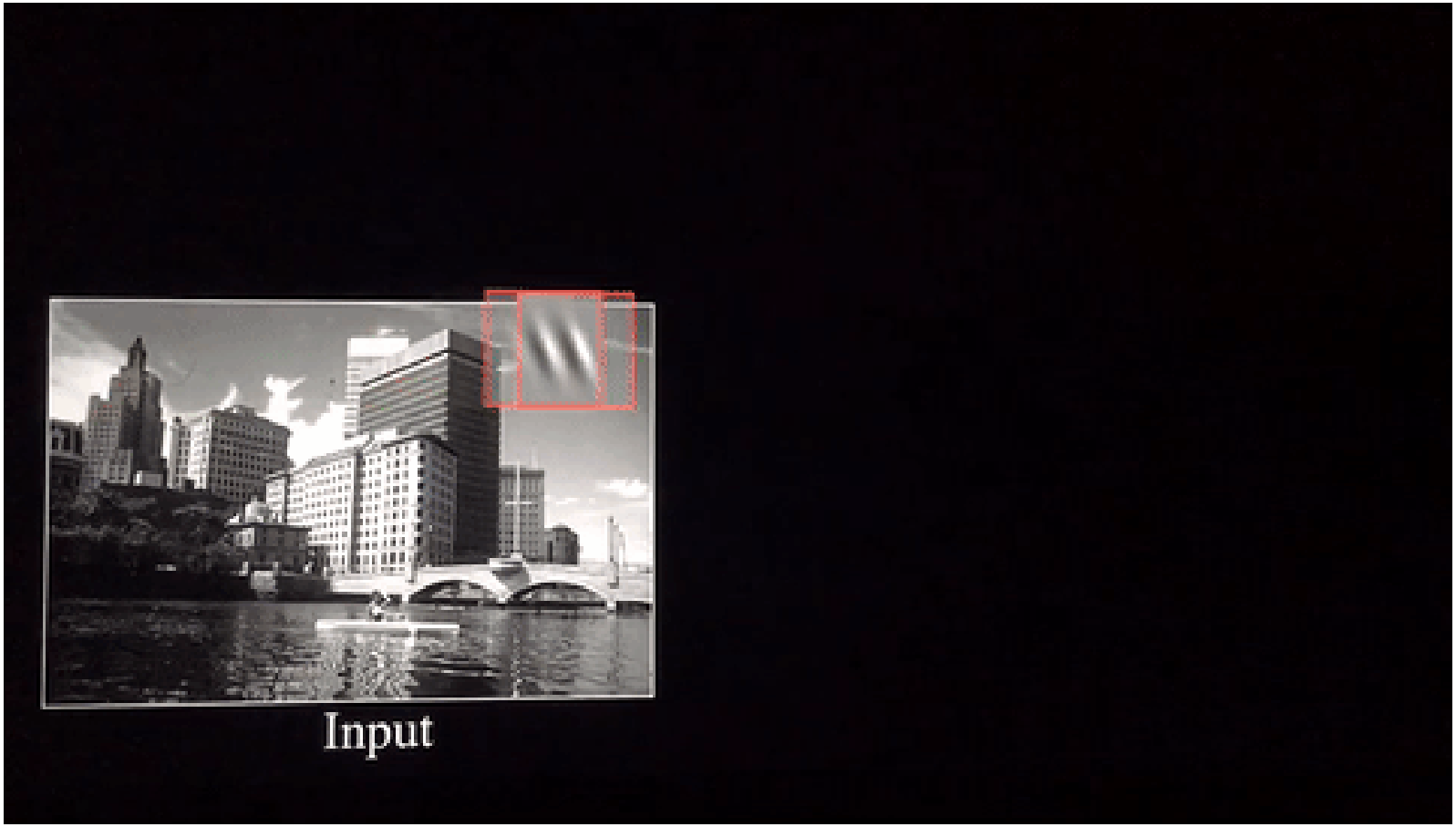

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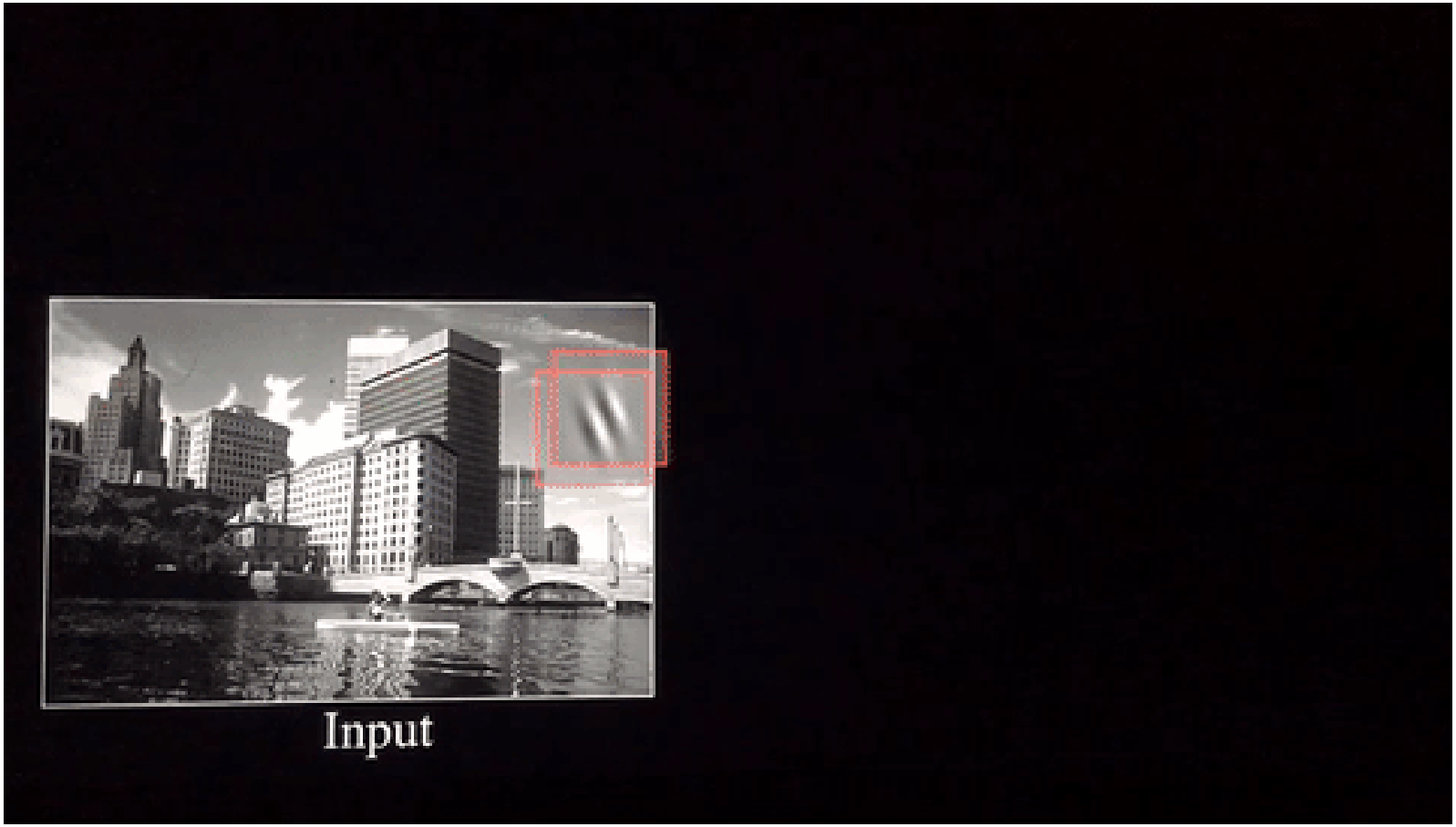

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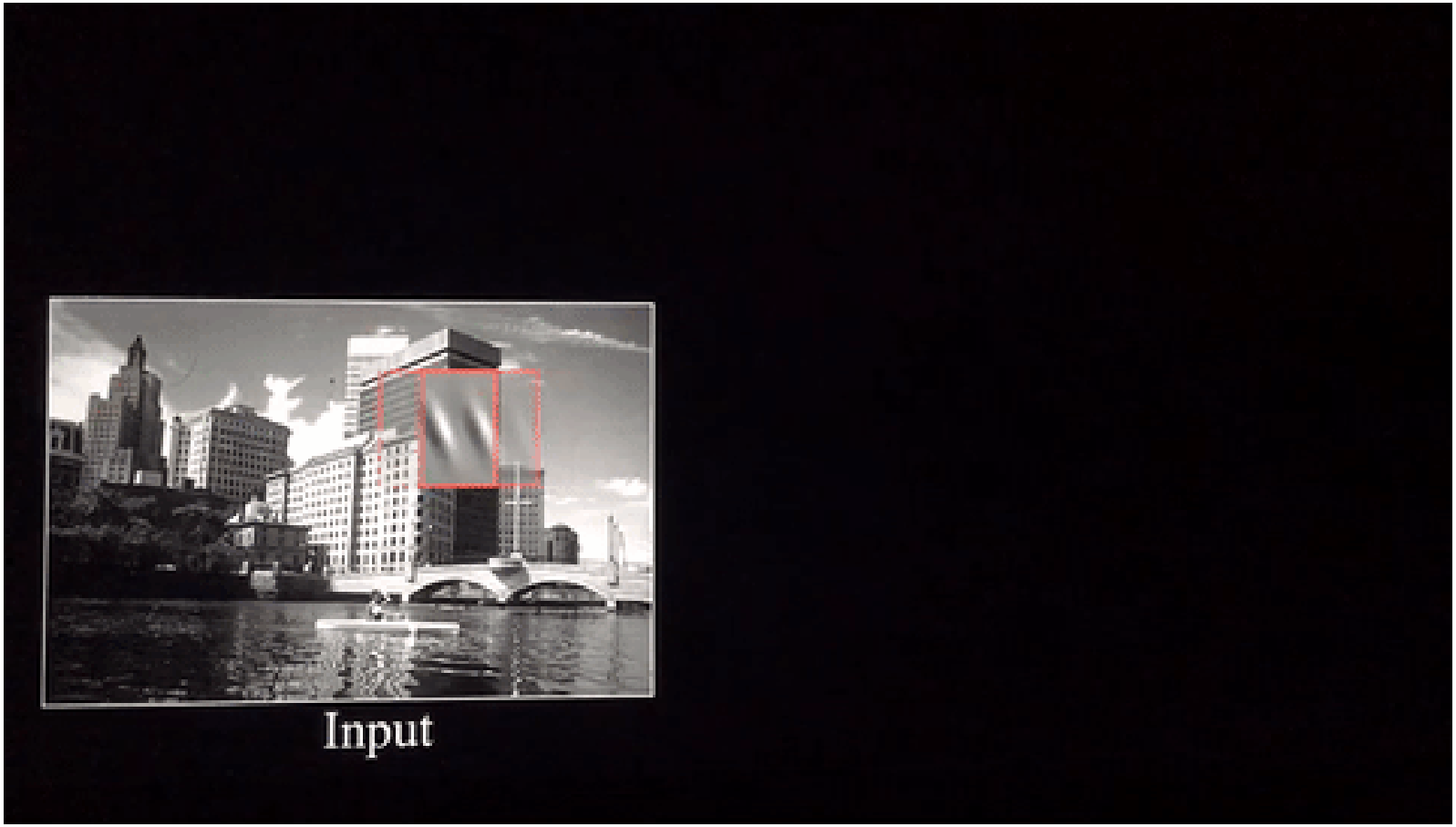

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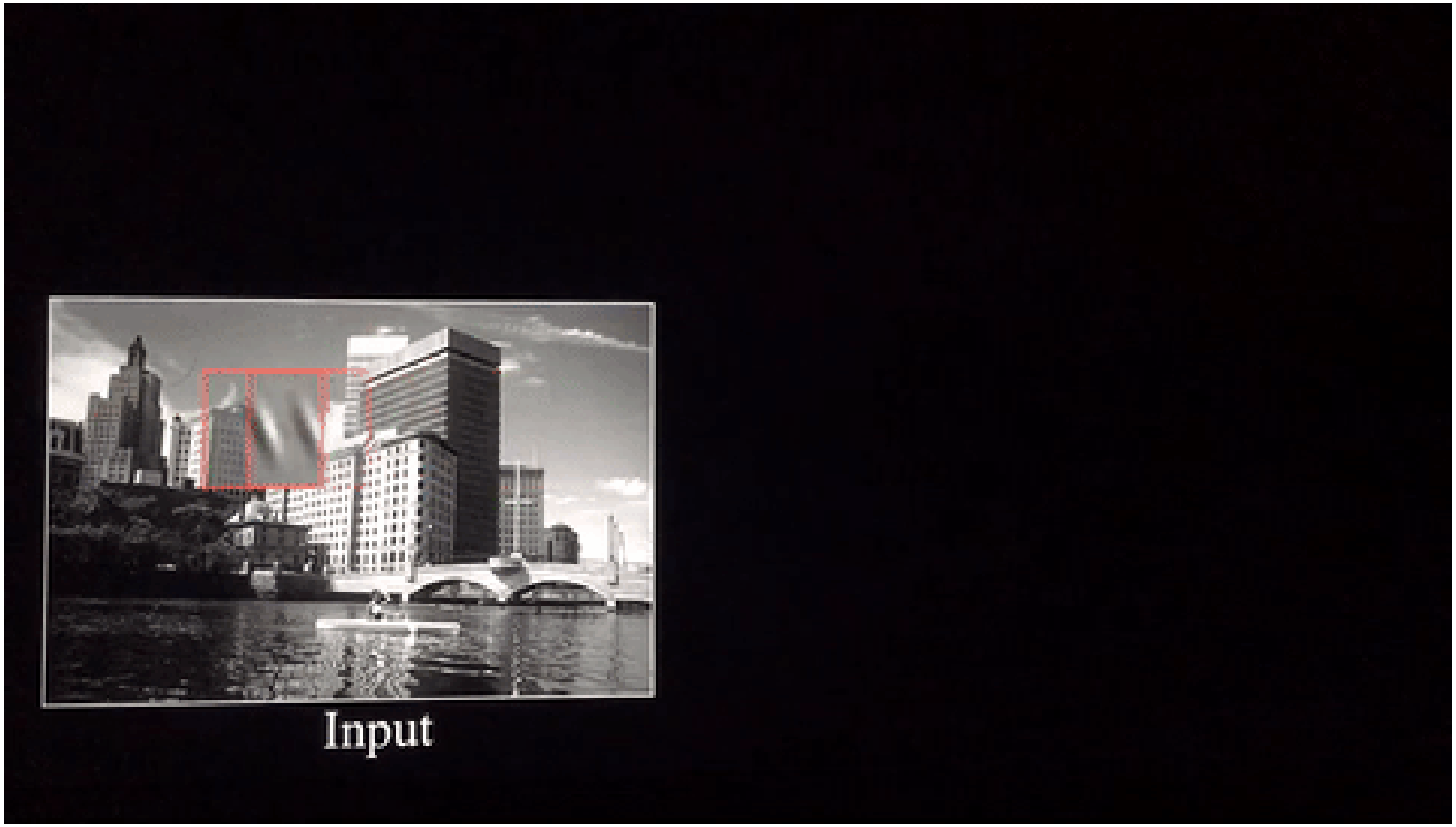

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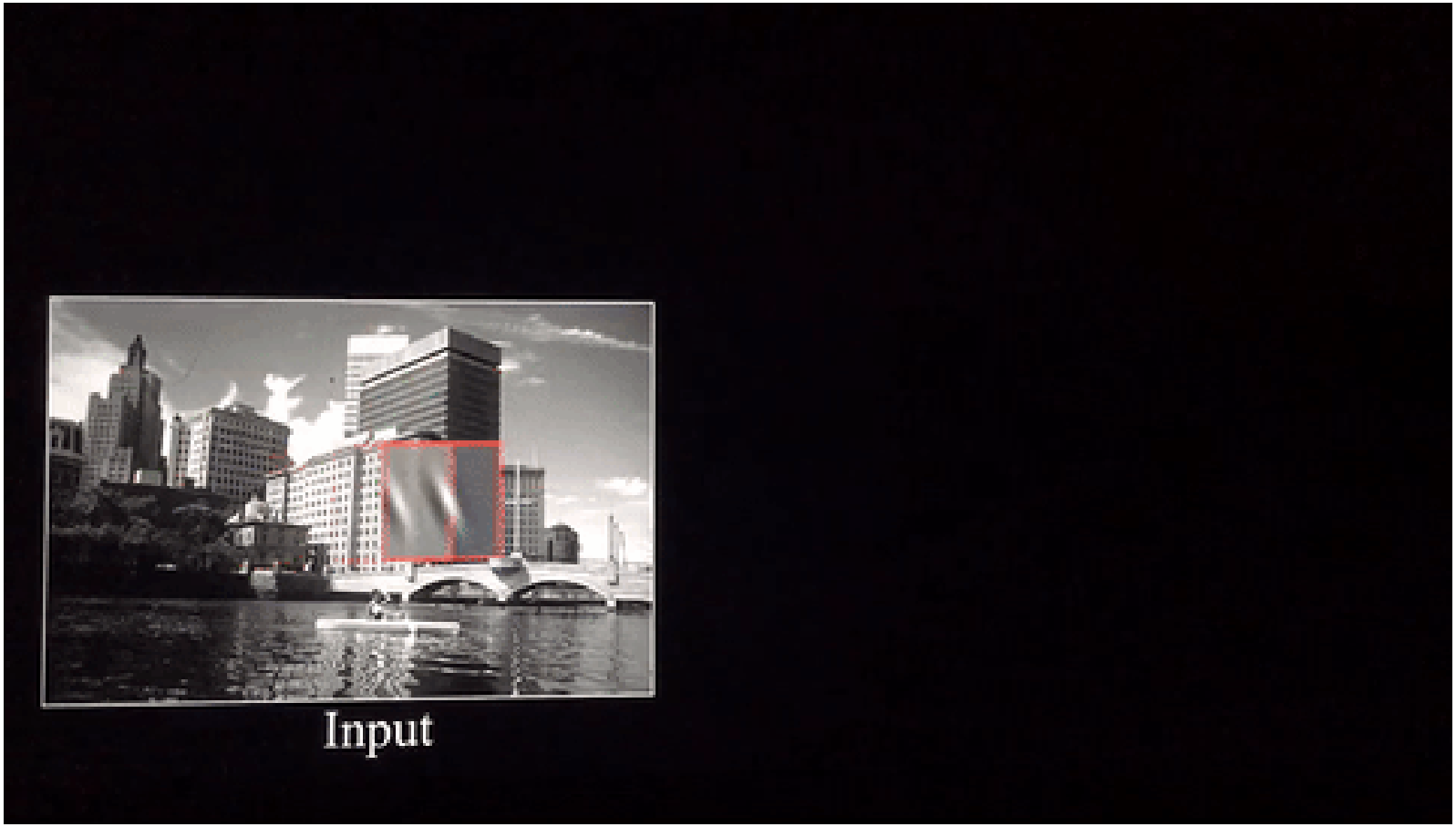

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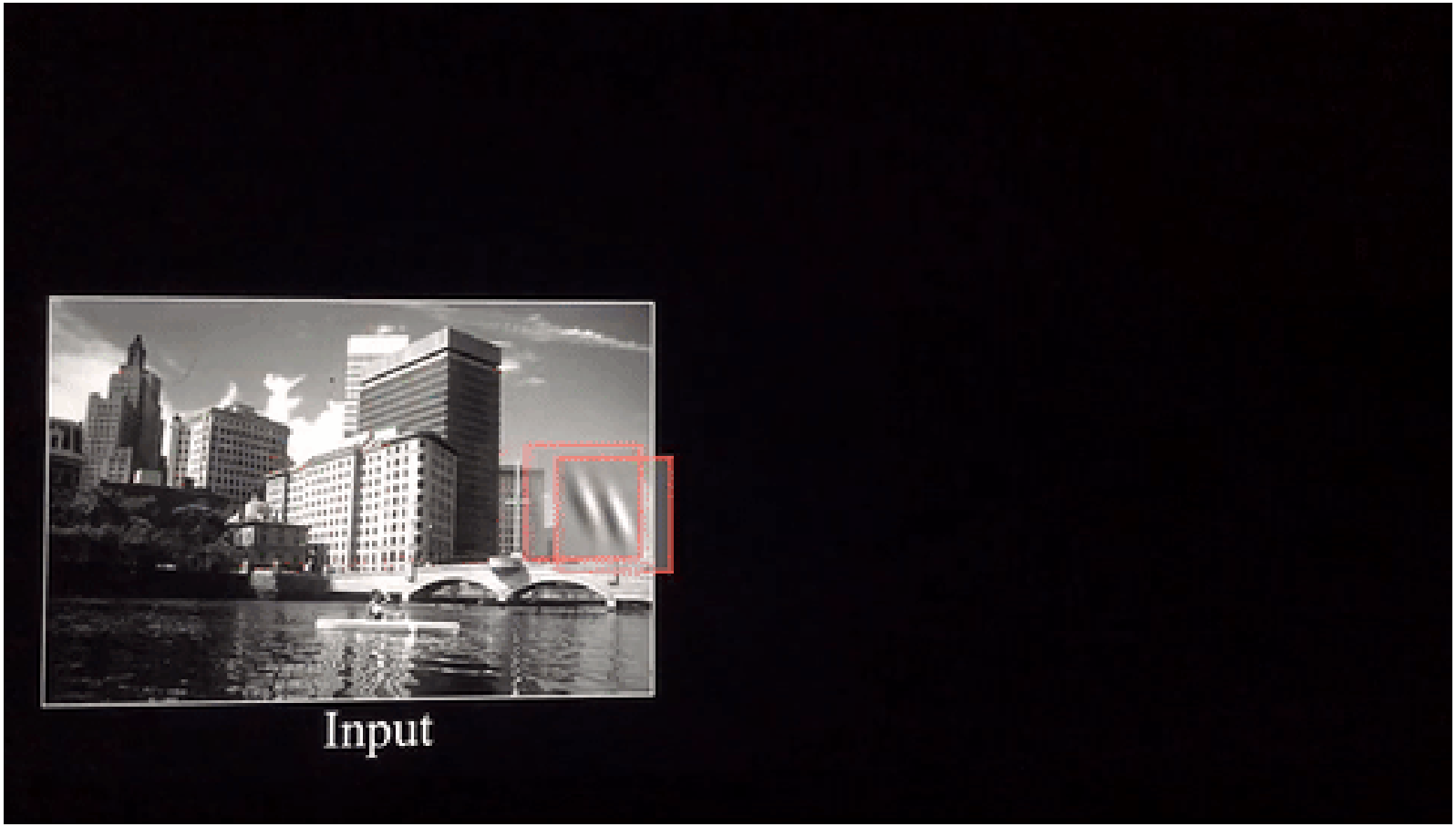

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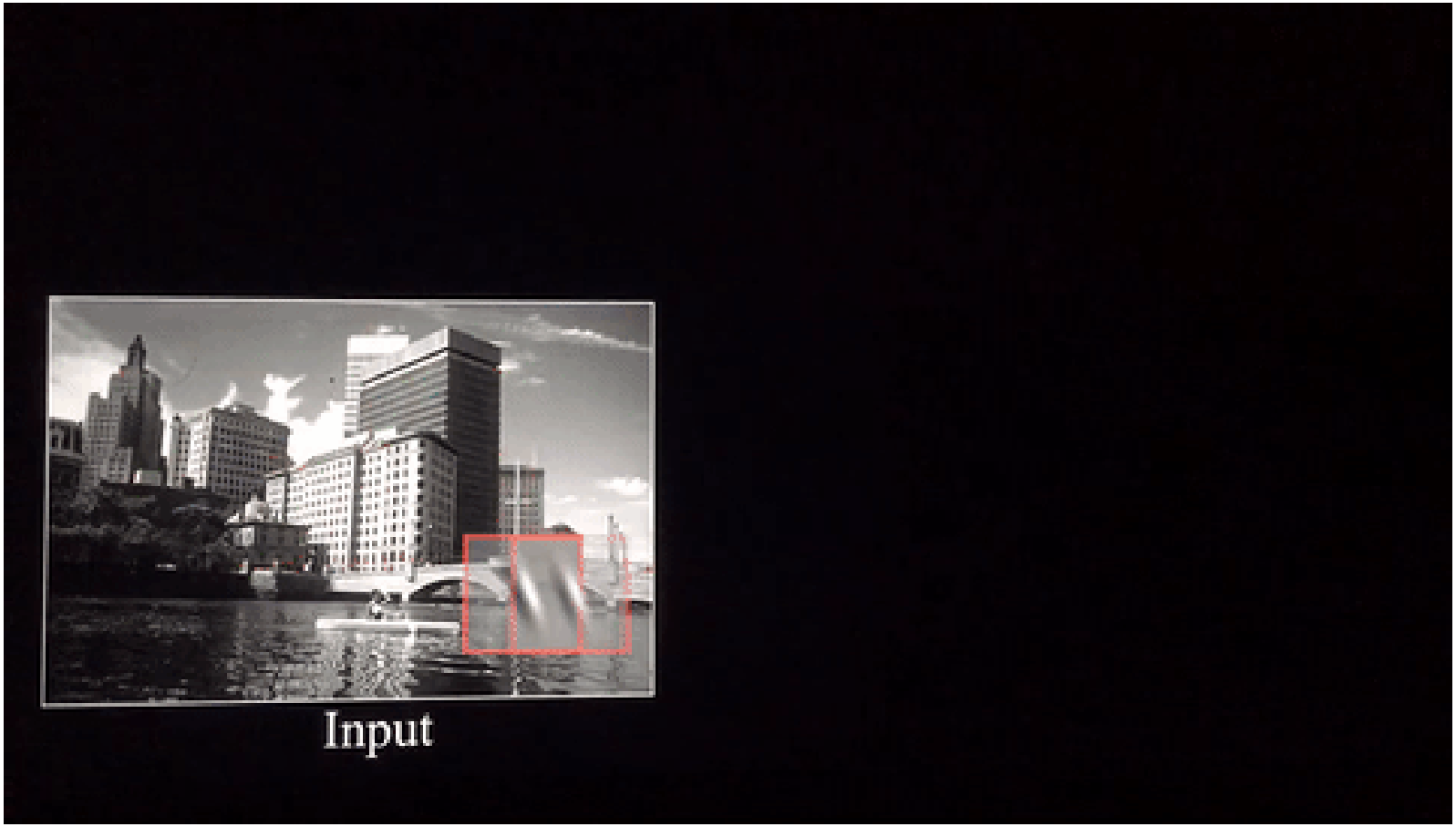

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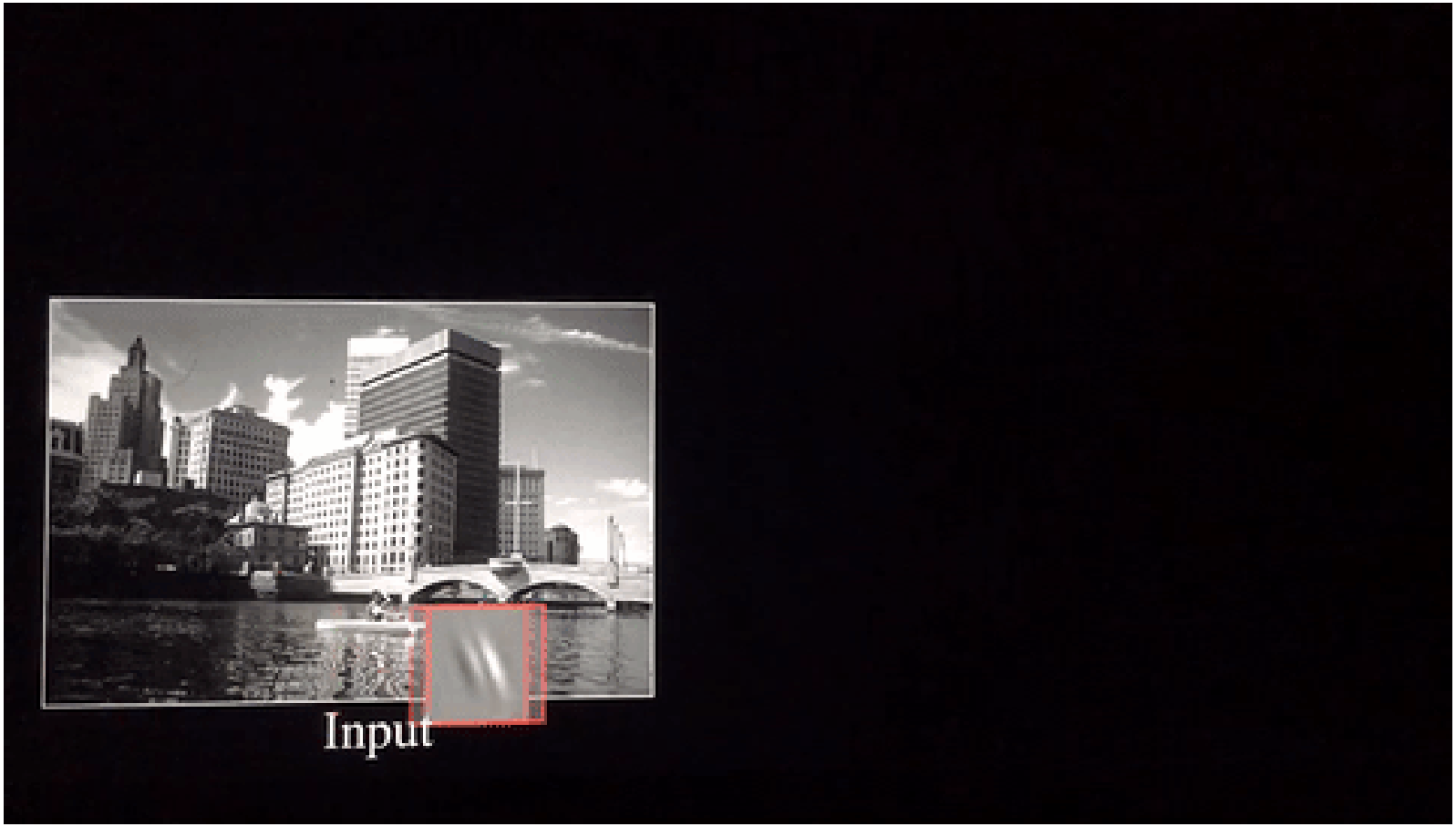

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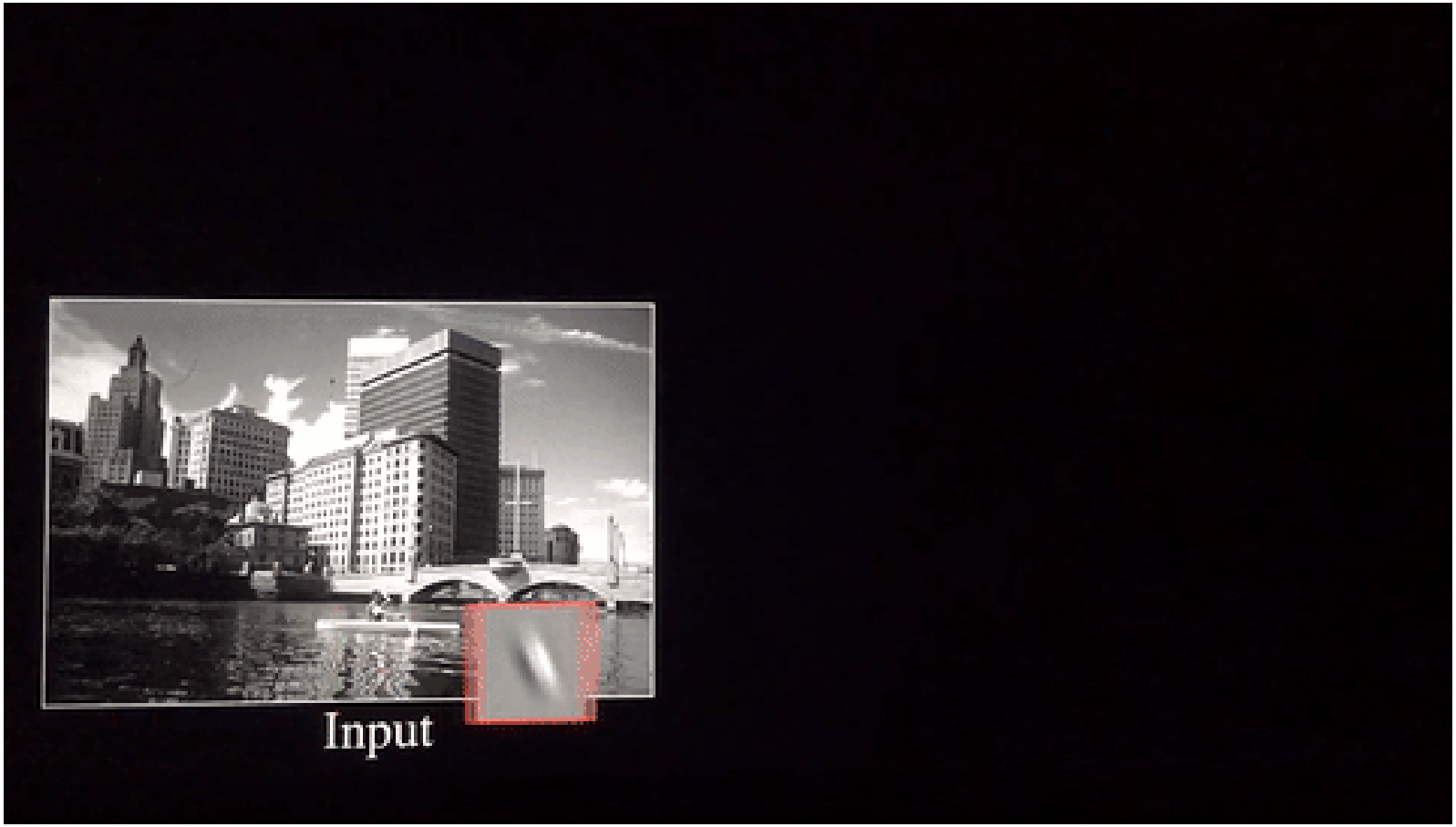

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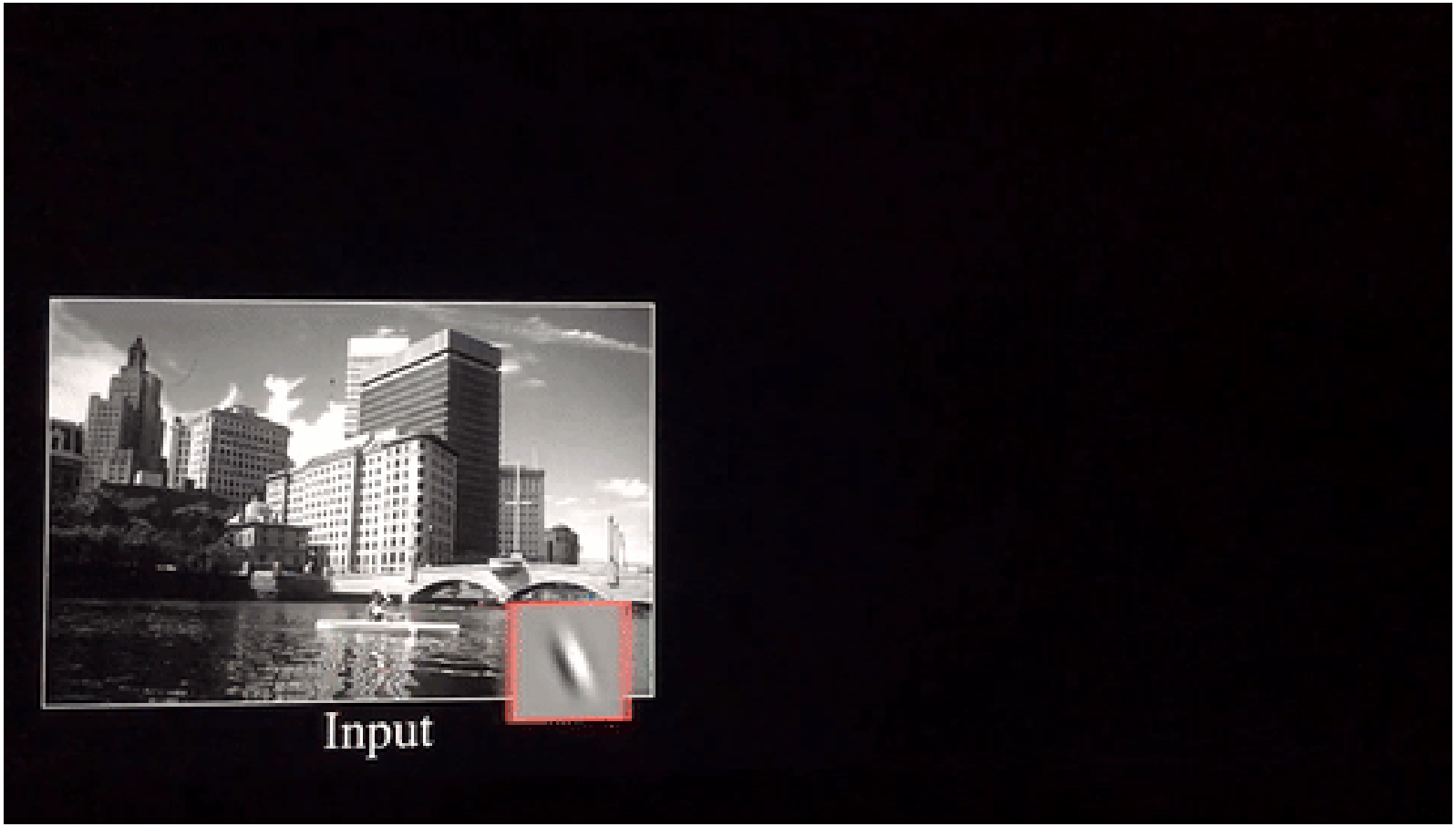

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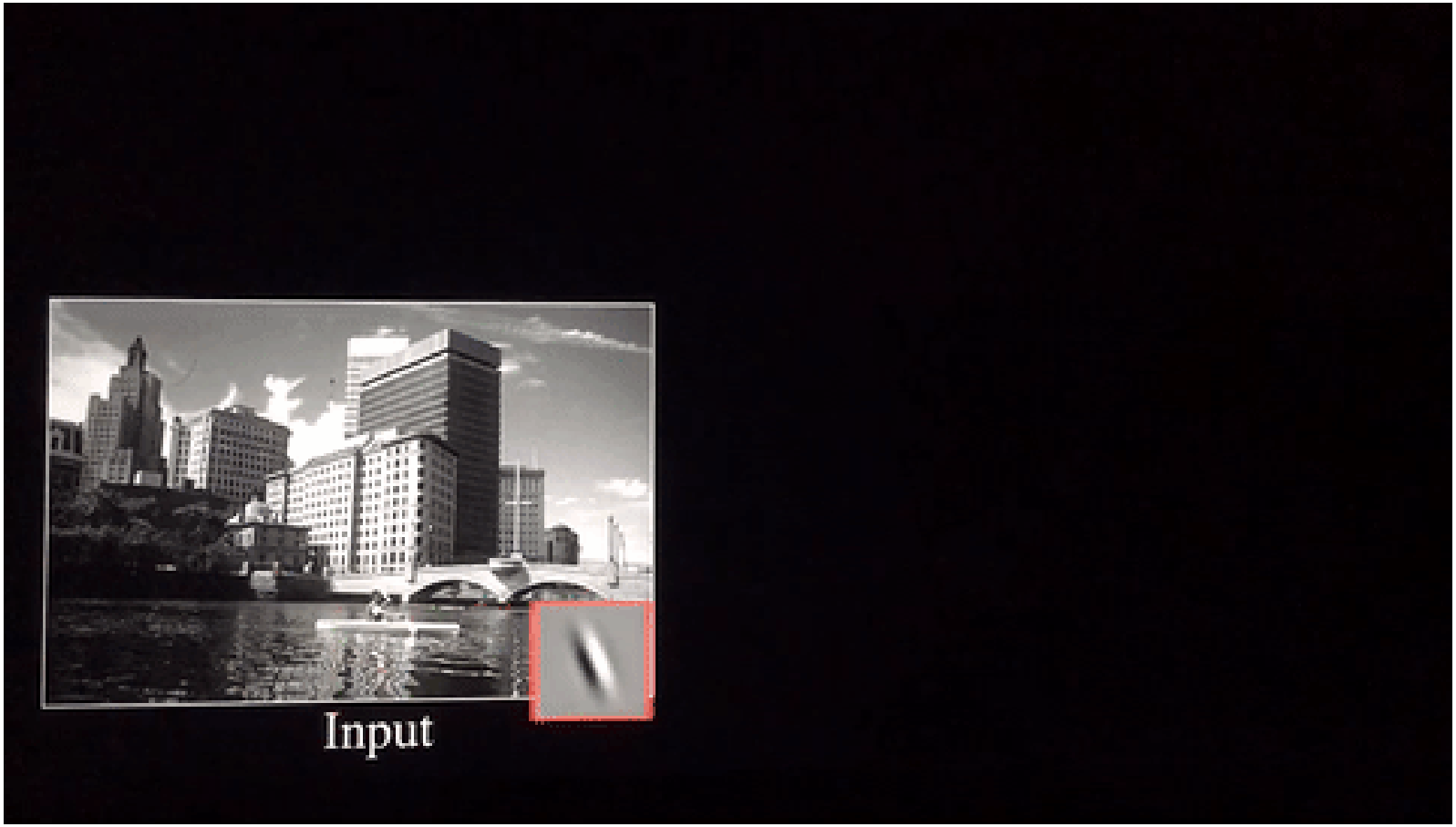

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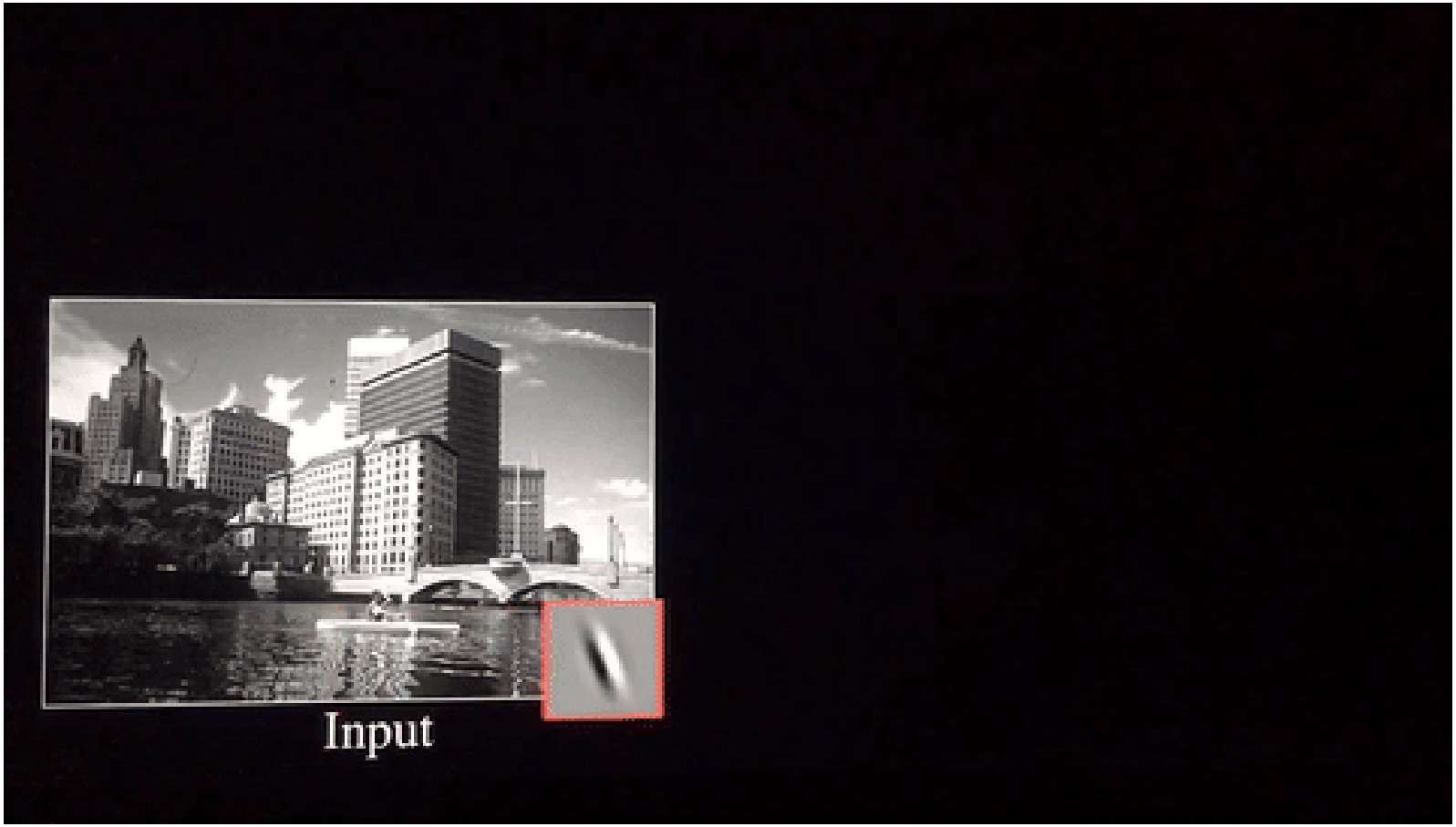

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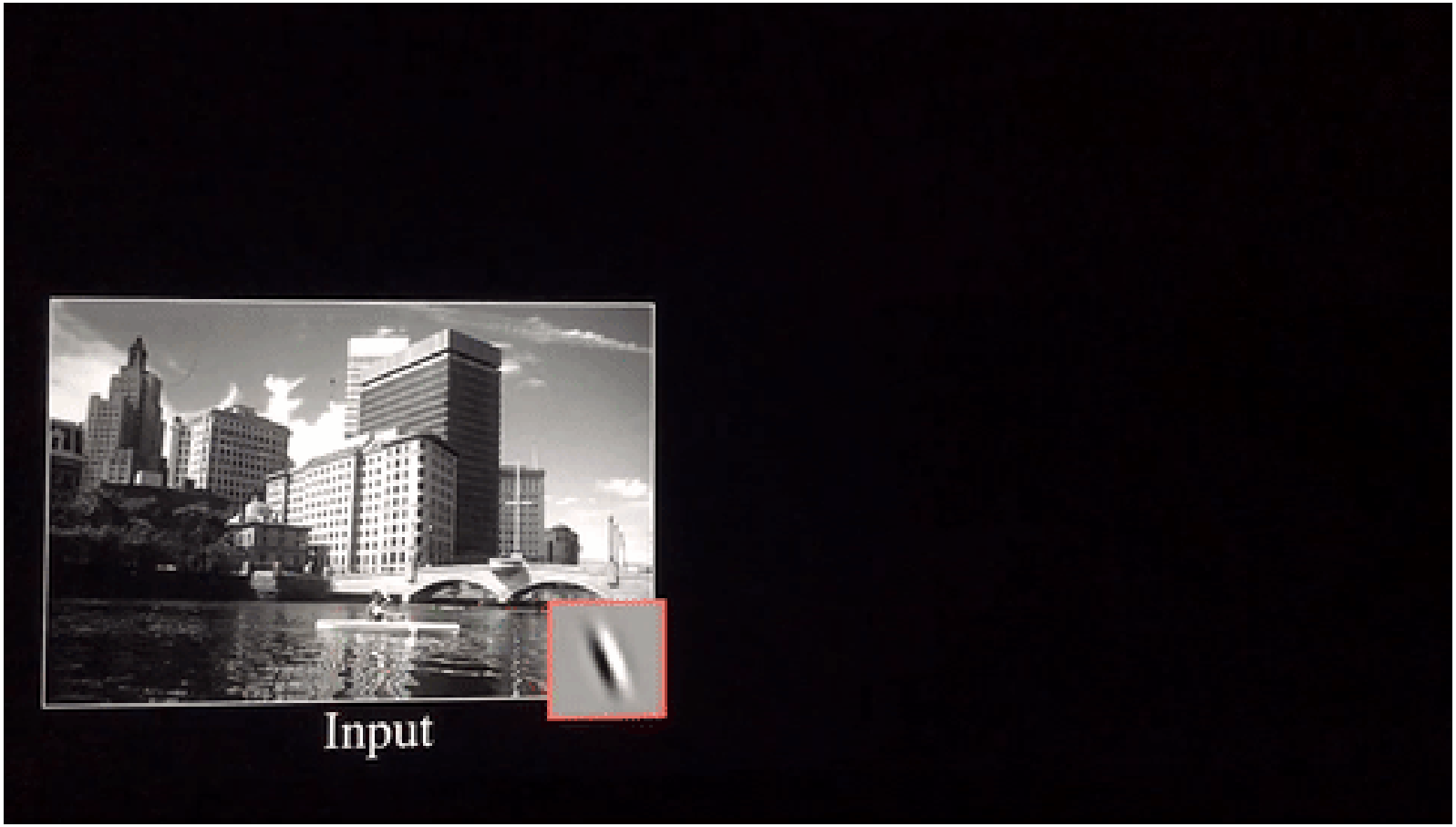

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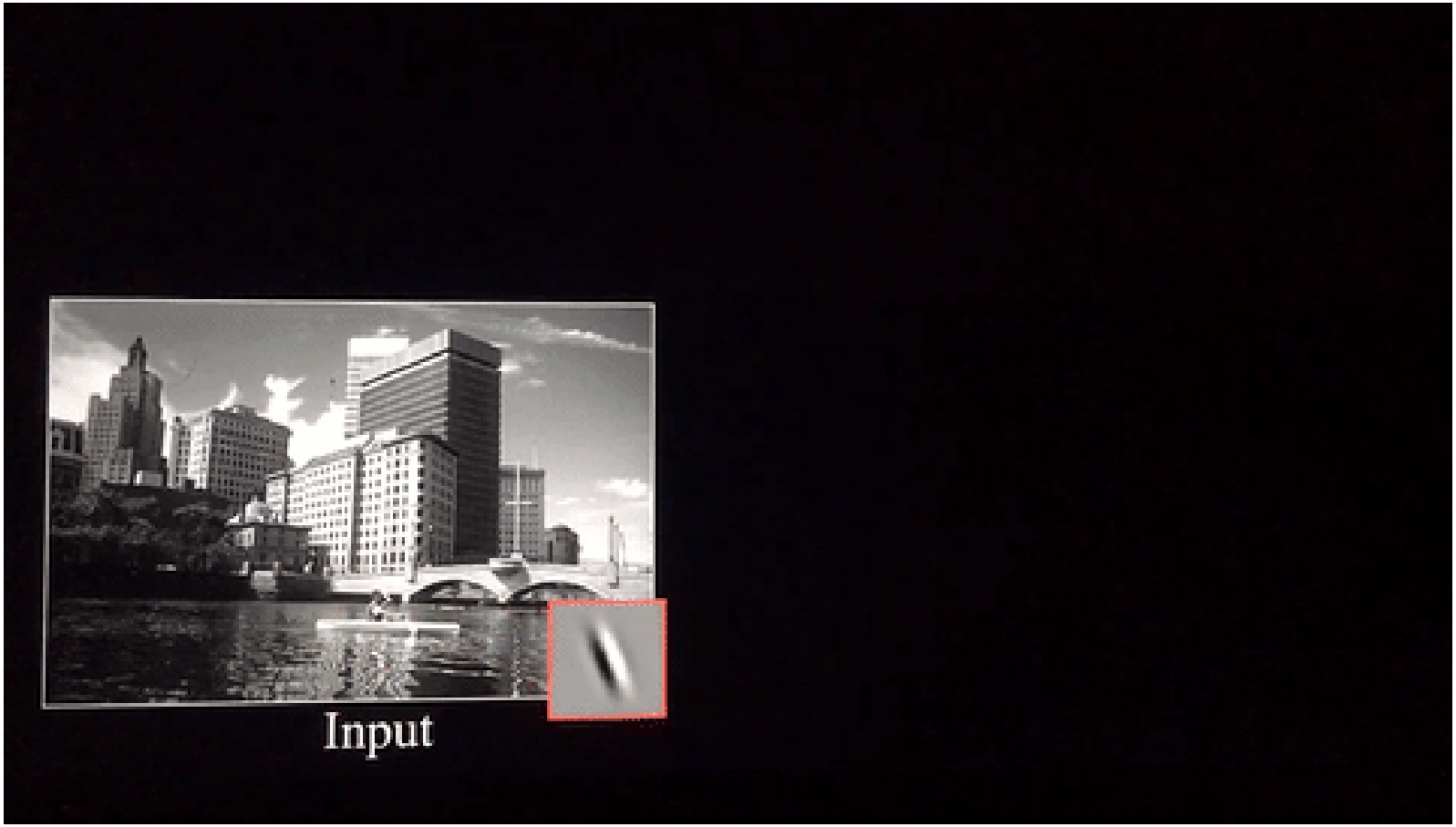

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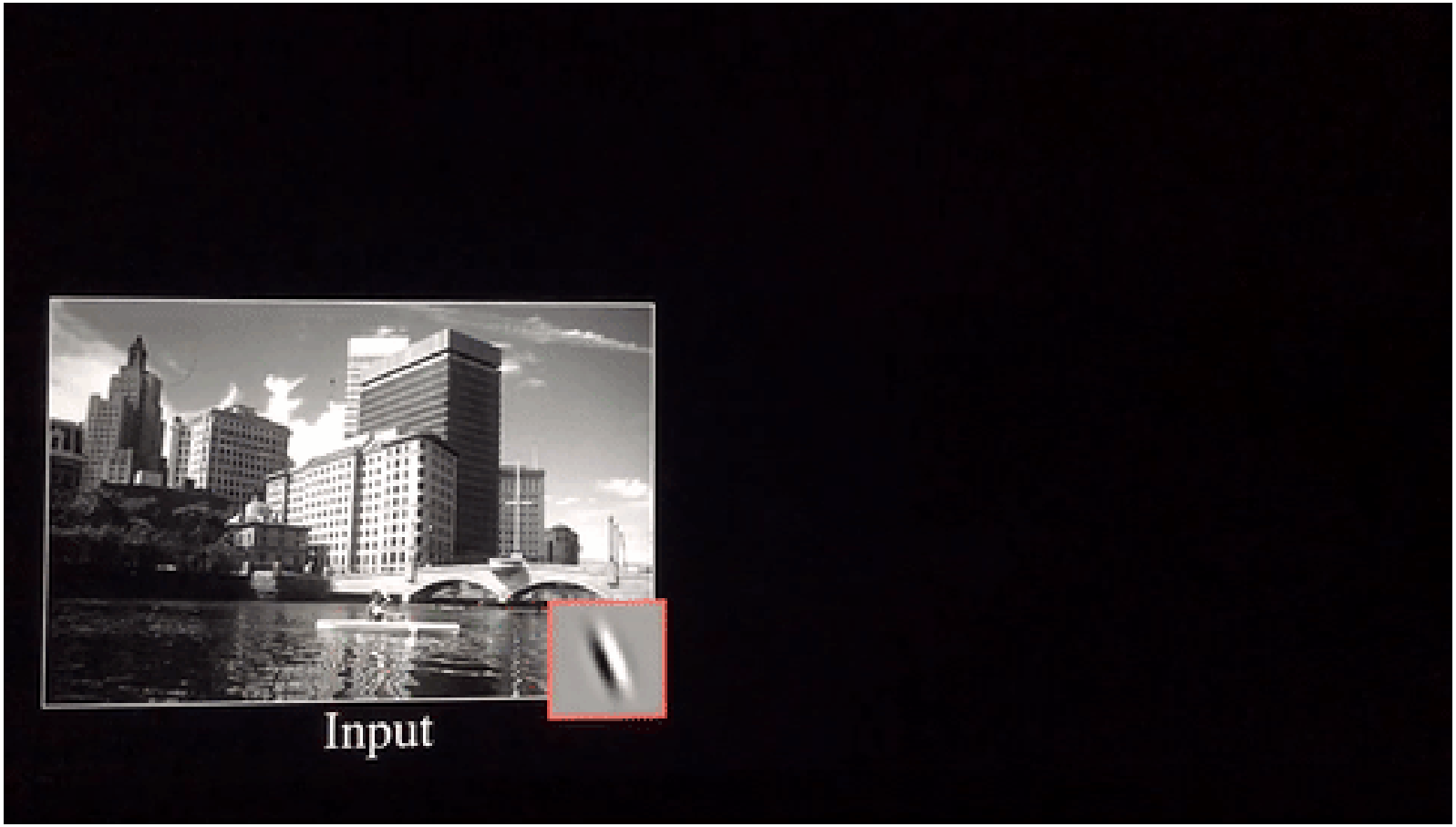

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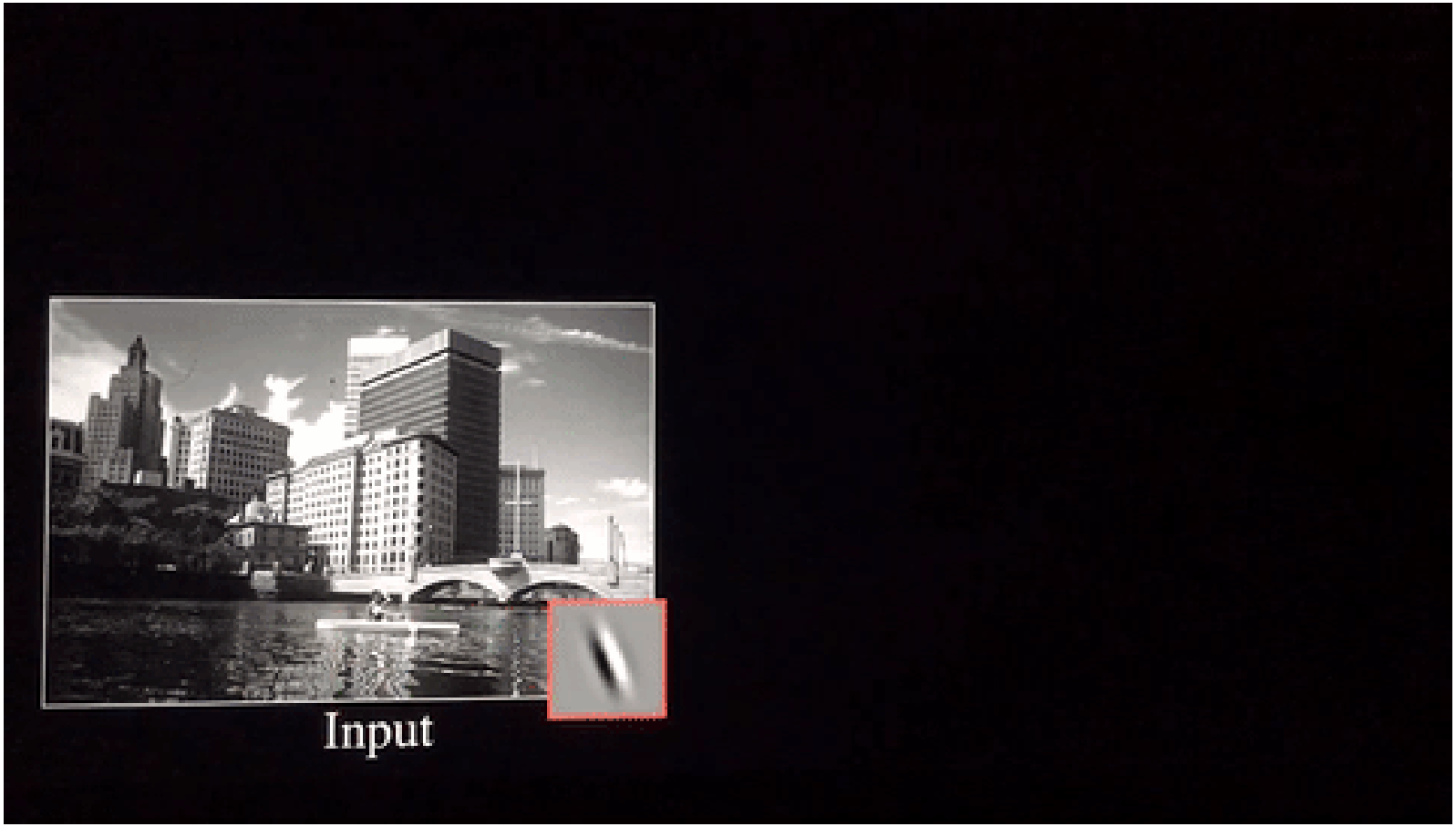

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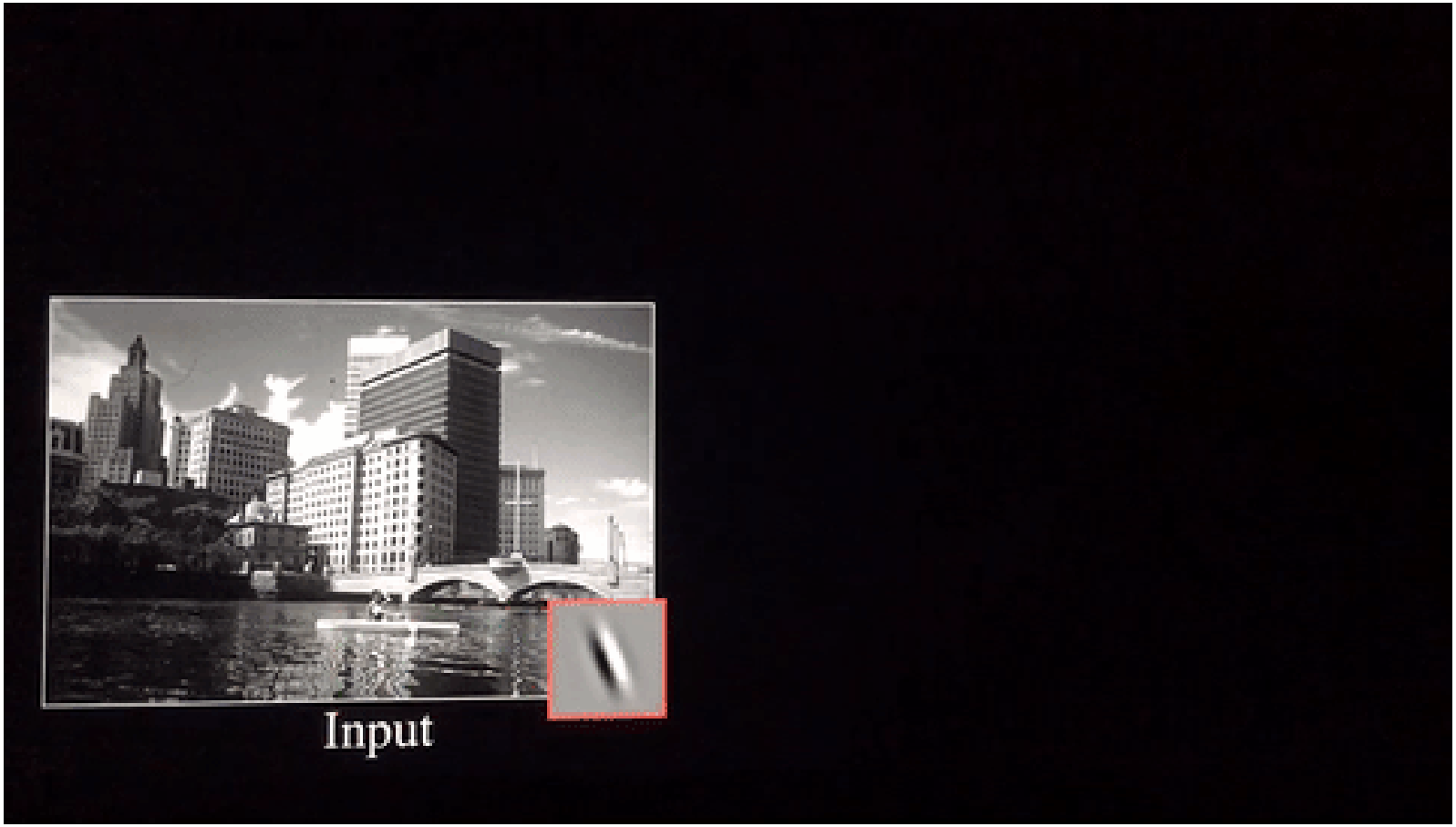

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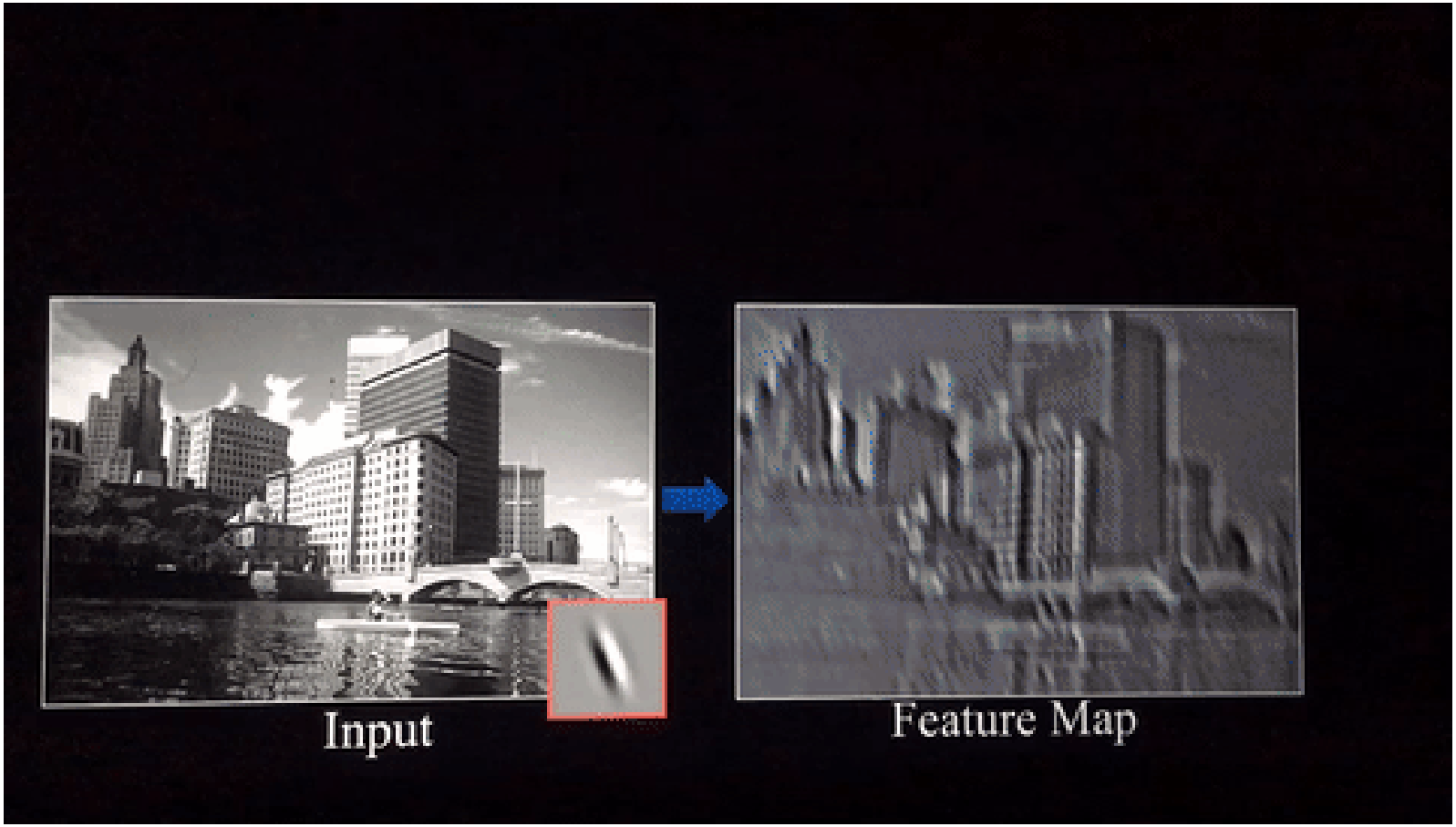

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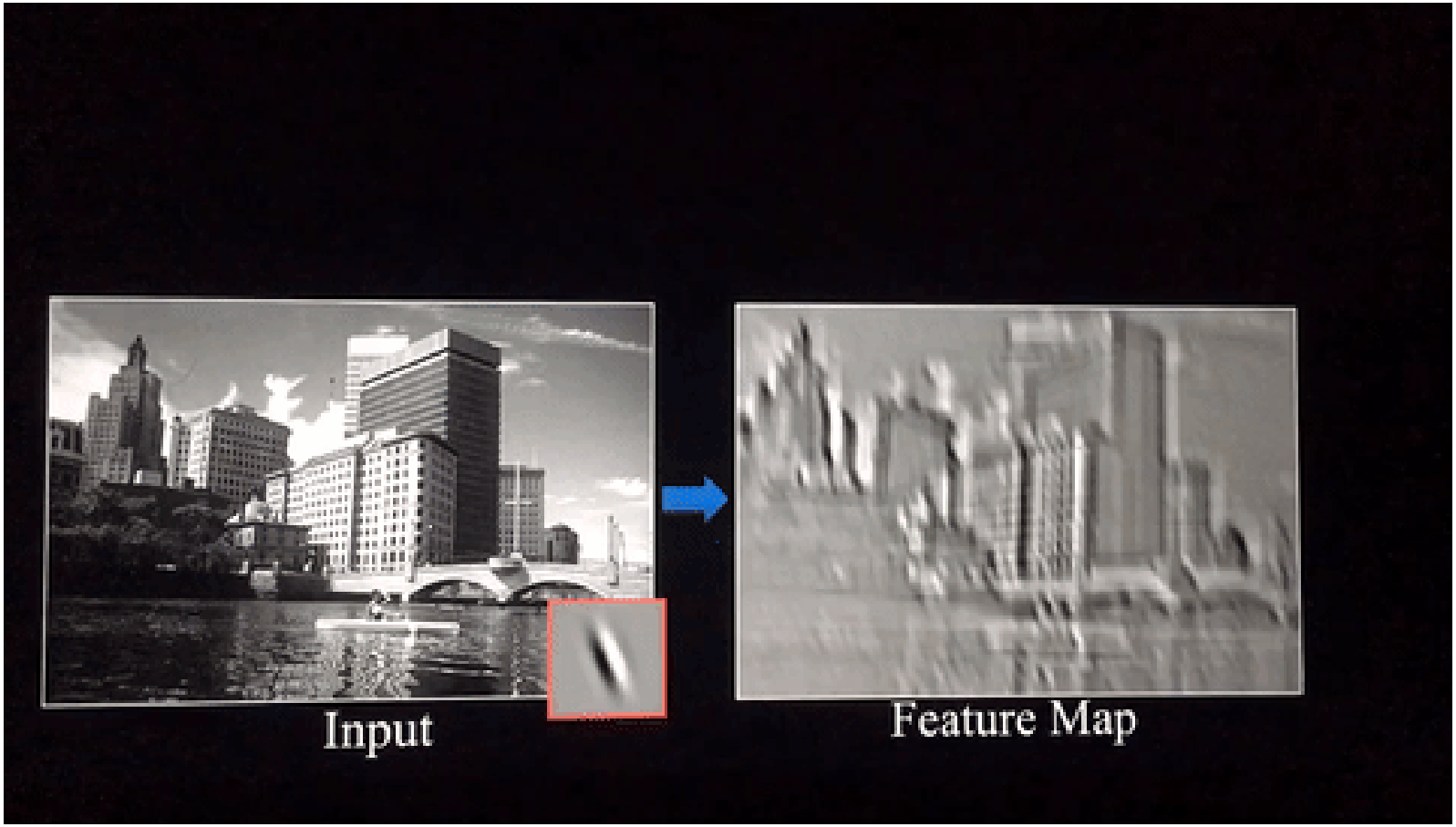

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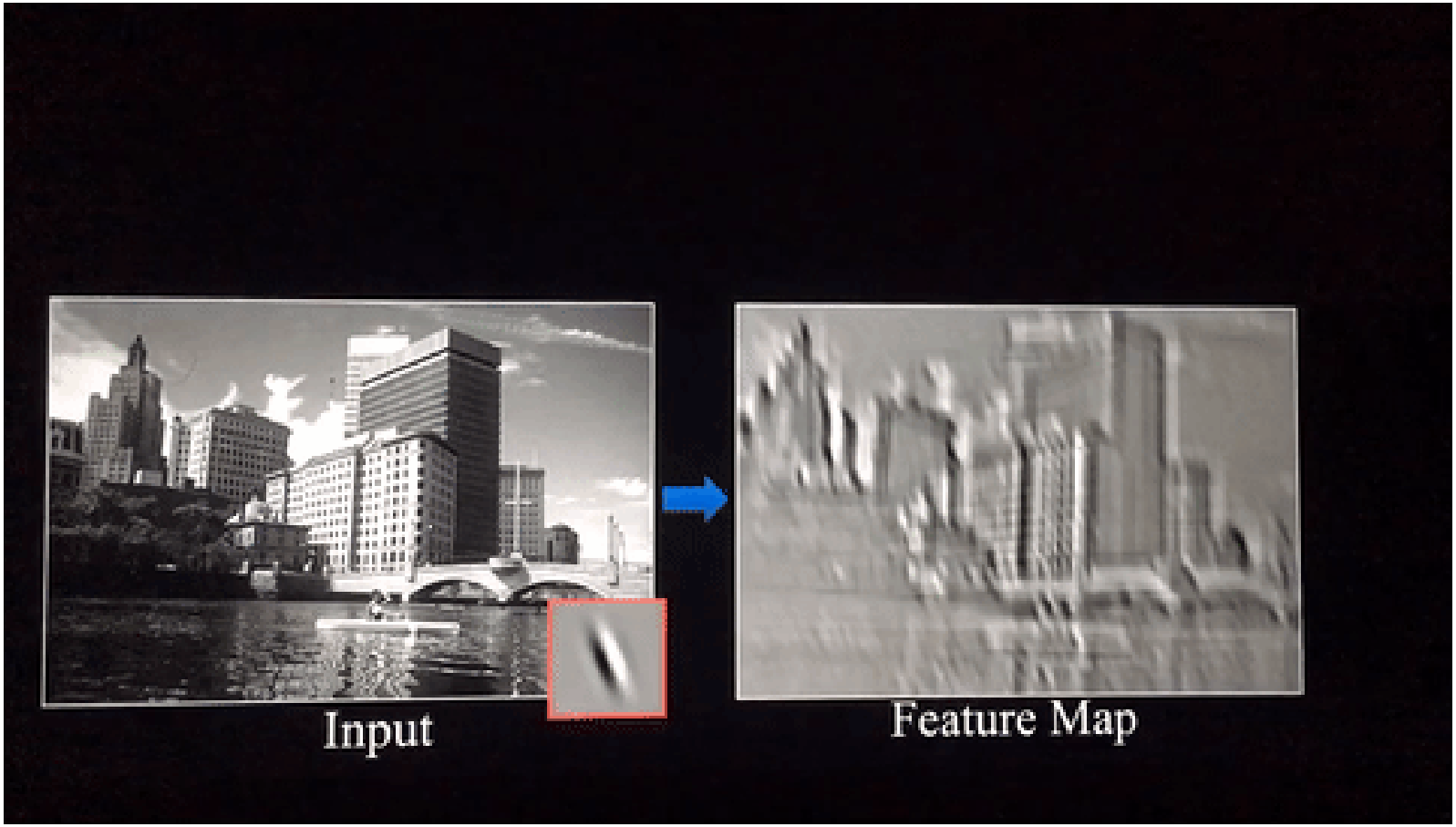

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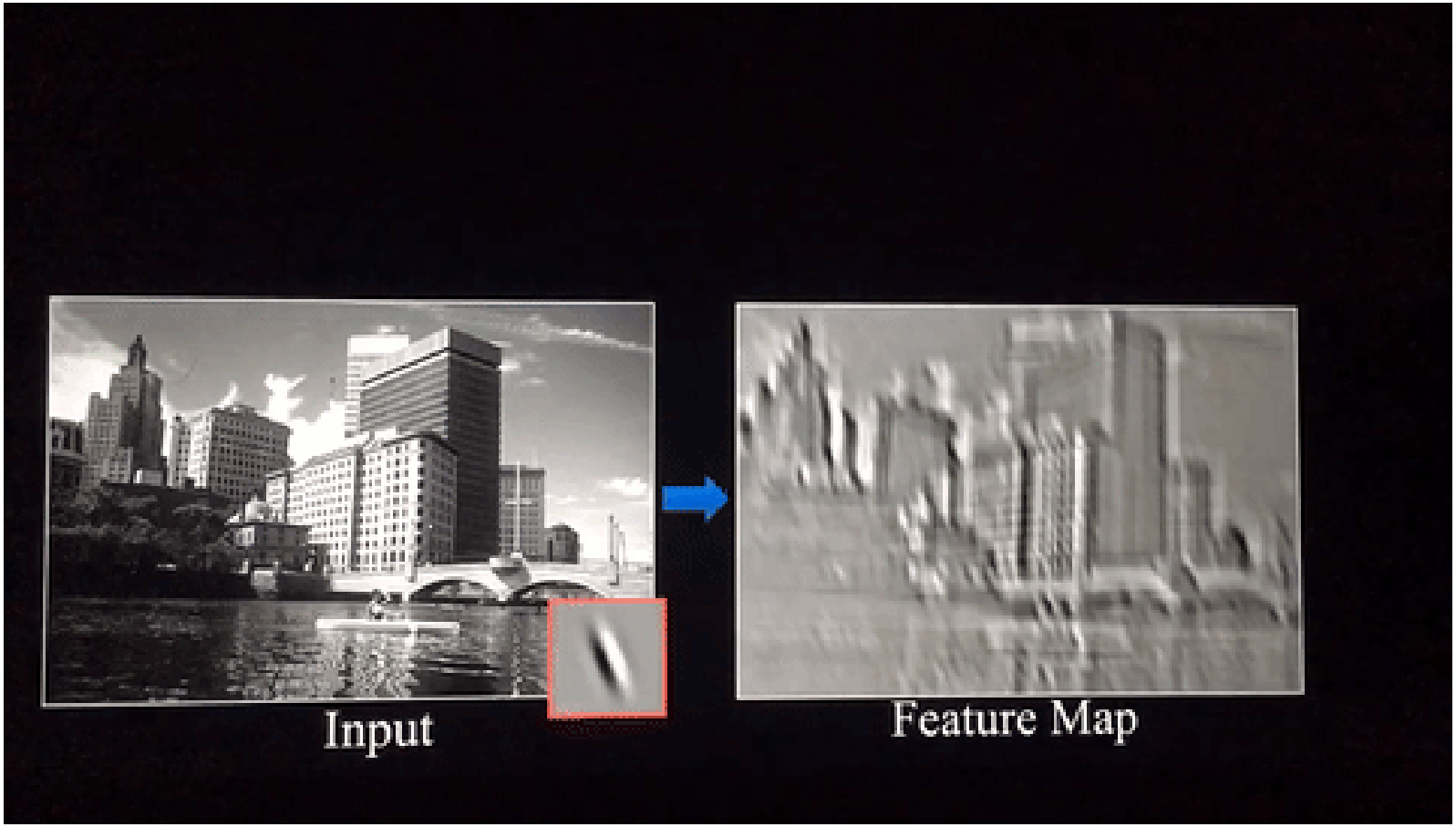

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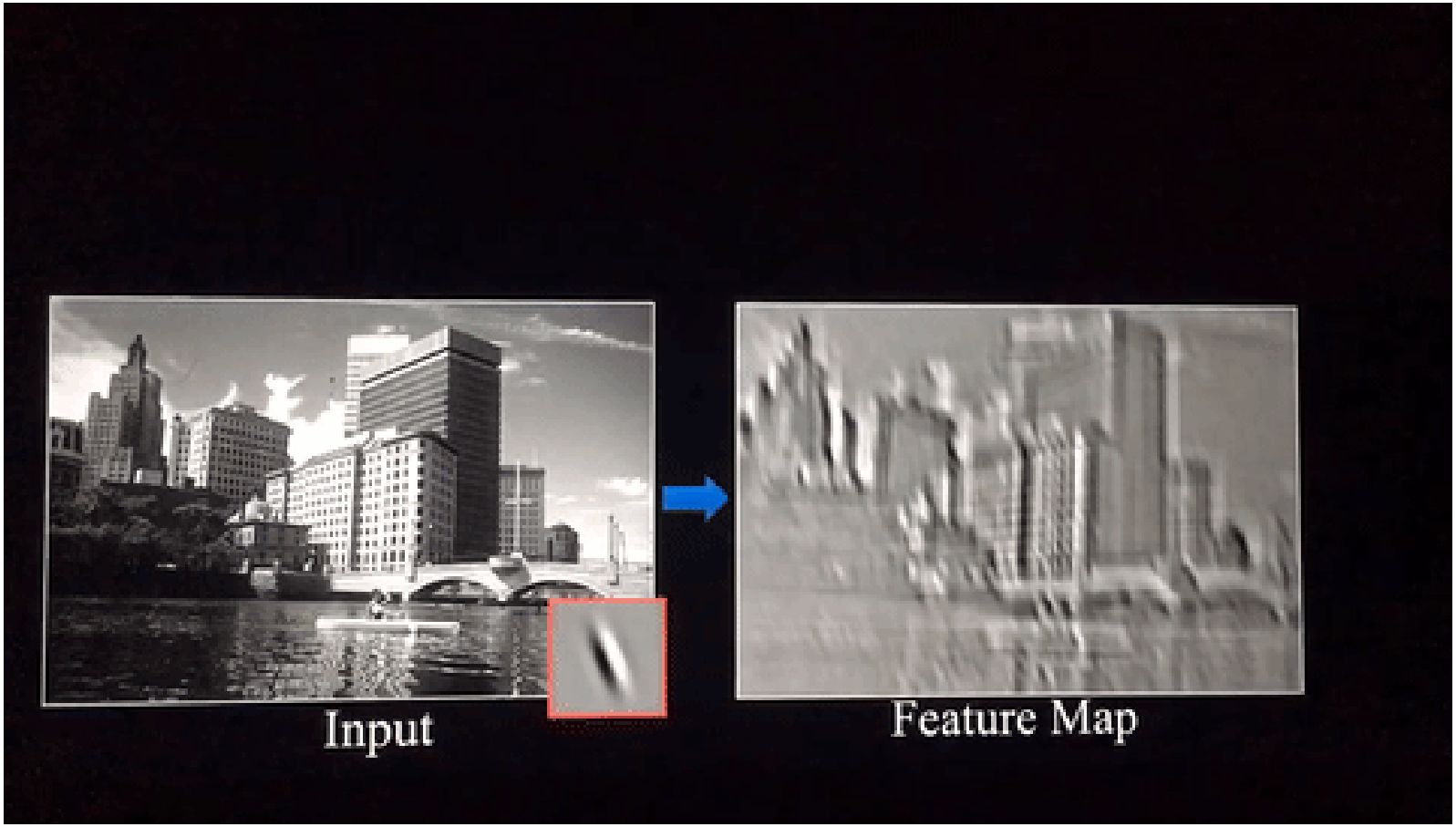

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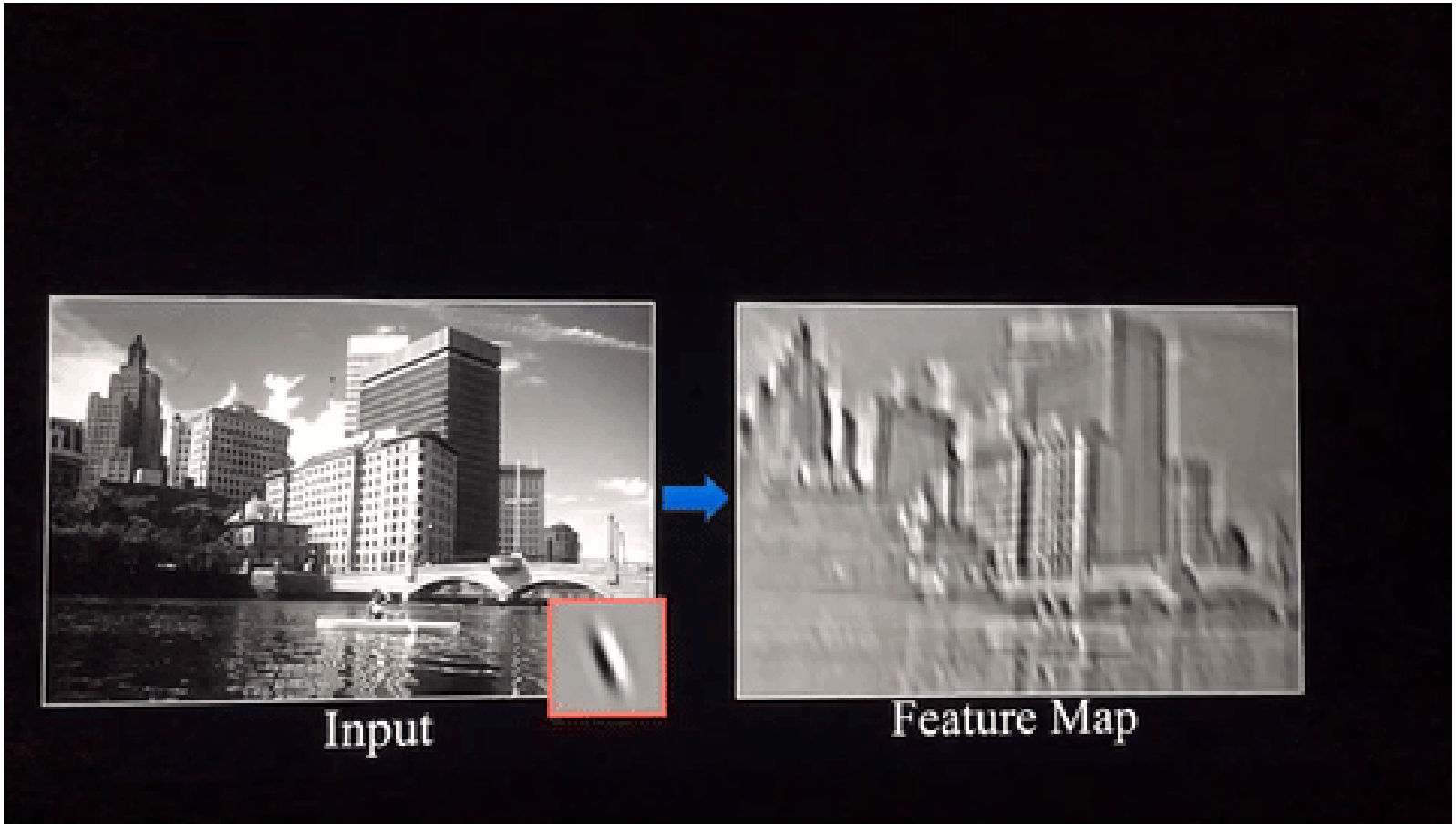

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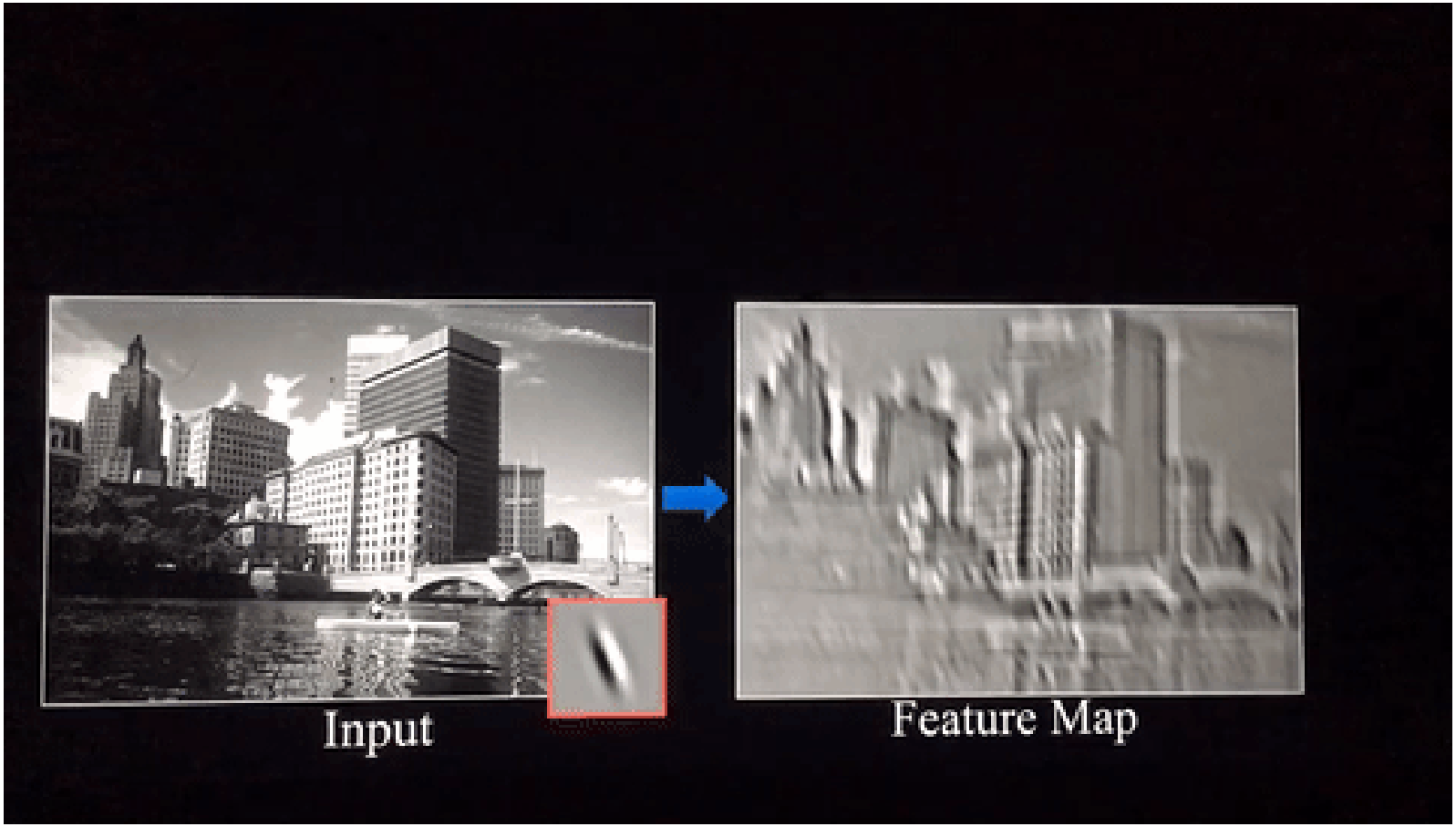

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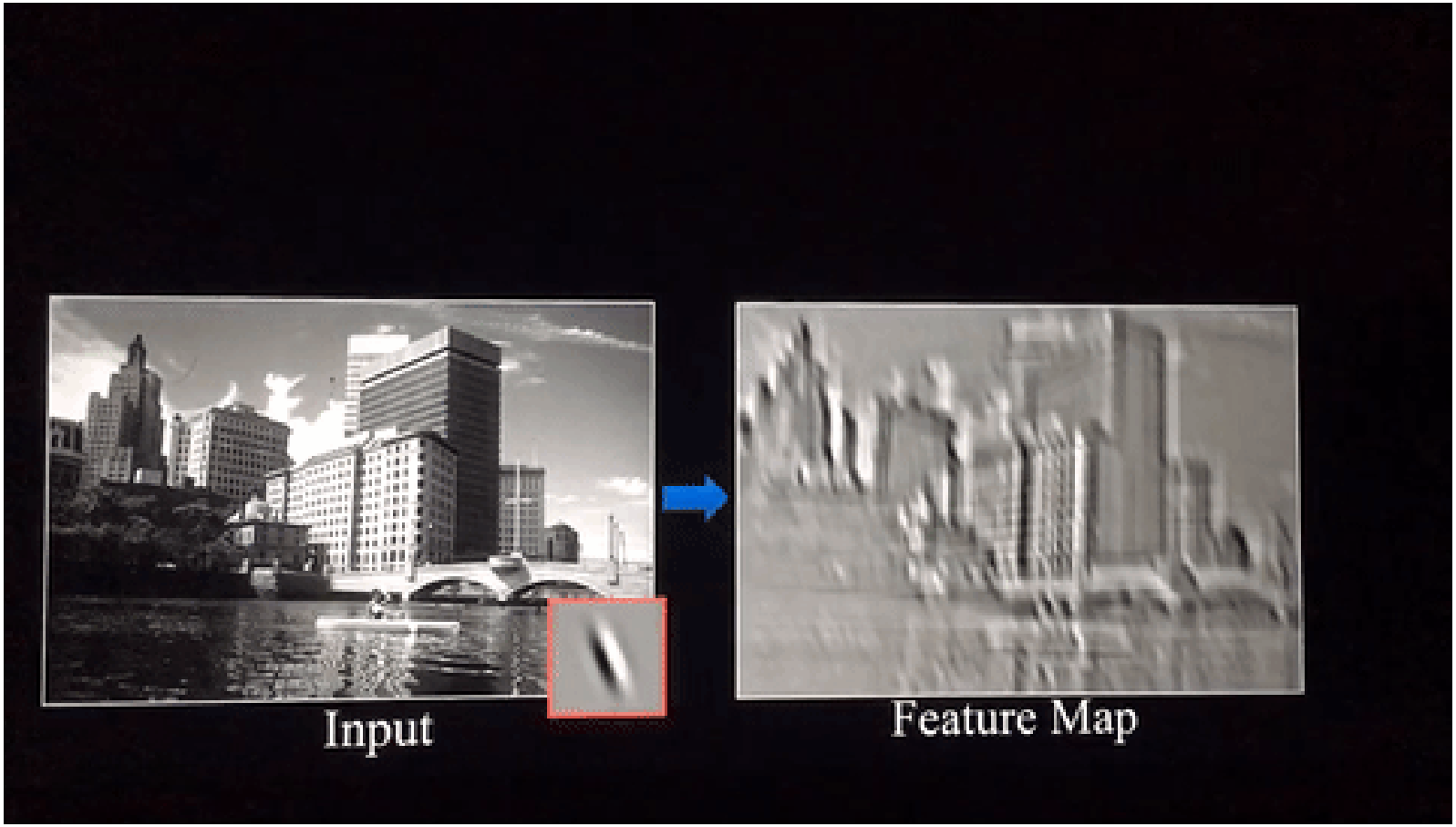

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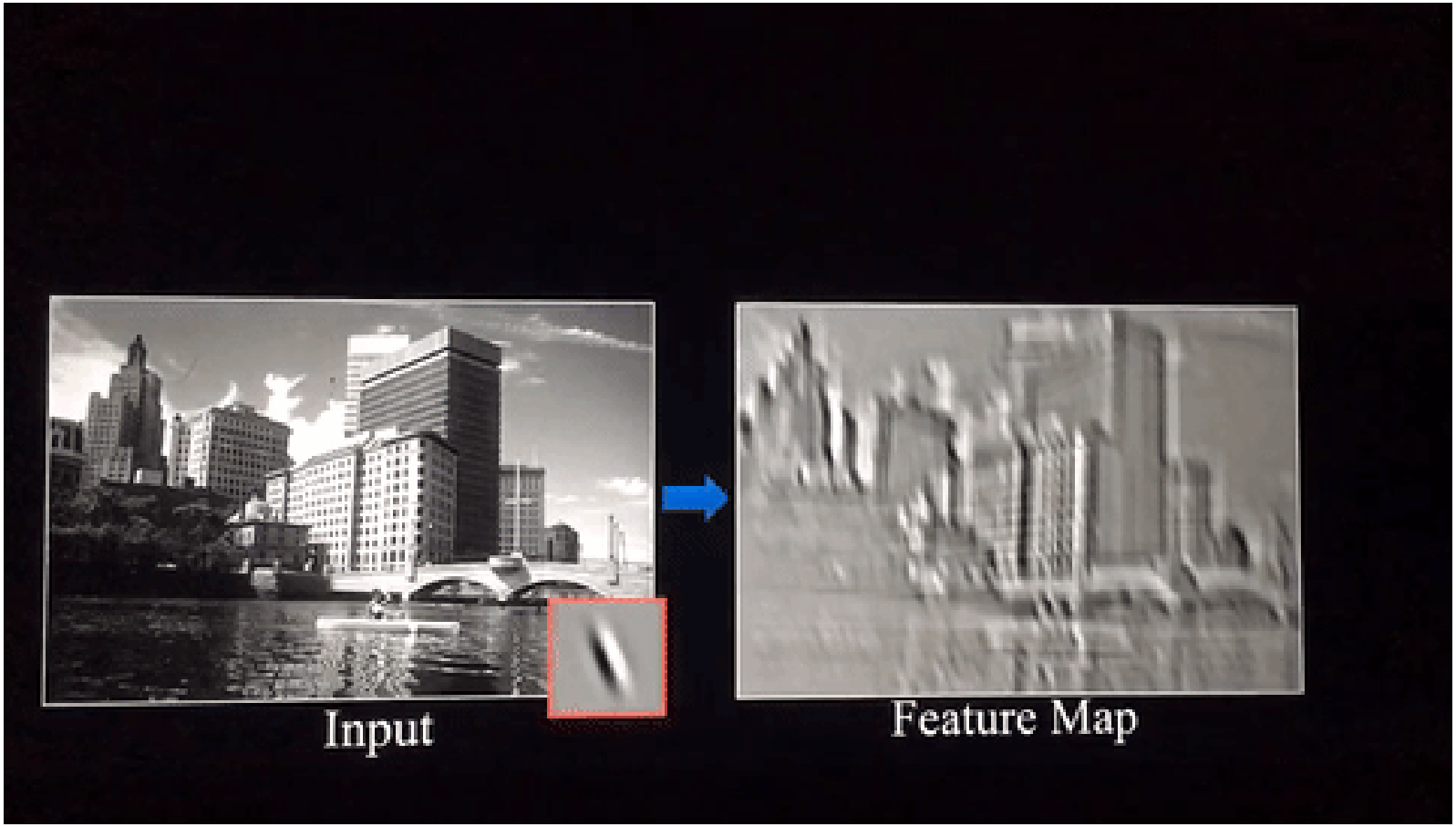

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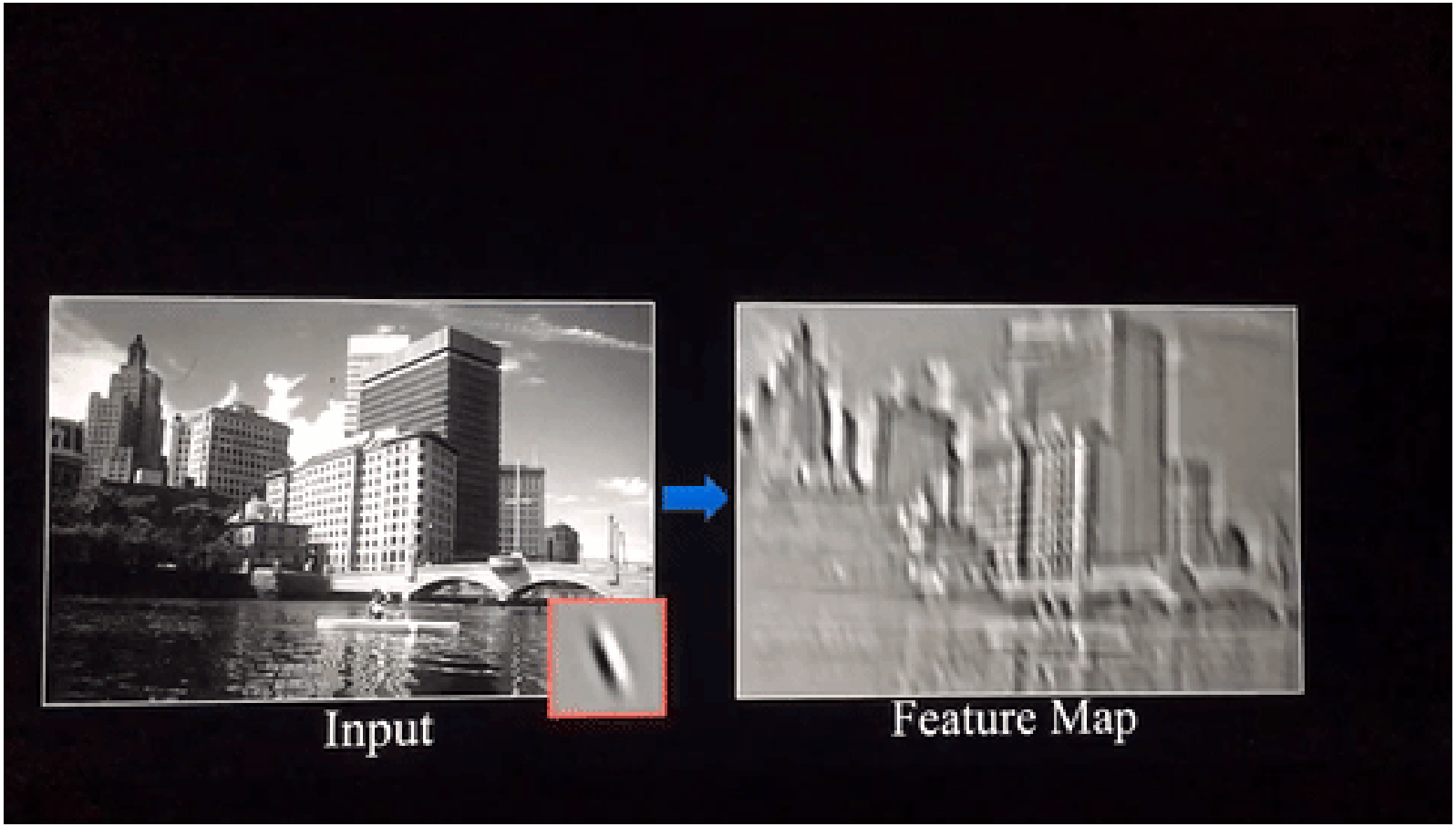

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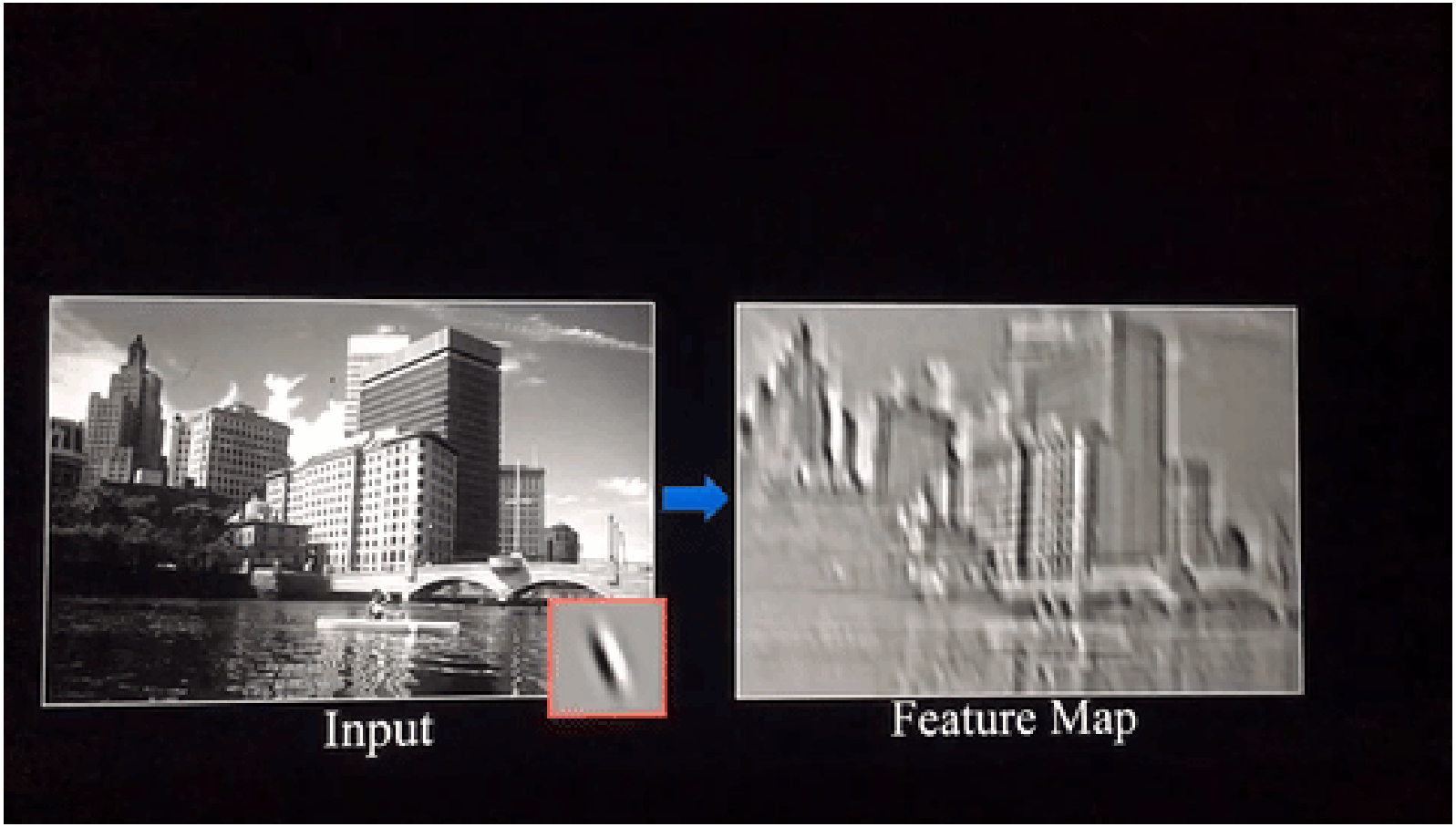

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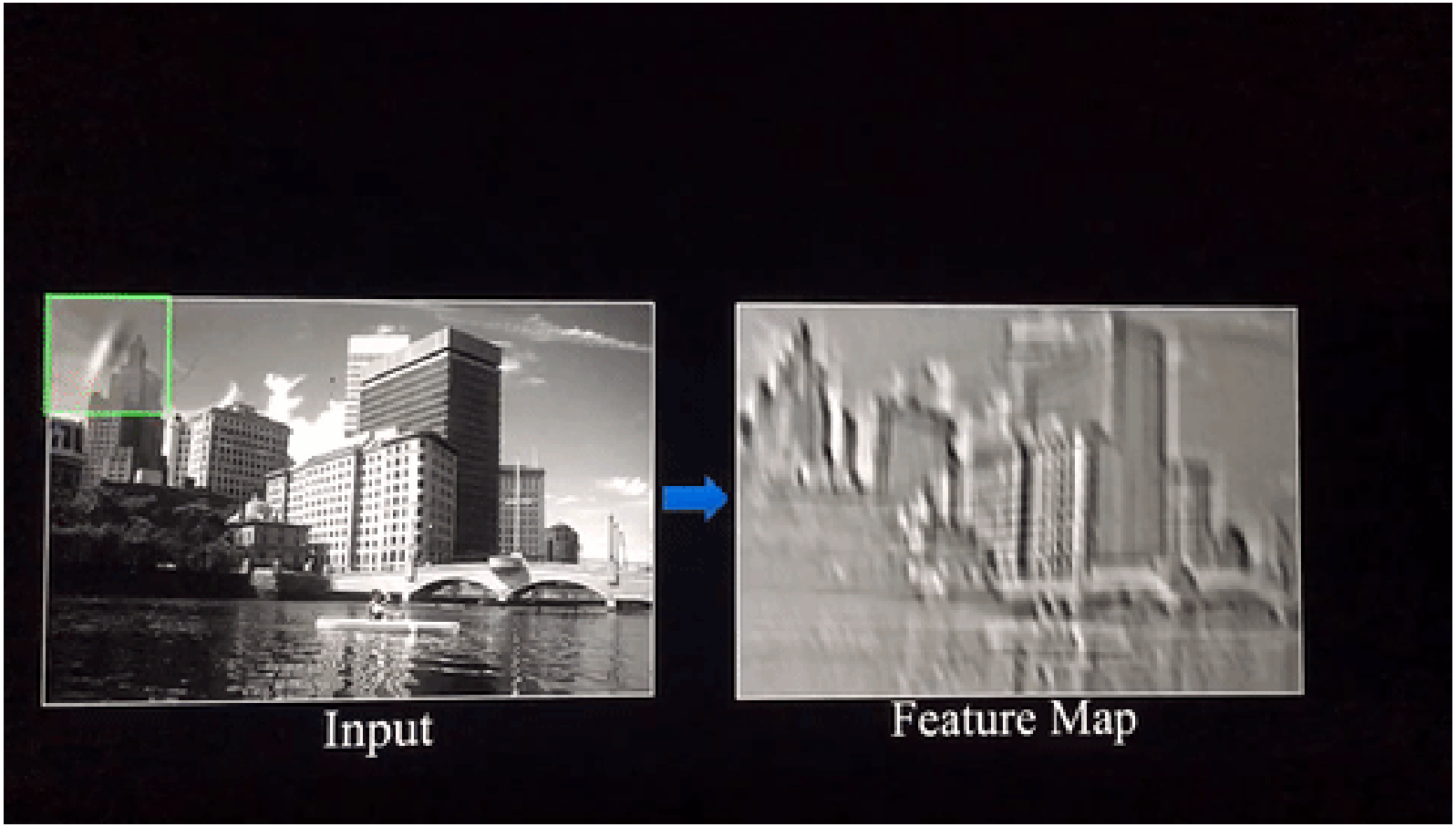

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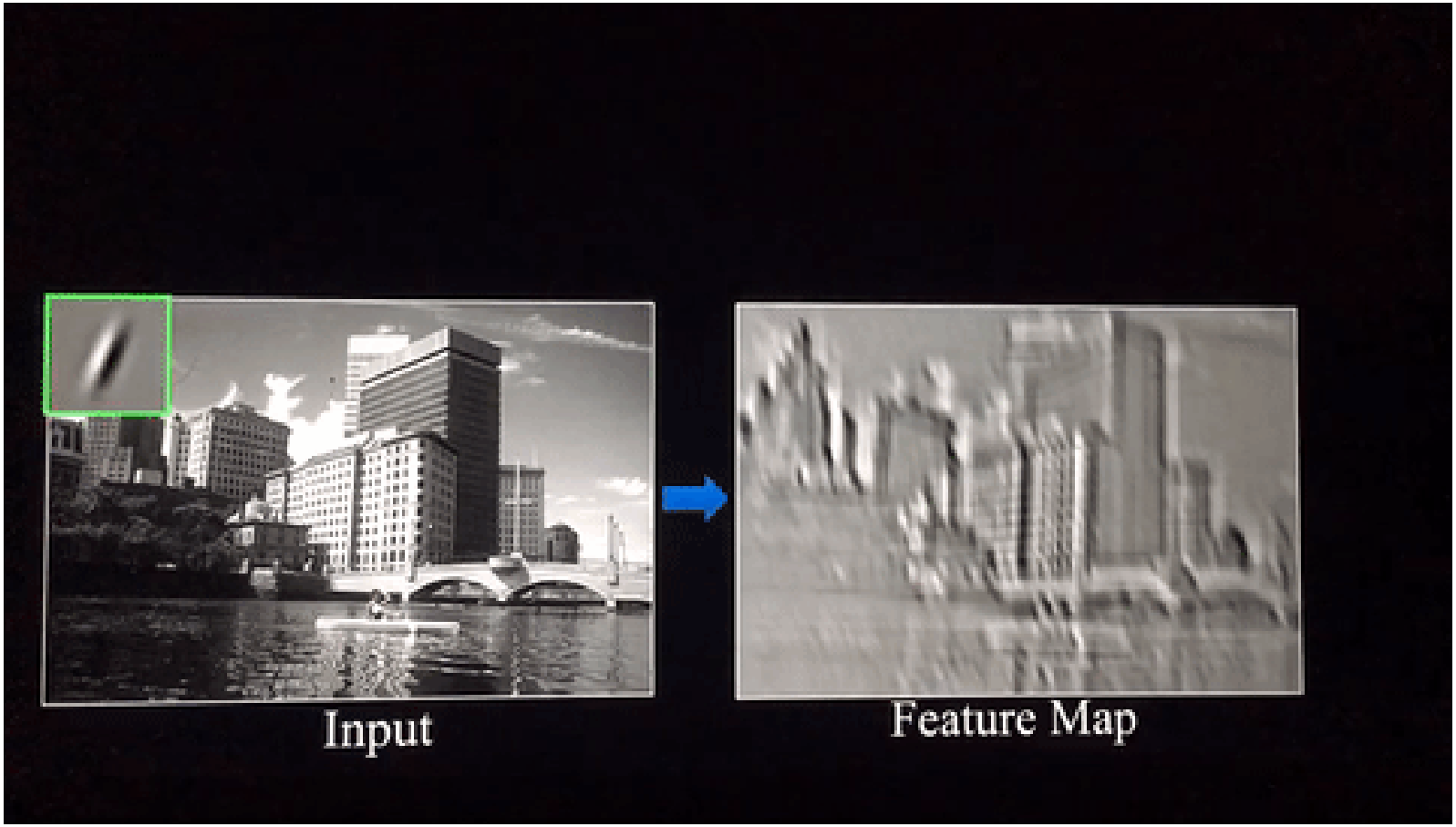

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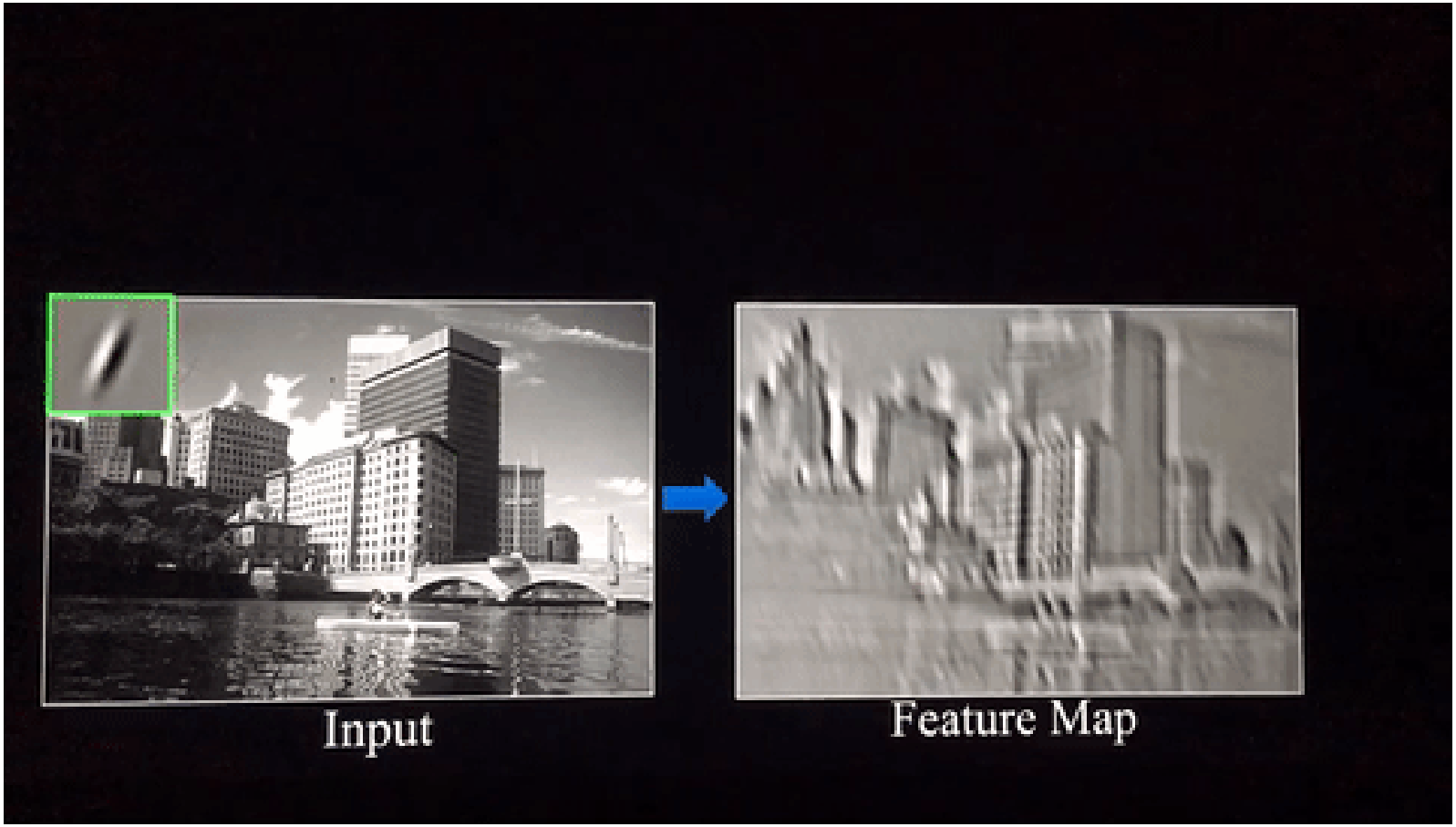

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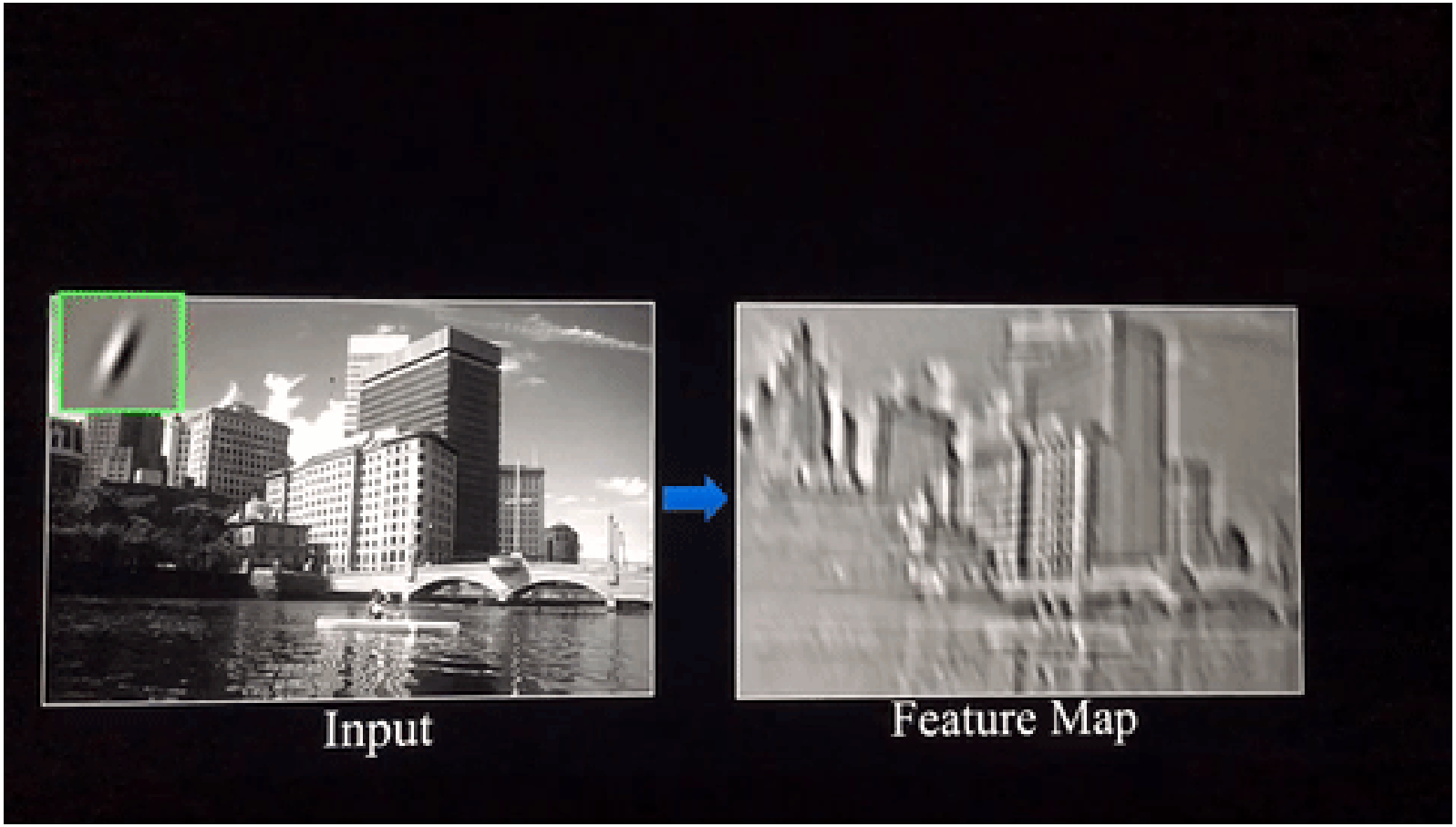

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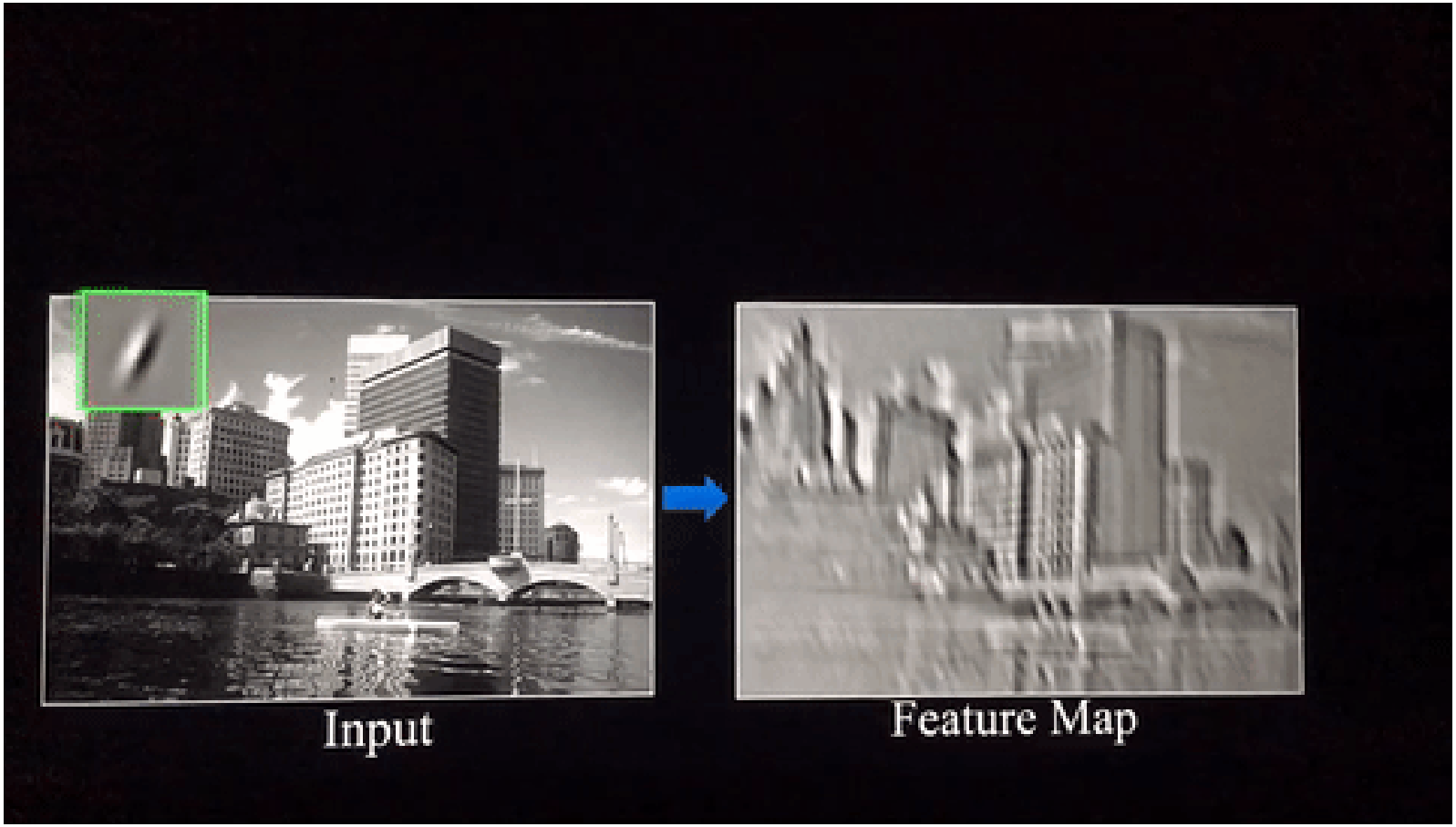

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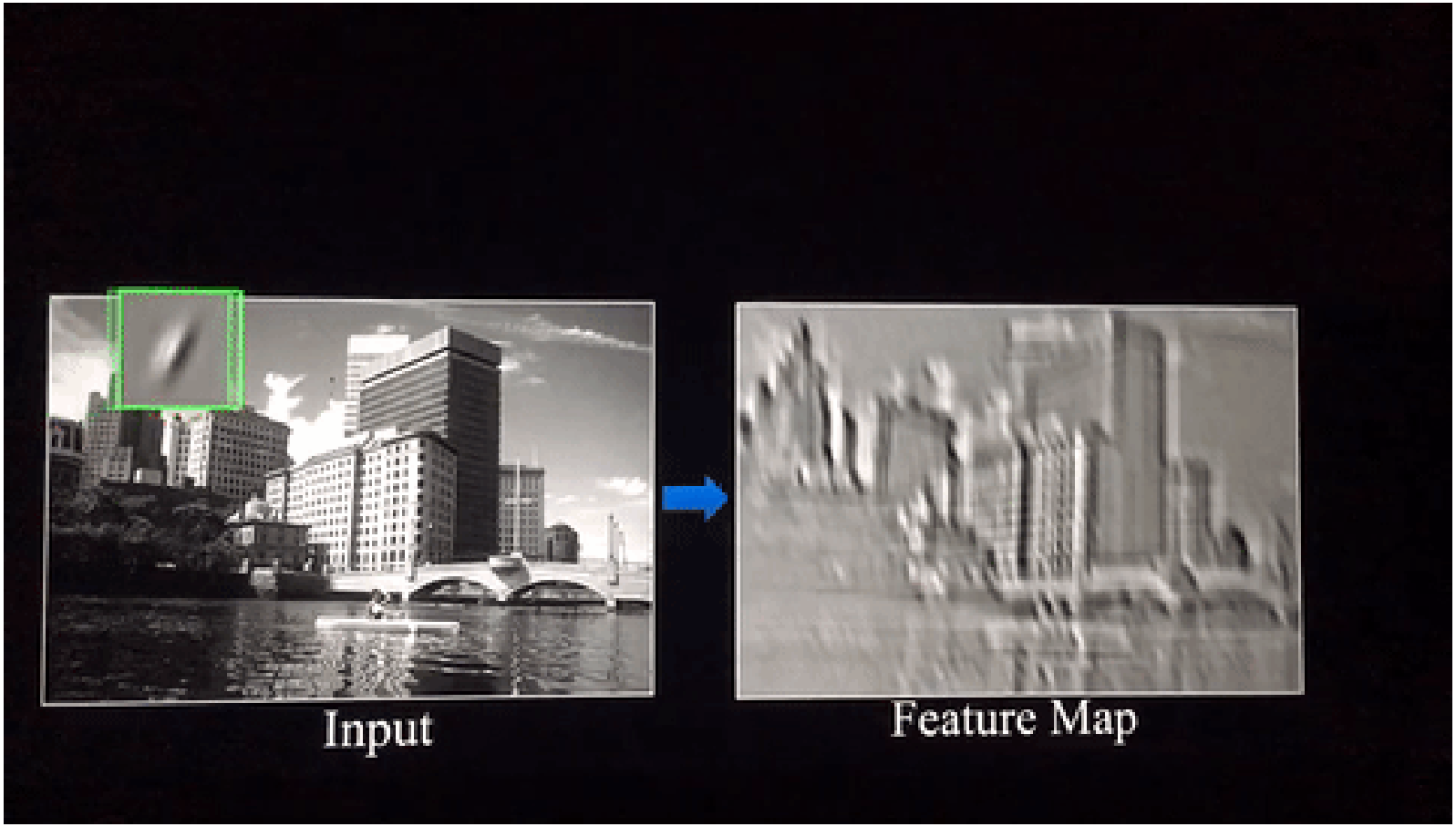

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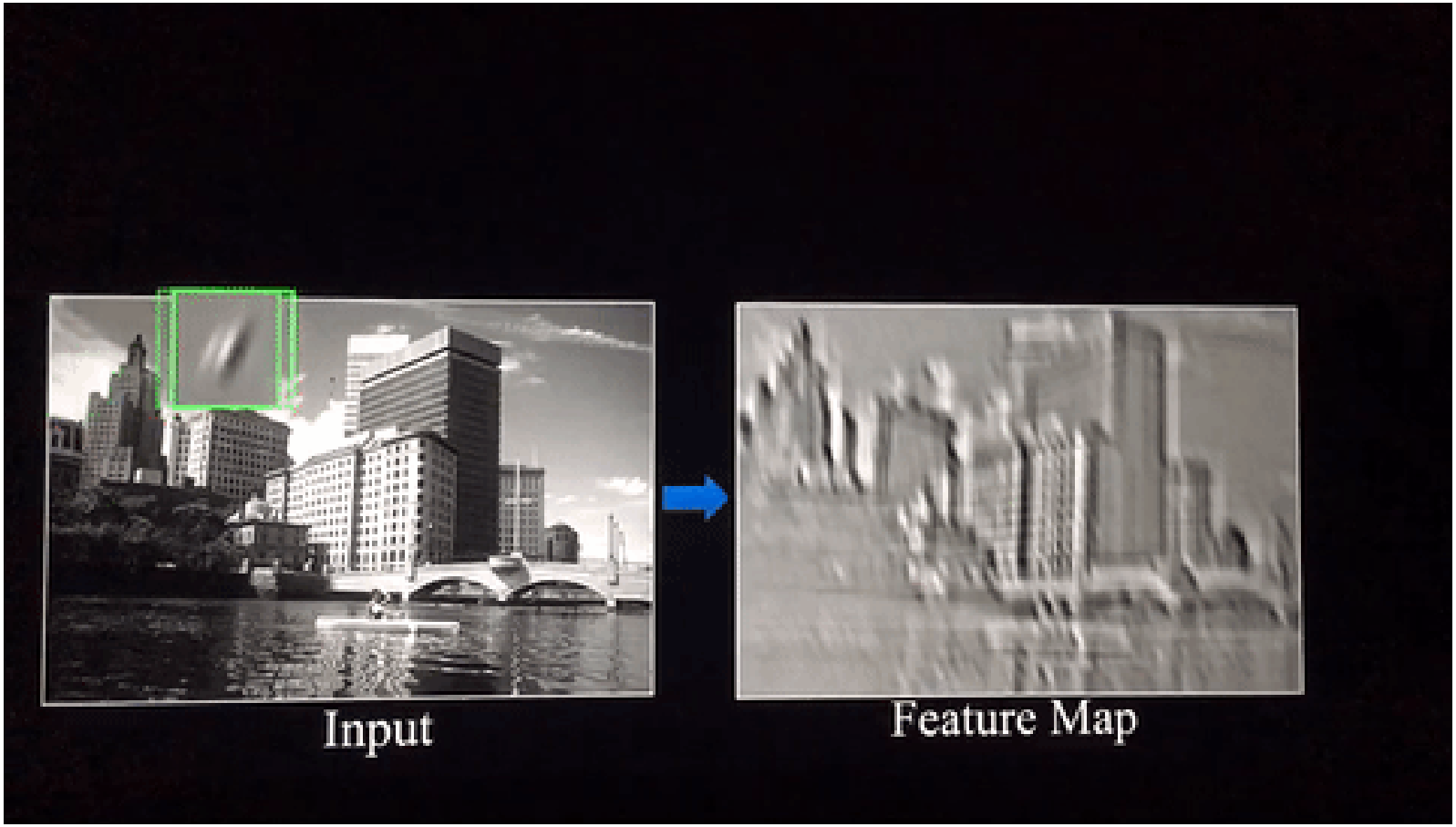

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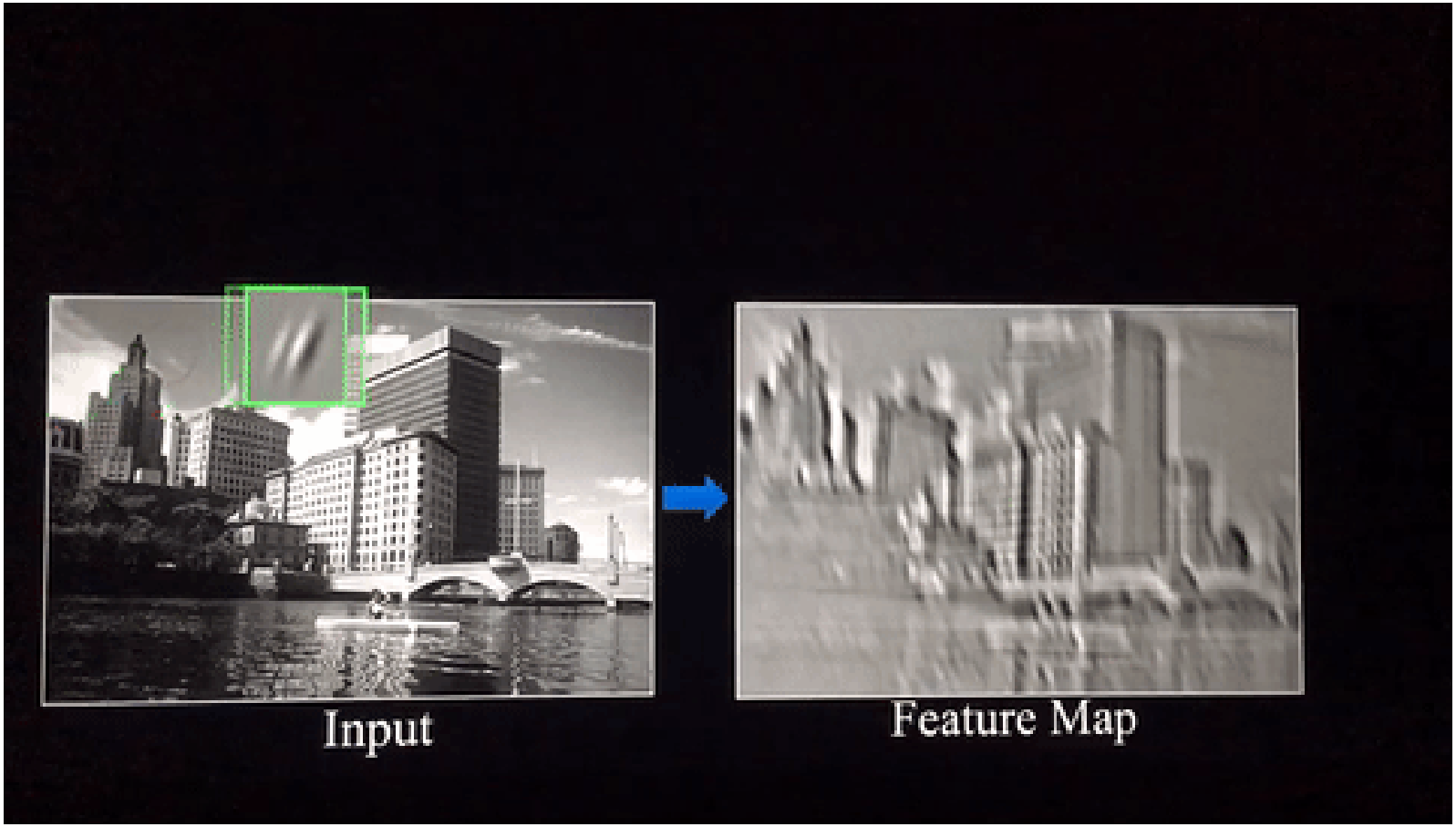

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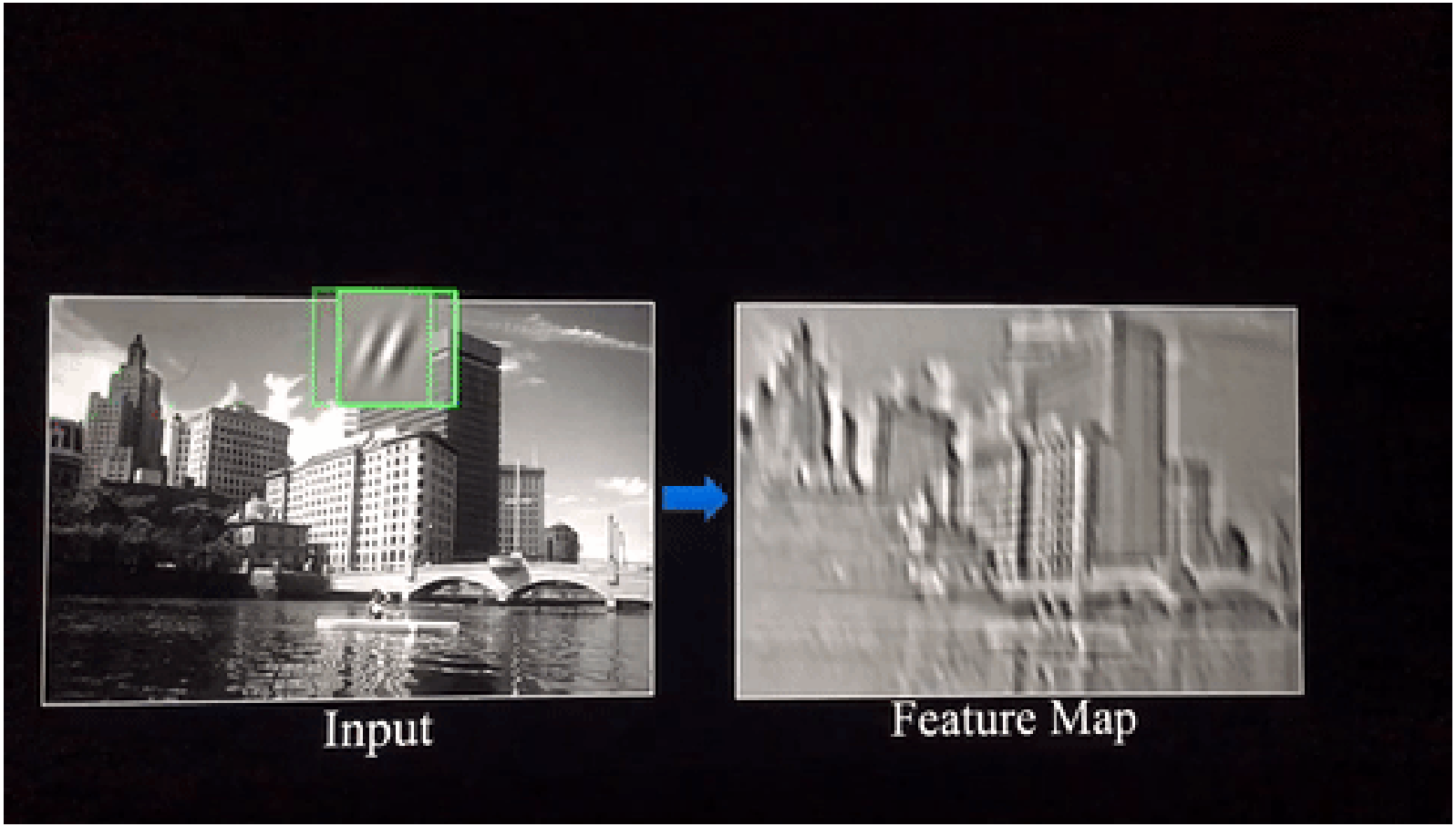

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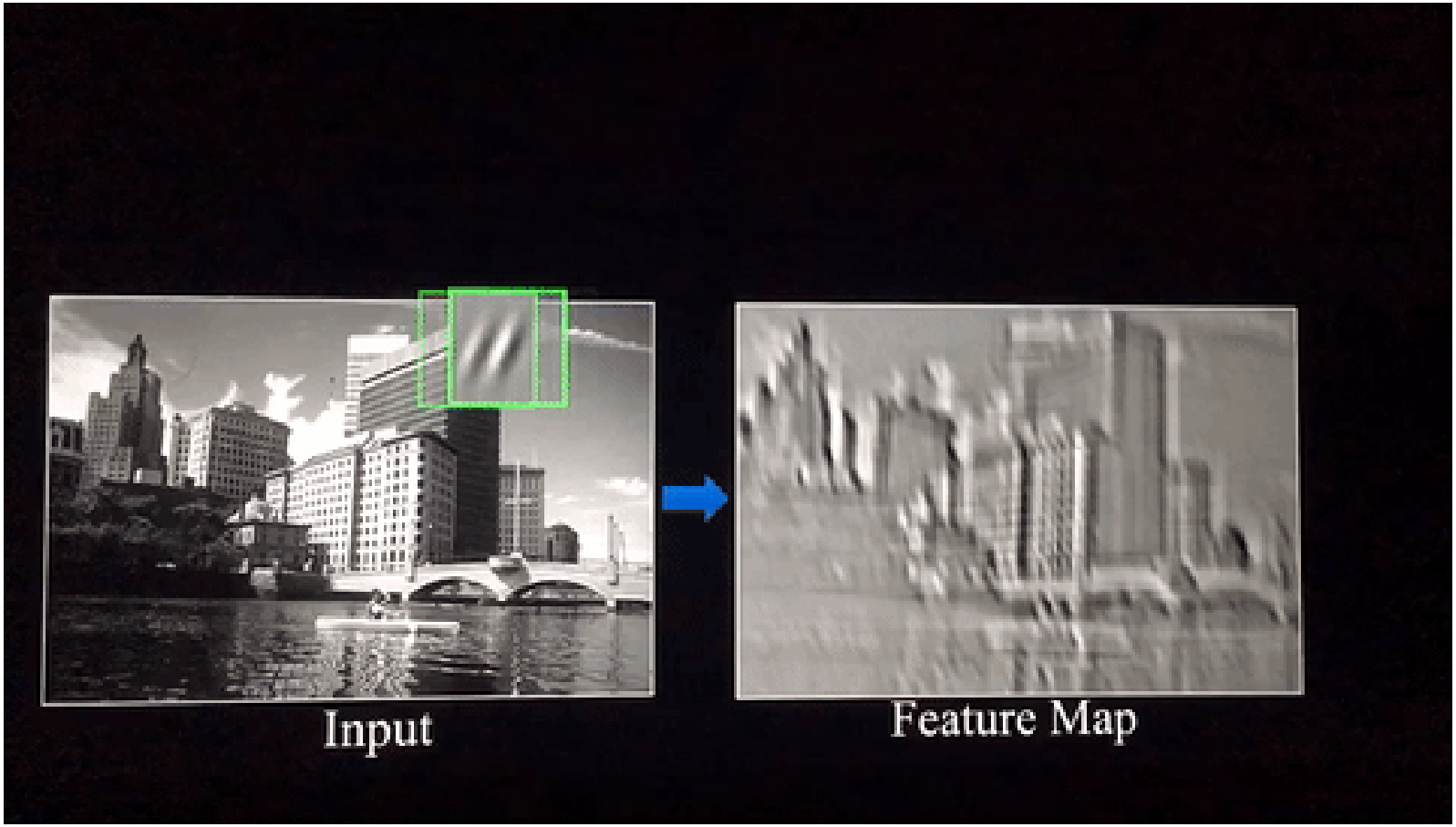
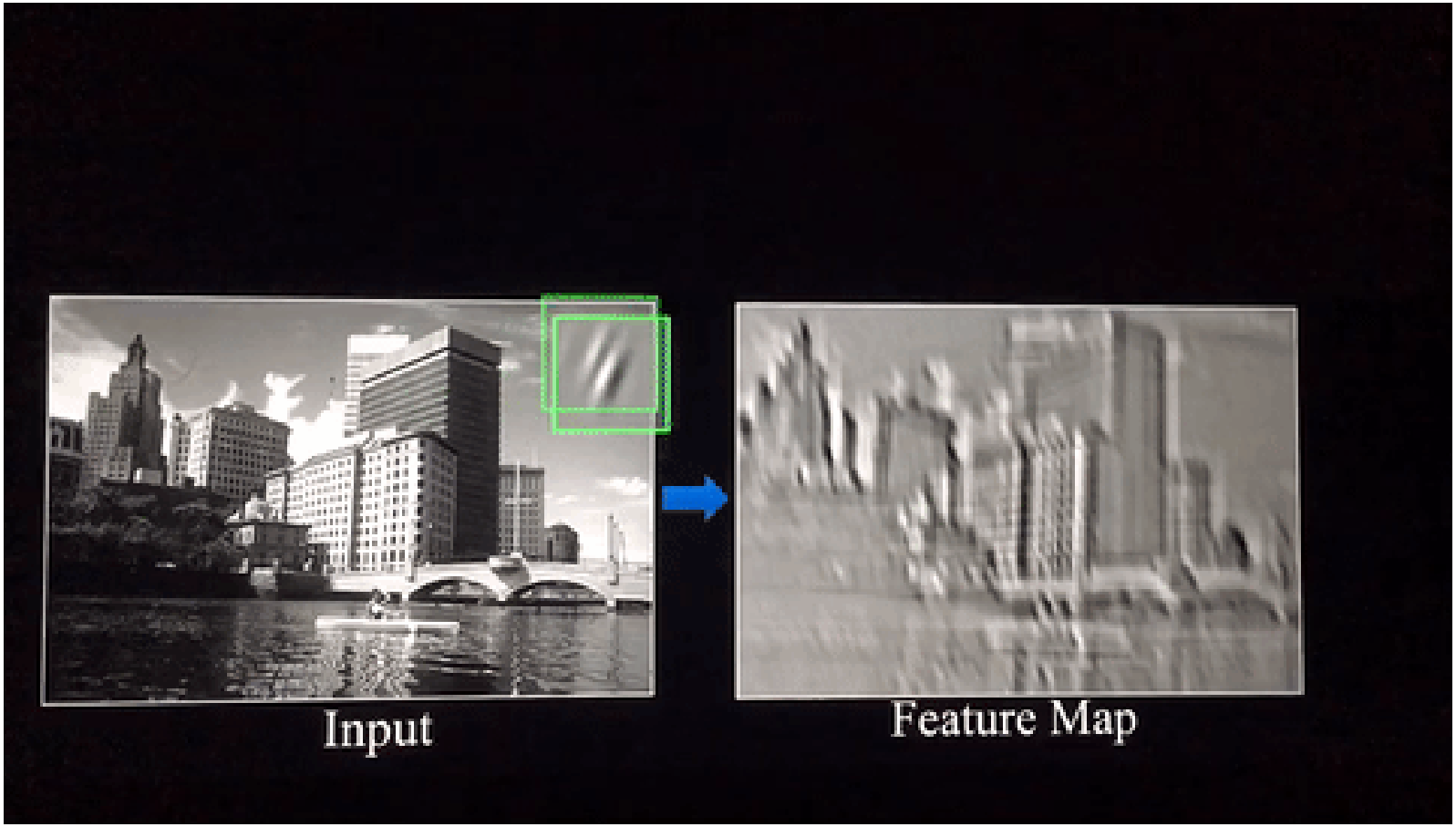
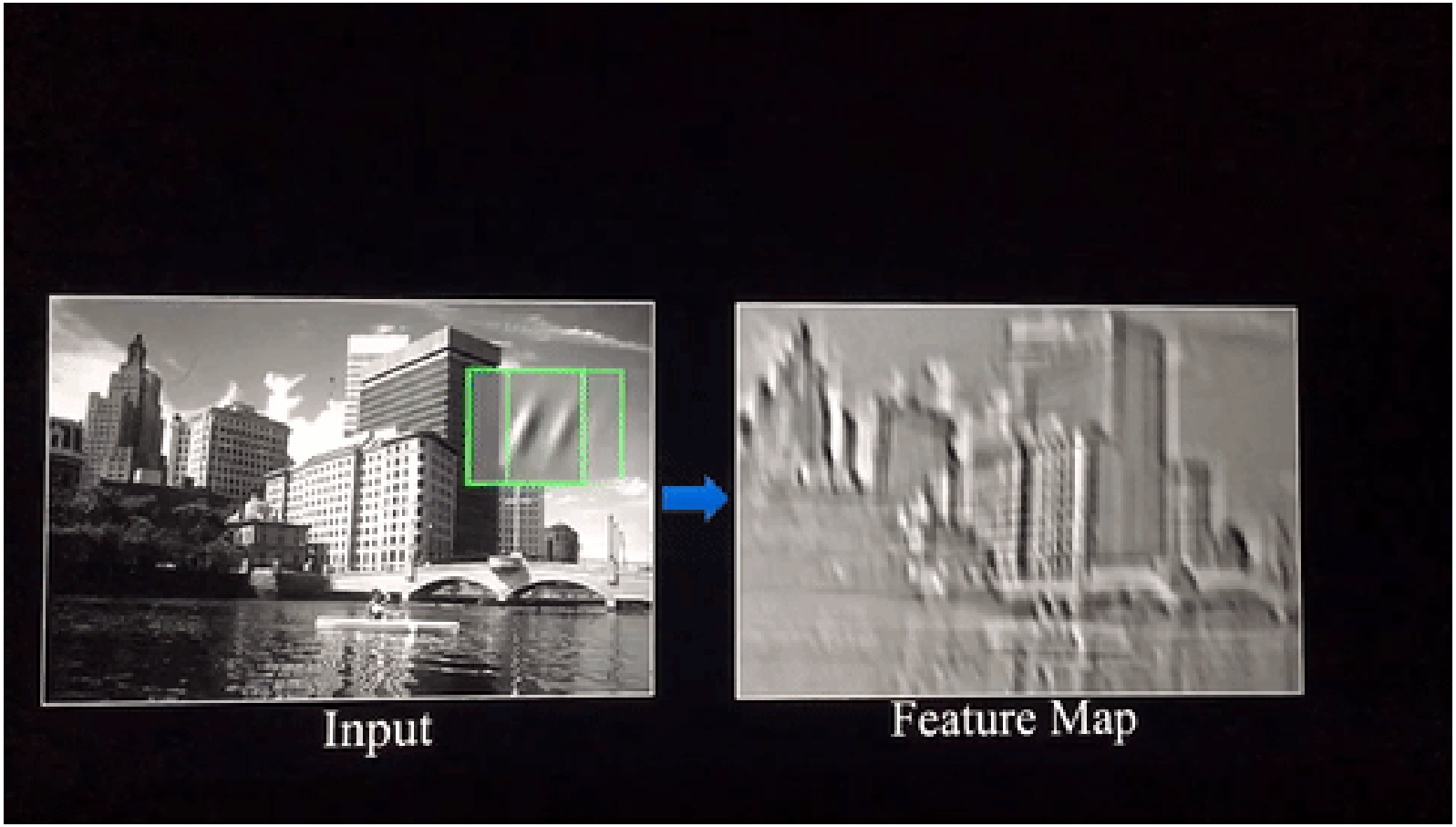


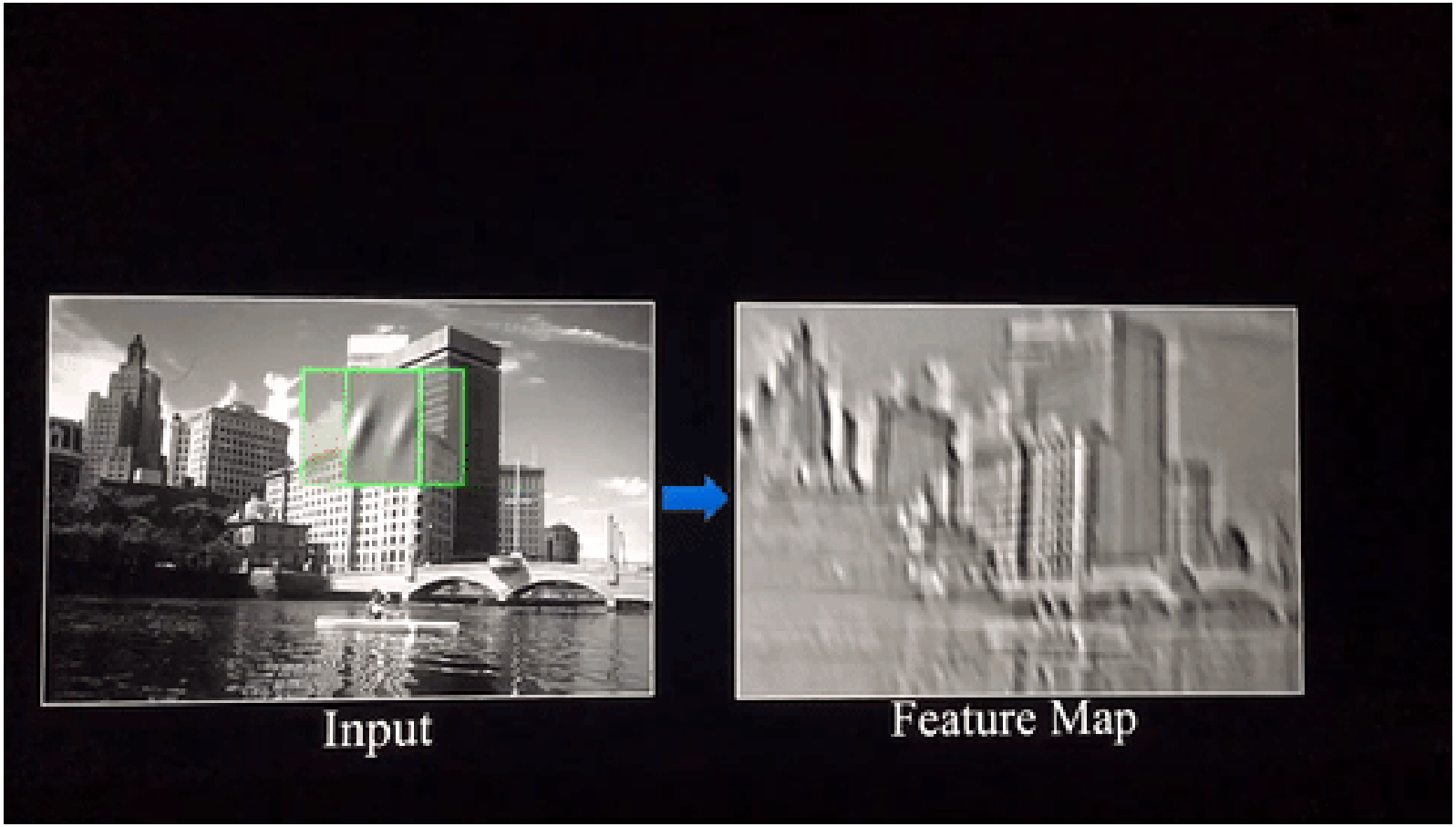
Convolution Layer



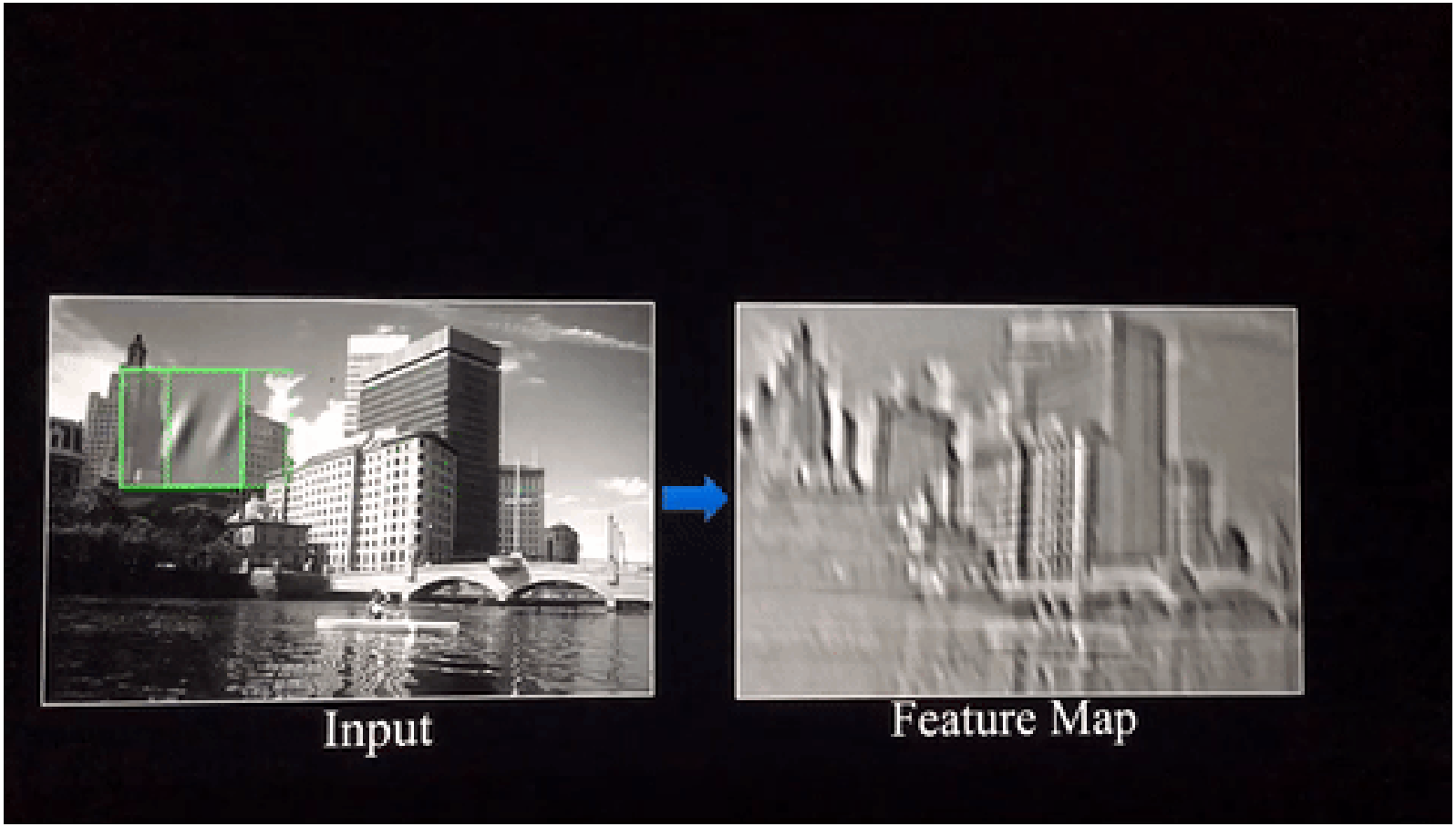
Convolution Layer



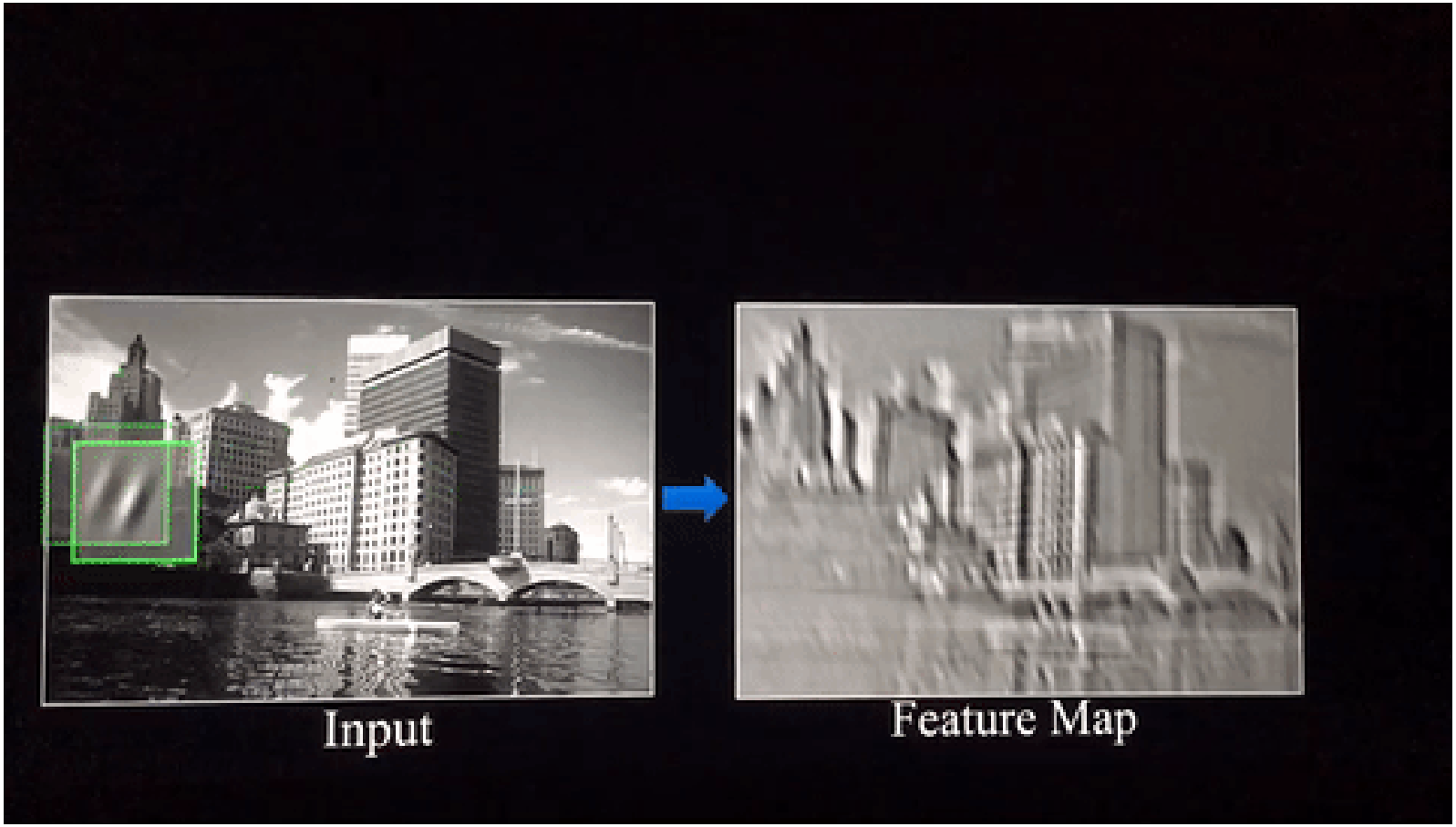
Convolution Layer



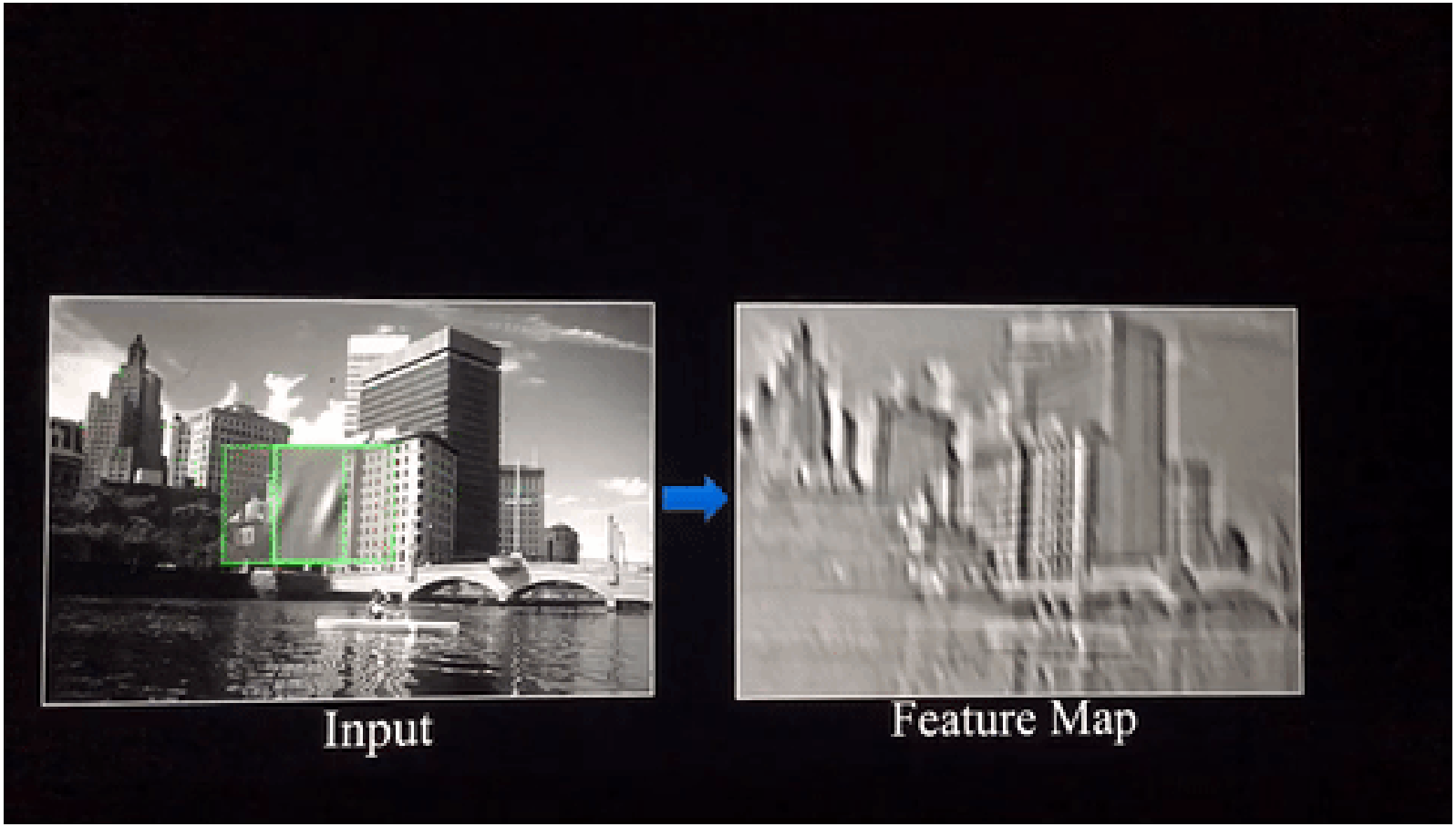
Convolution Layer



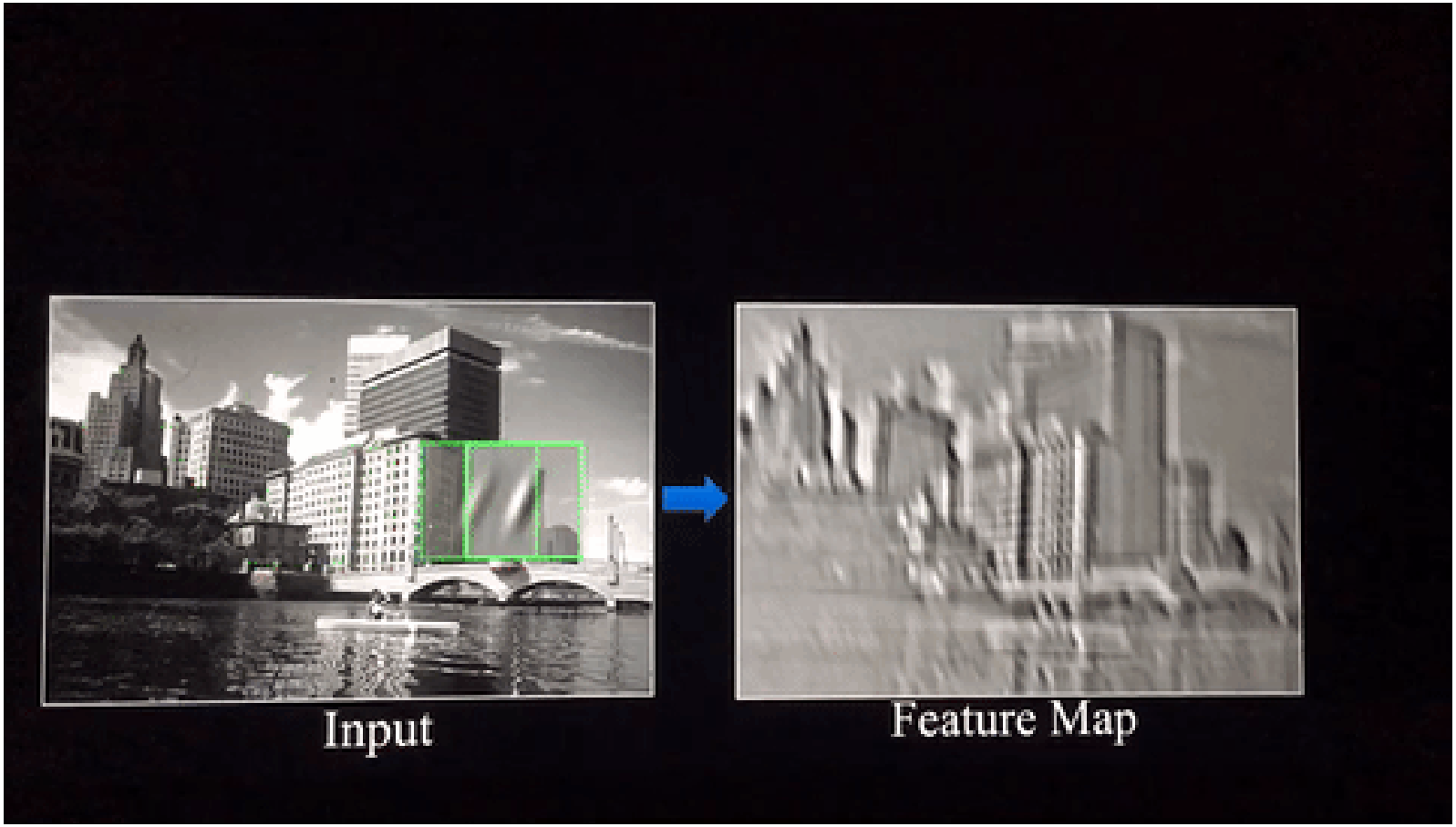
Convolution Layer



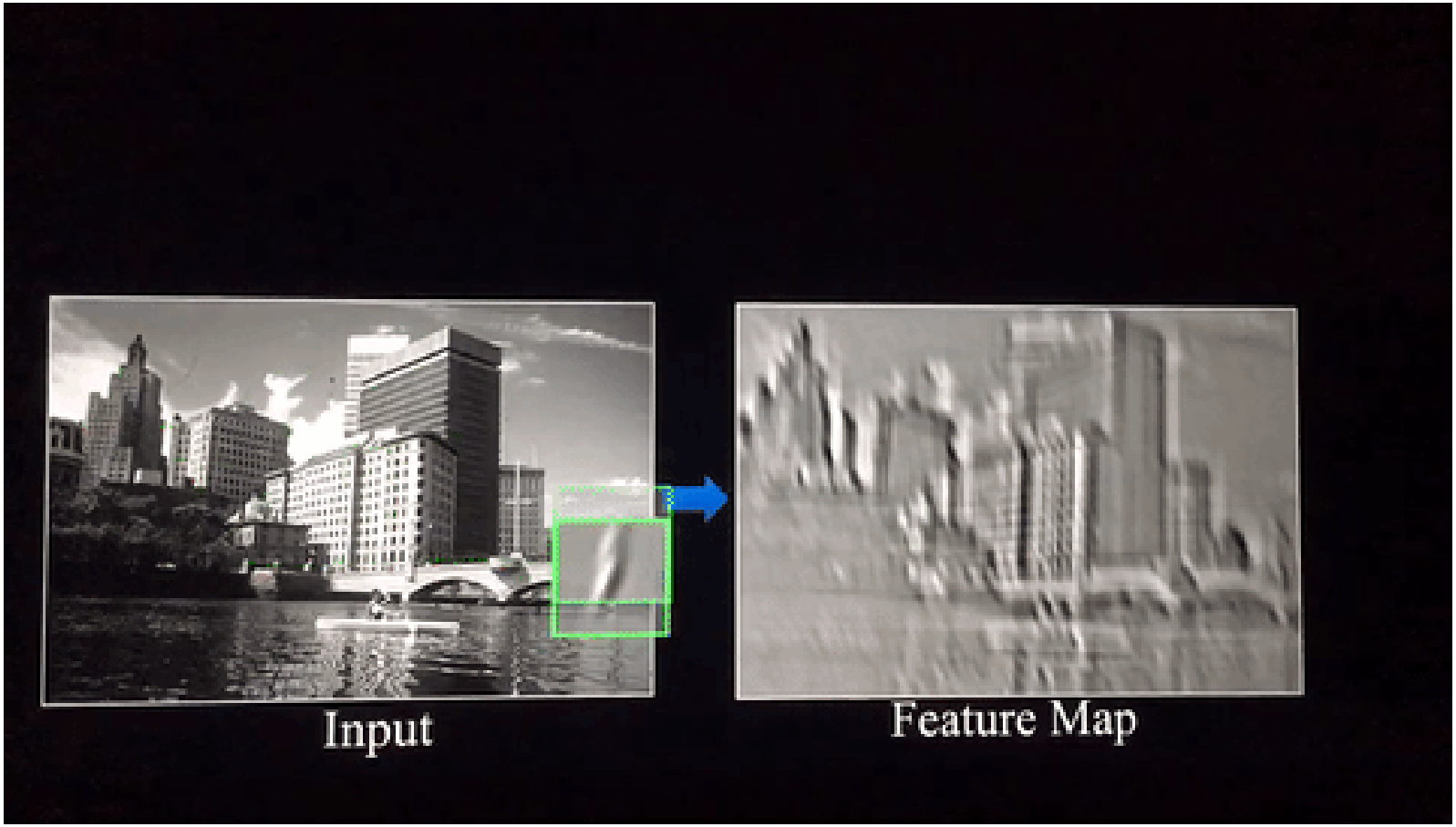
Convolution Layer



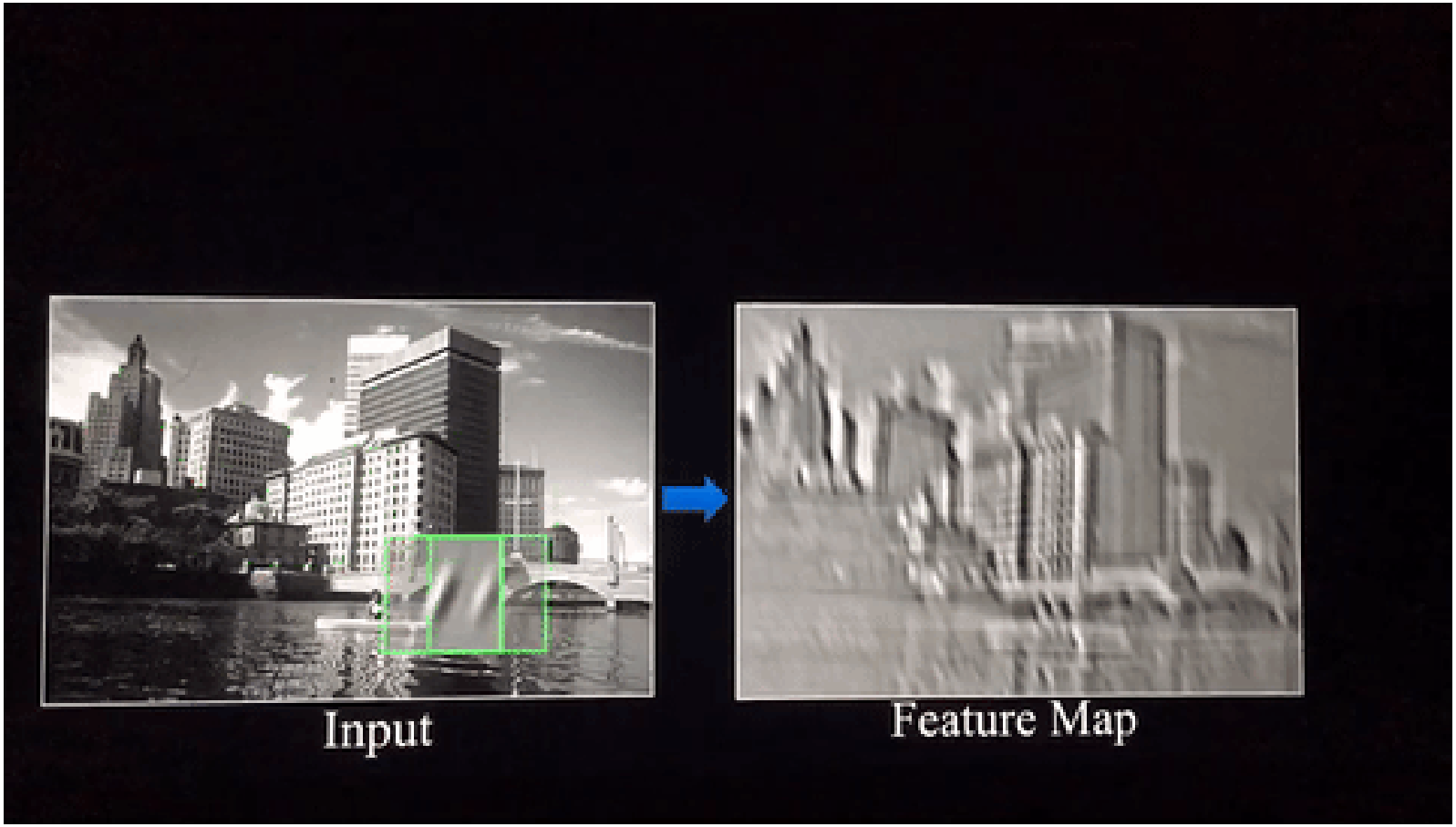
Convolution Layer



Convolution Layer



Convolution Layer



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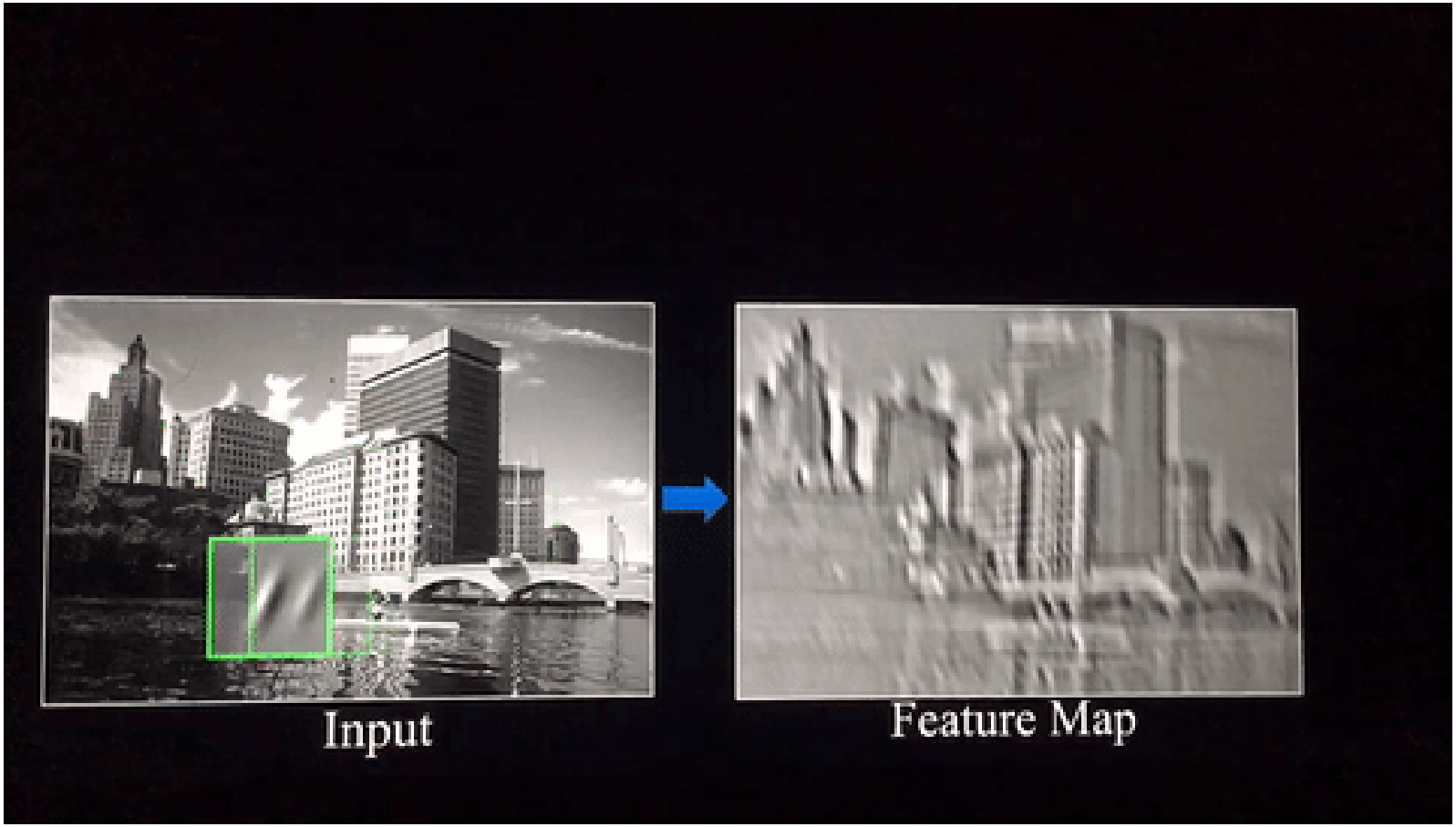
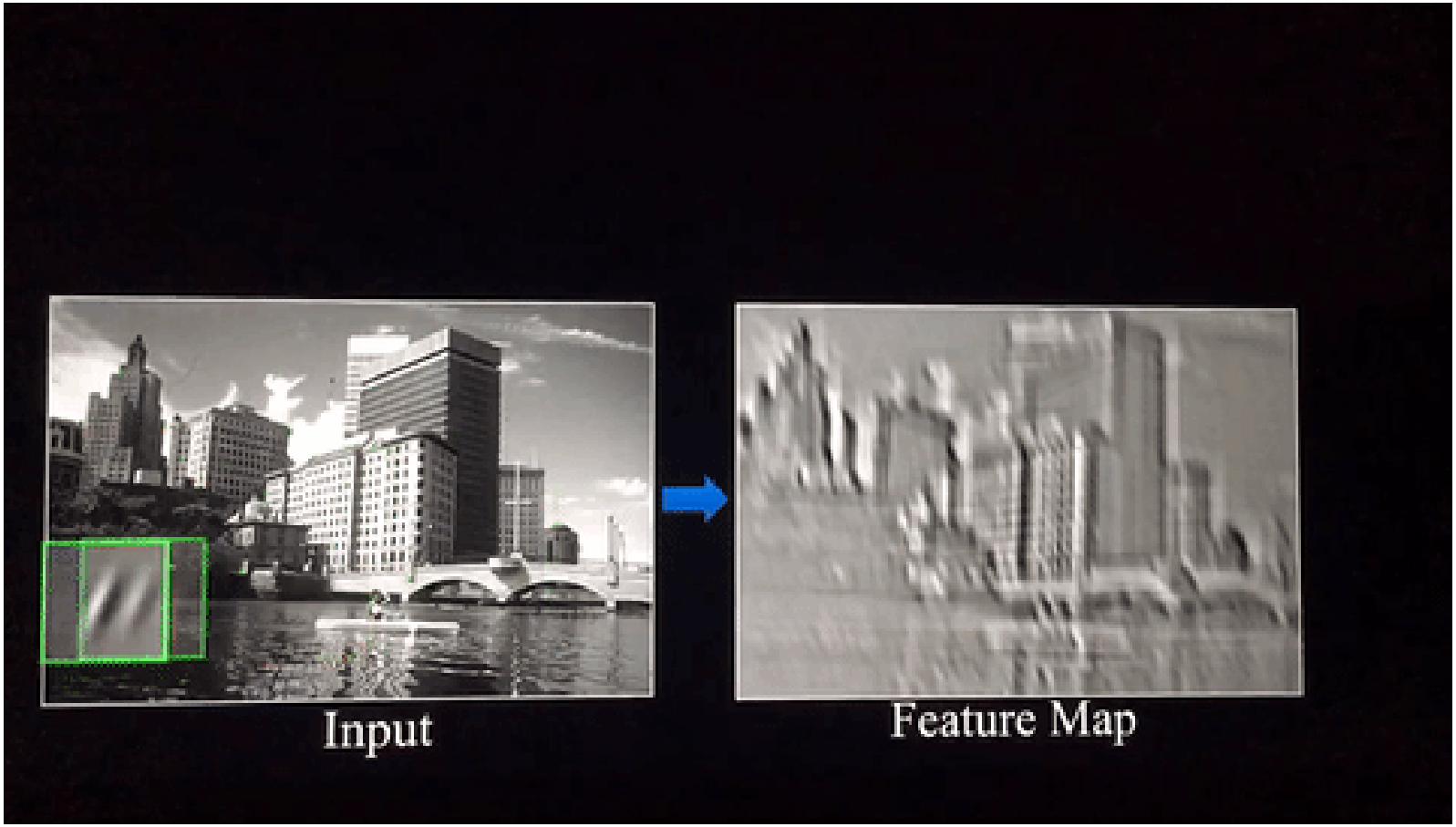
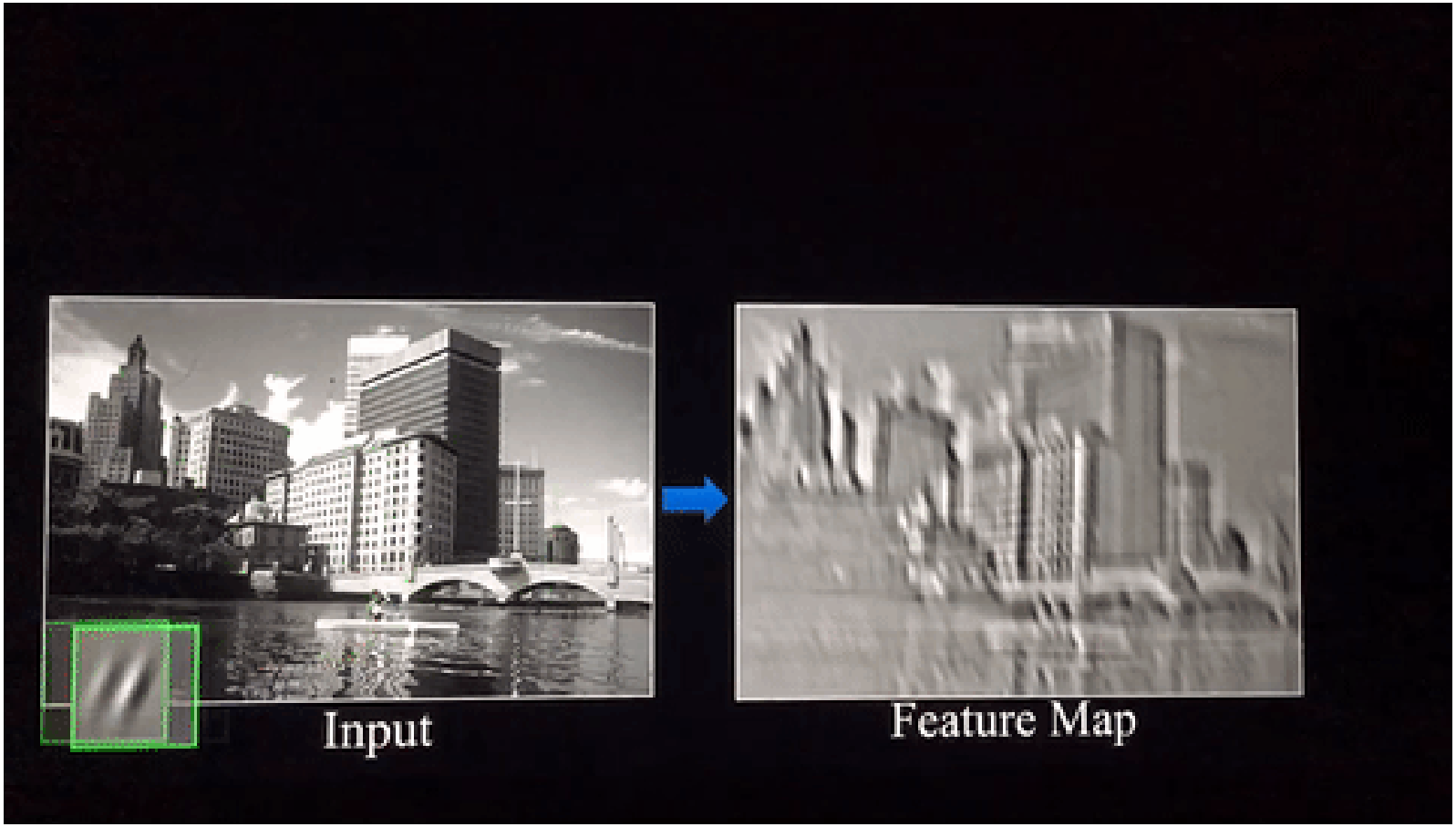


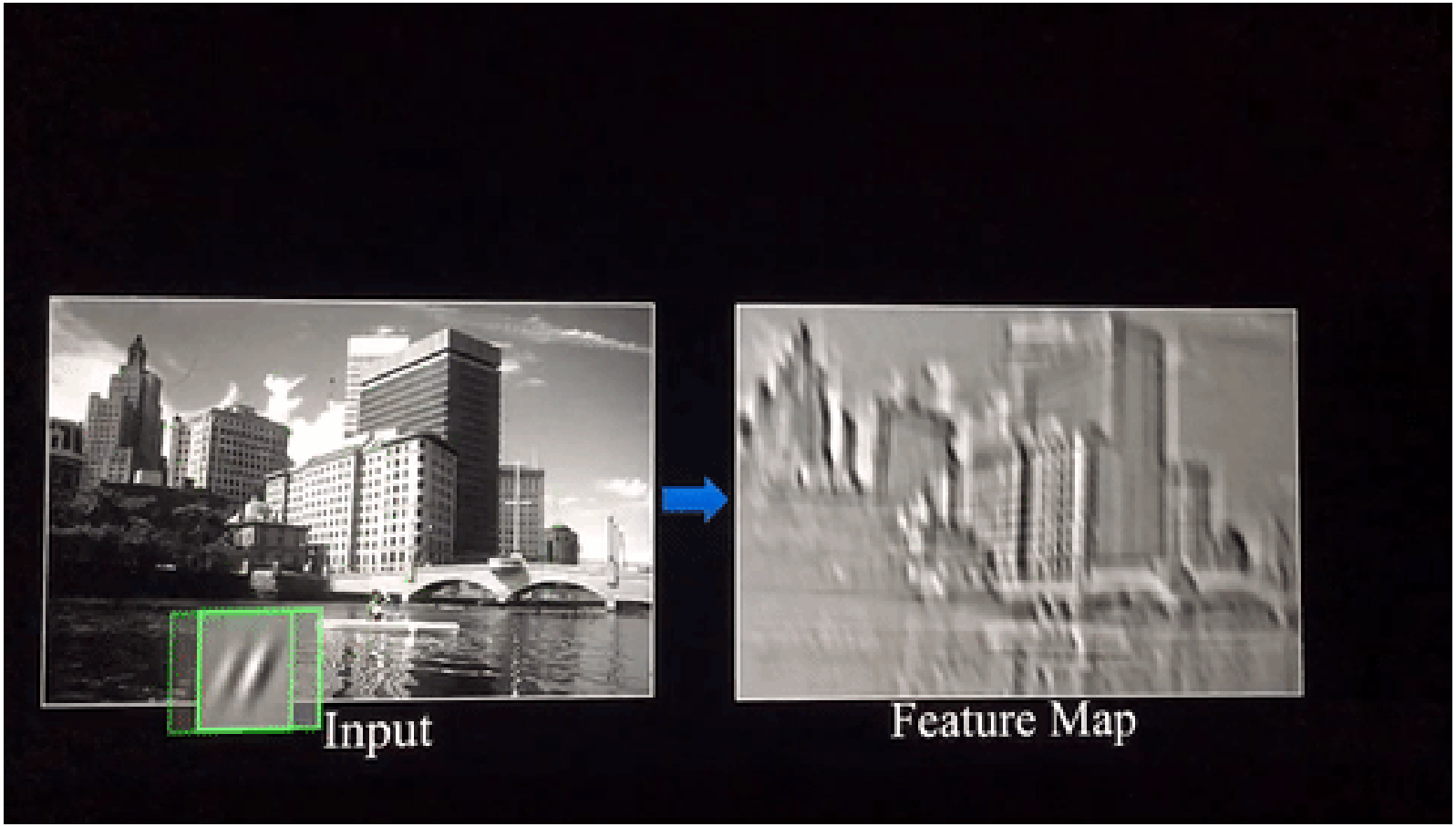
Convolution Layer



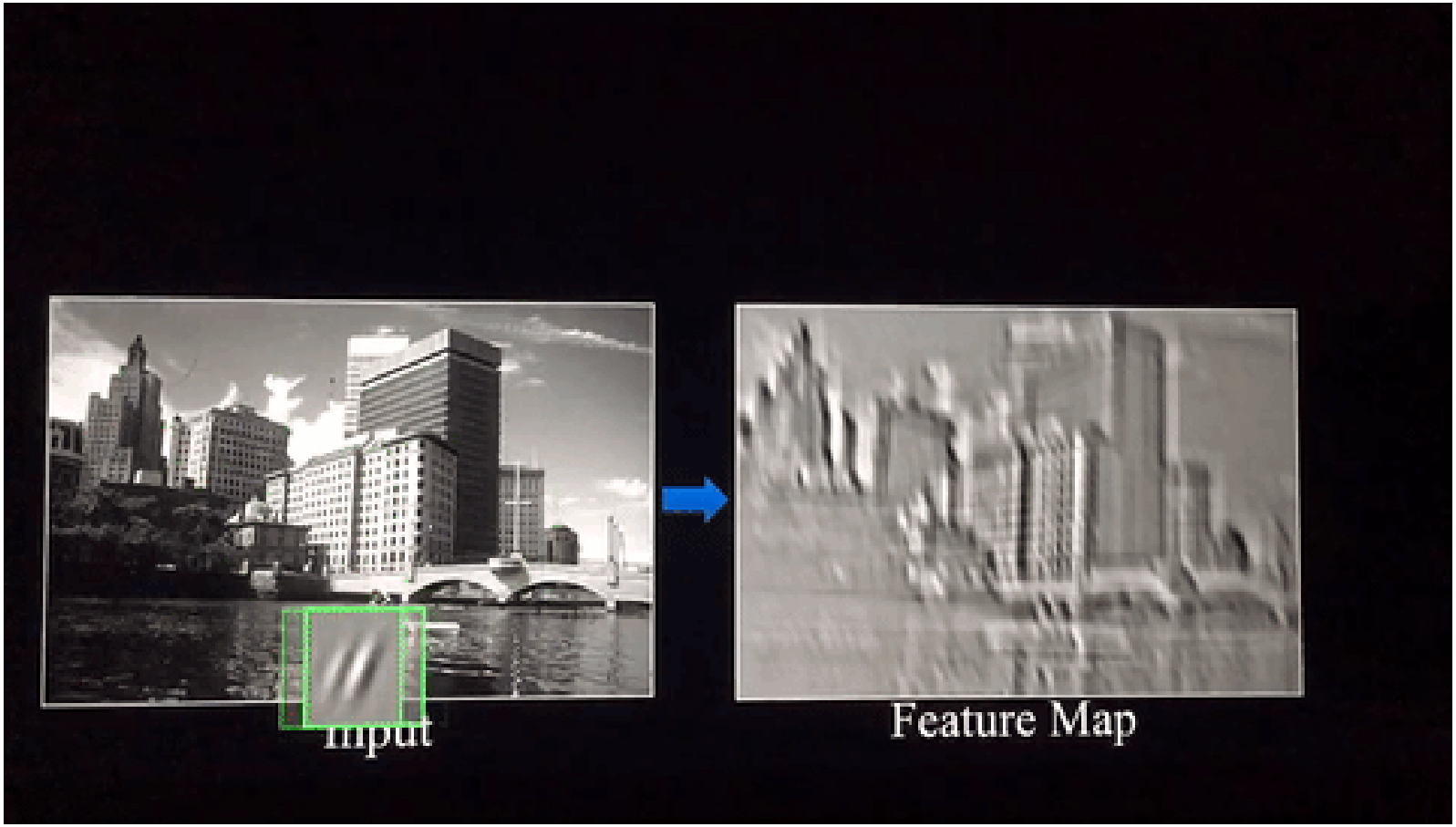
Convolution Layer



Convolution Layer



Convolution Layer



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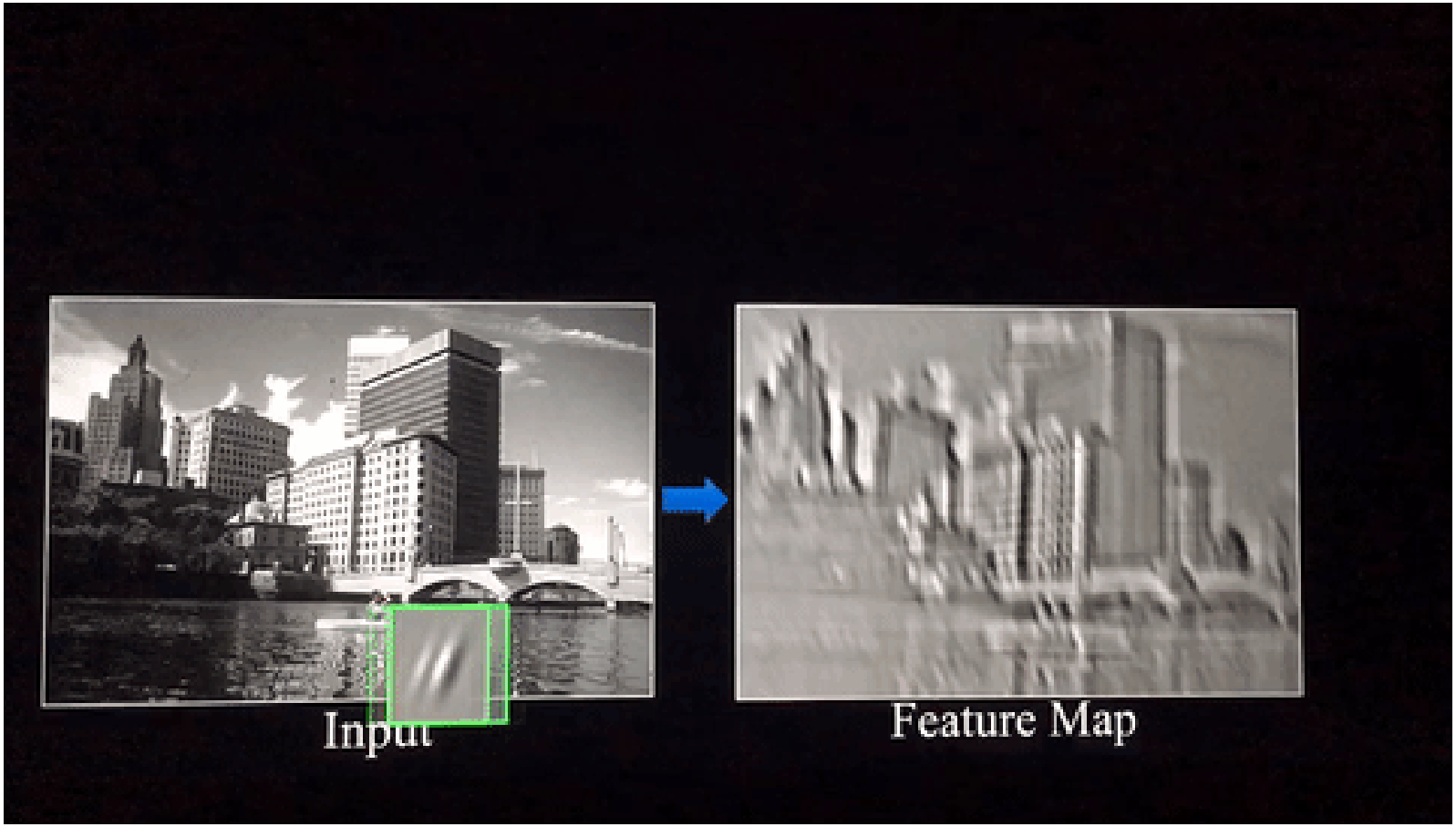

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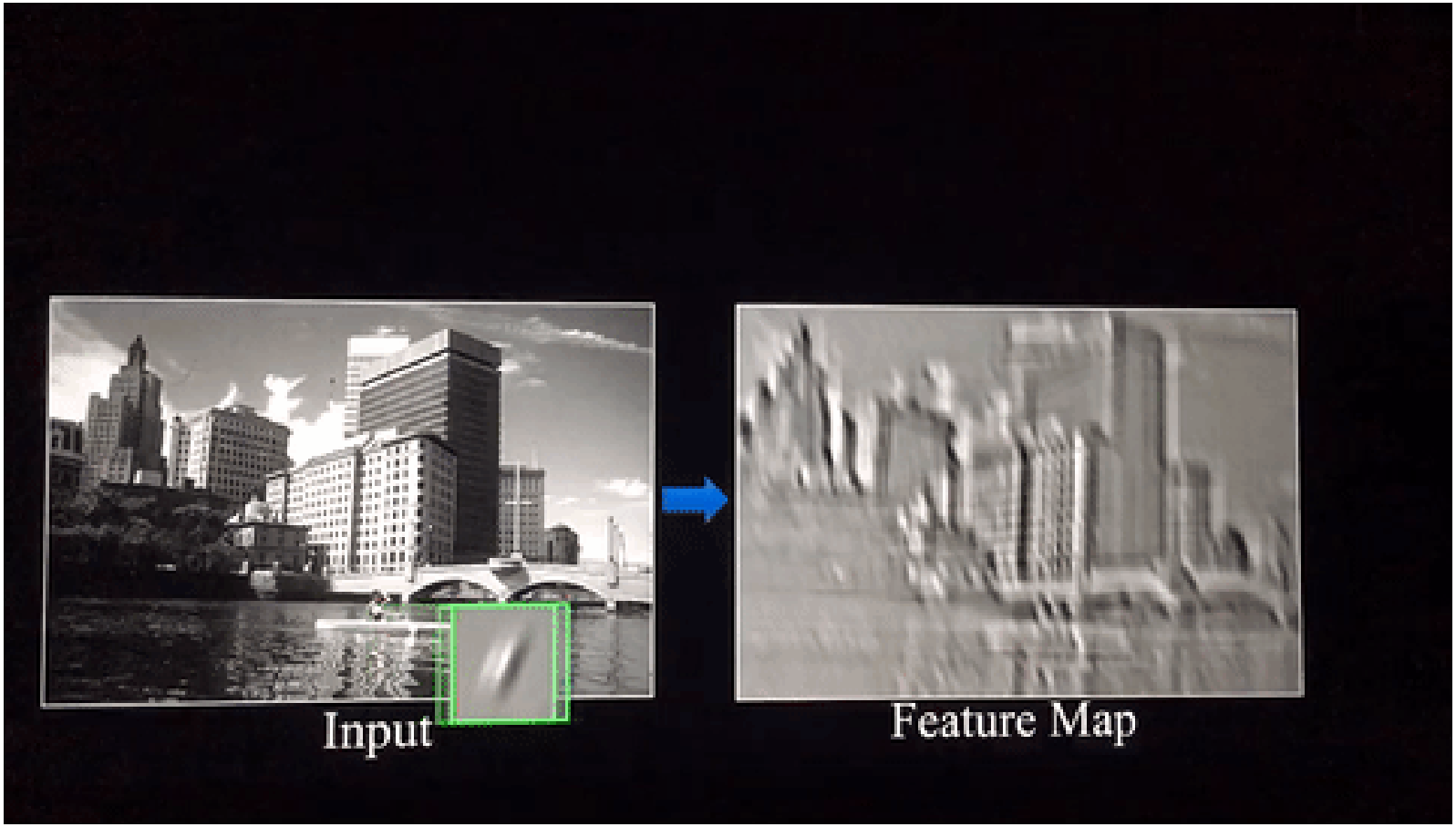

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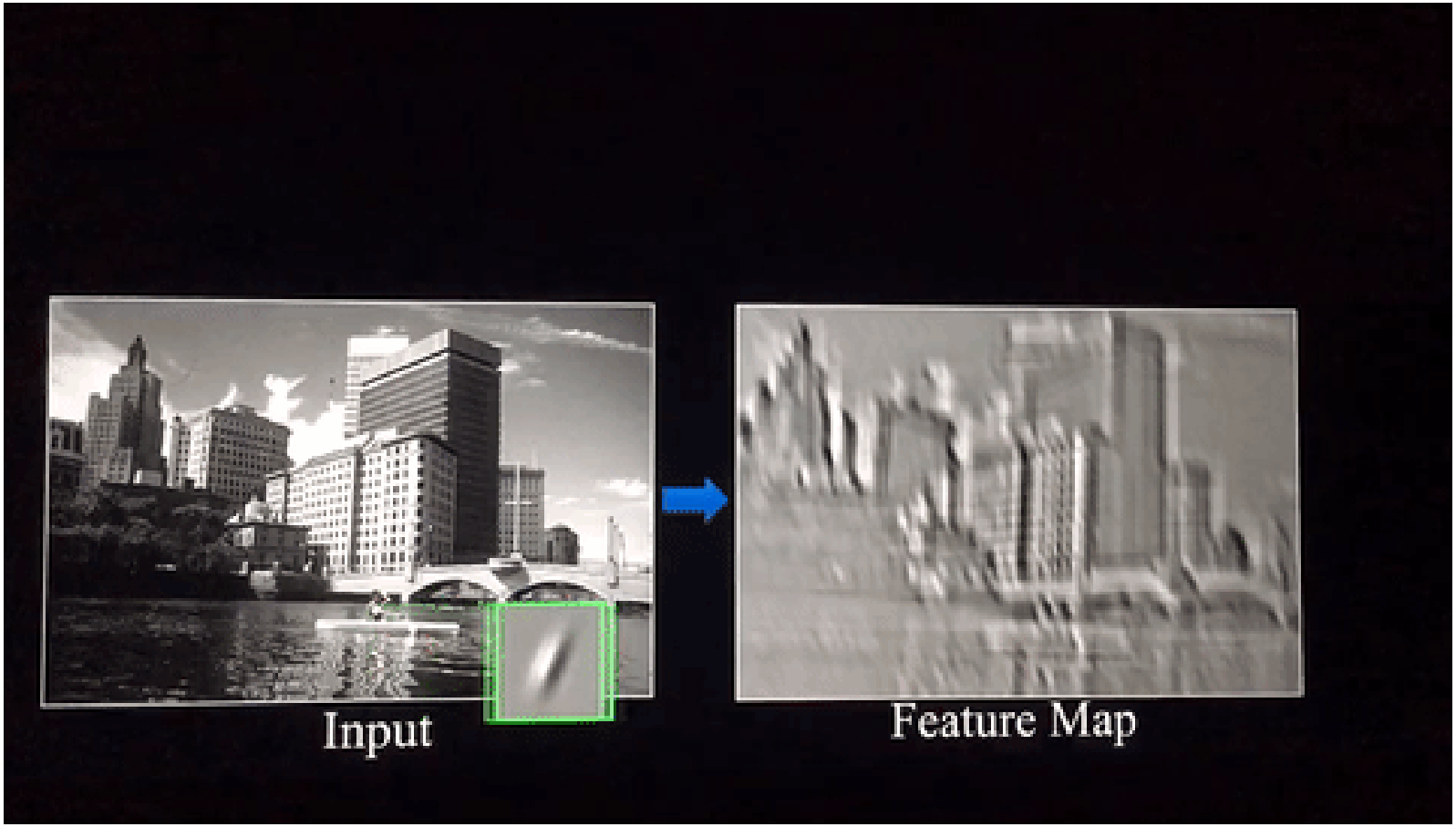
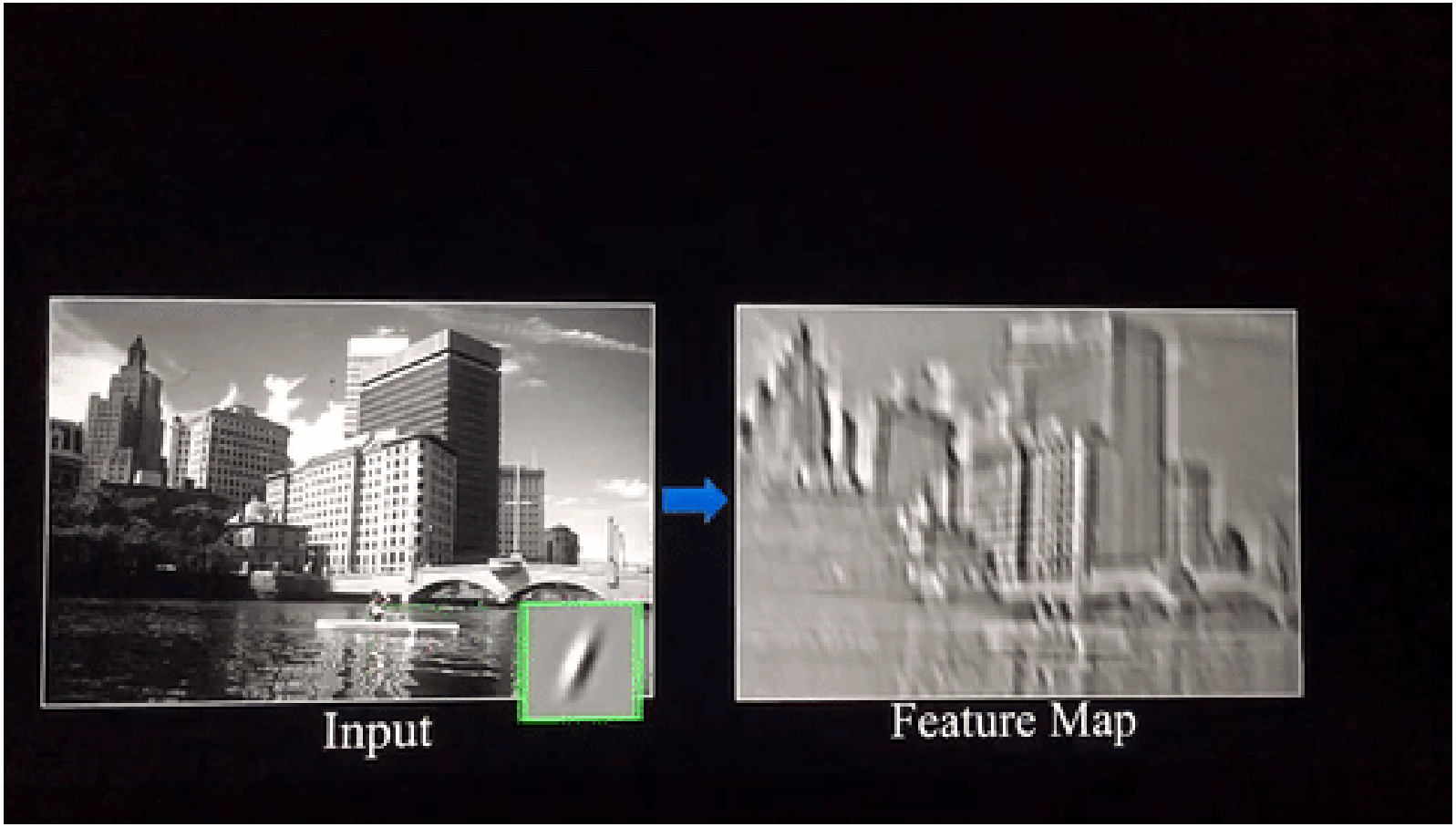
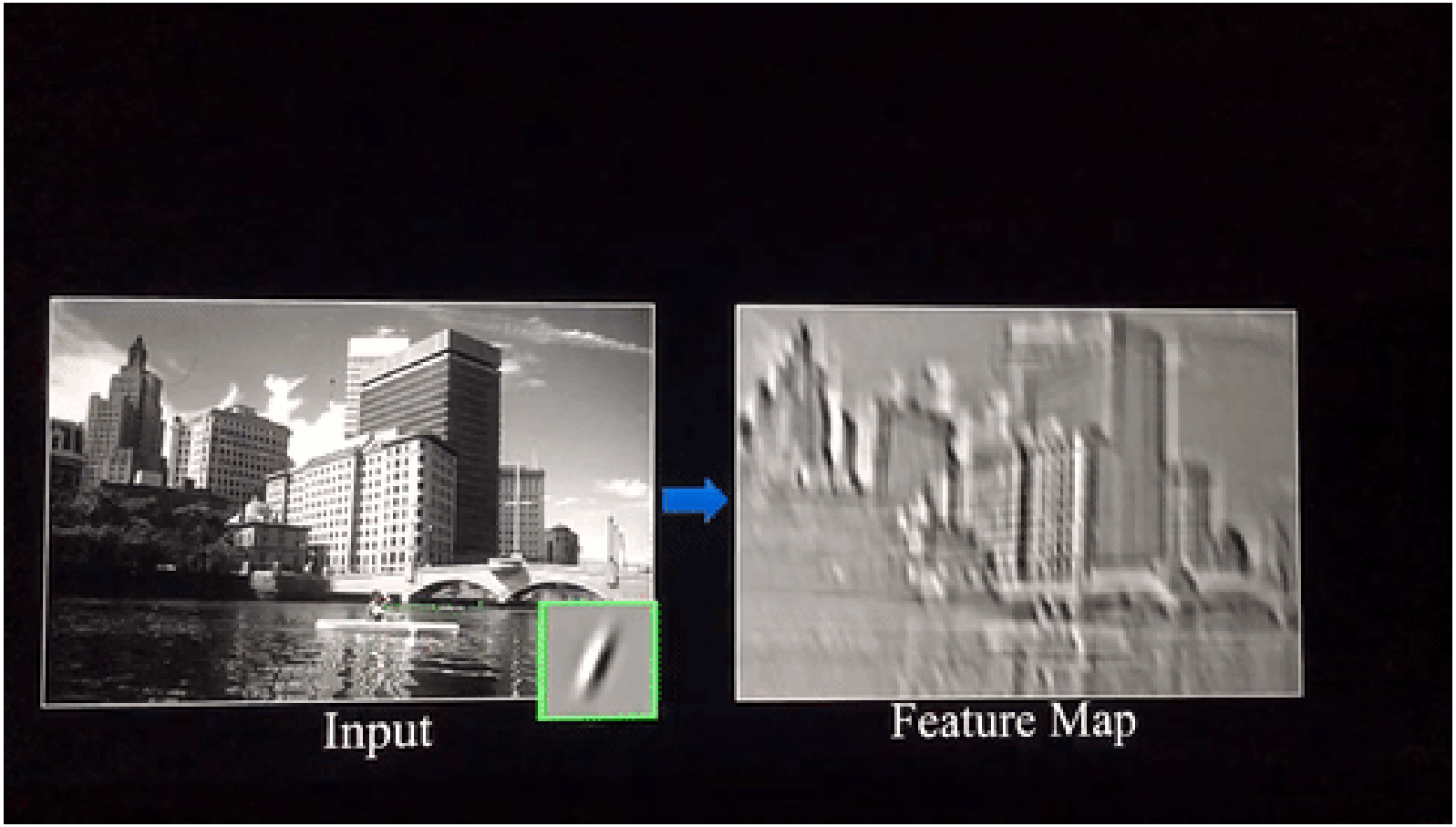


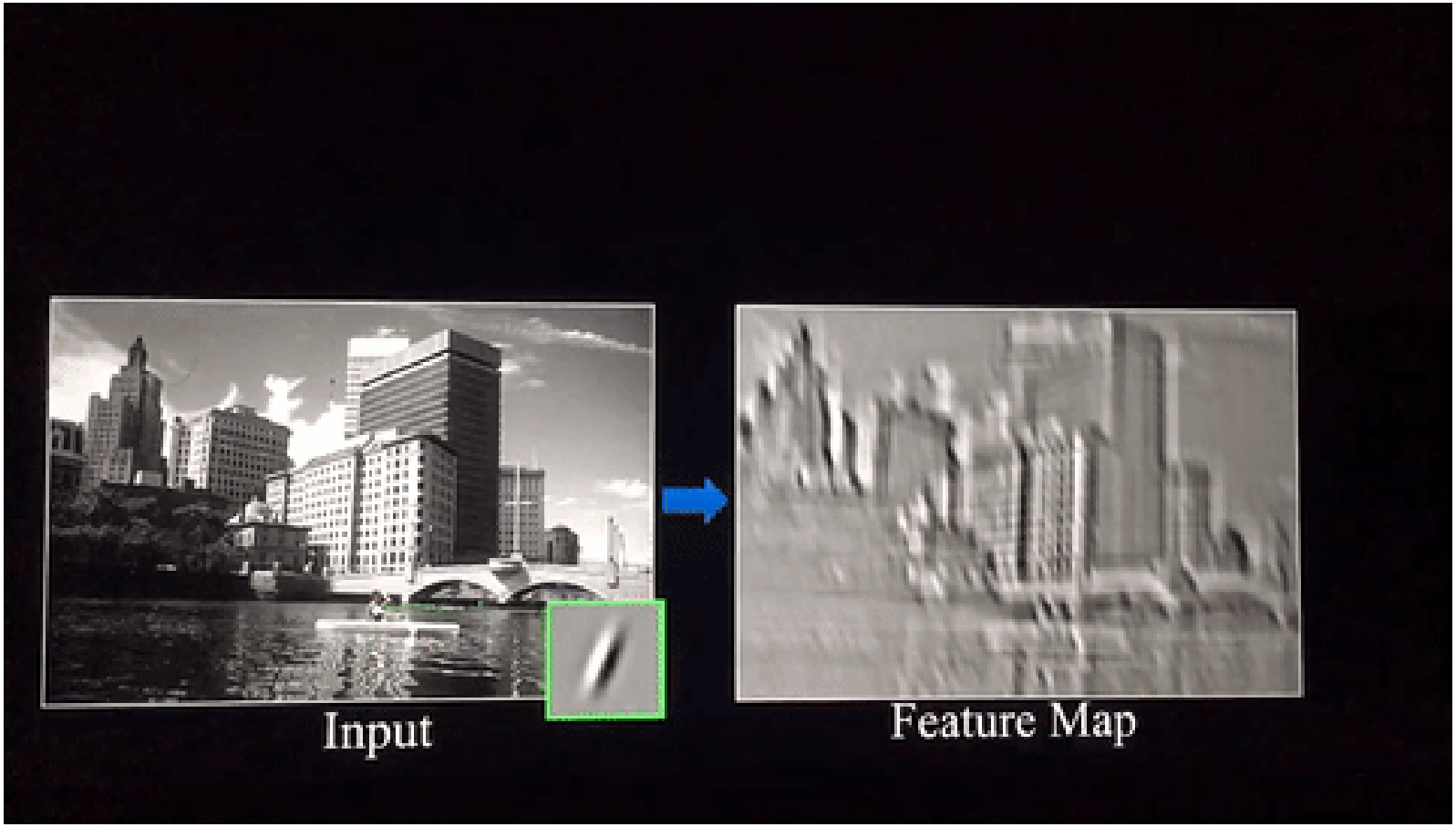
Convolution Layer



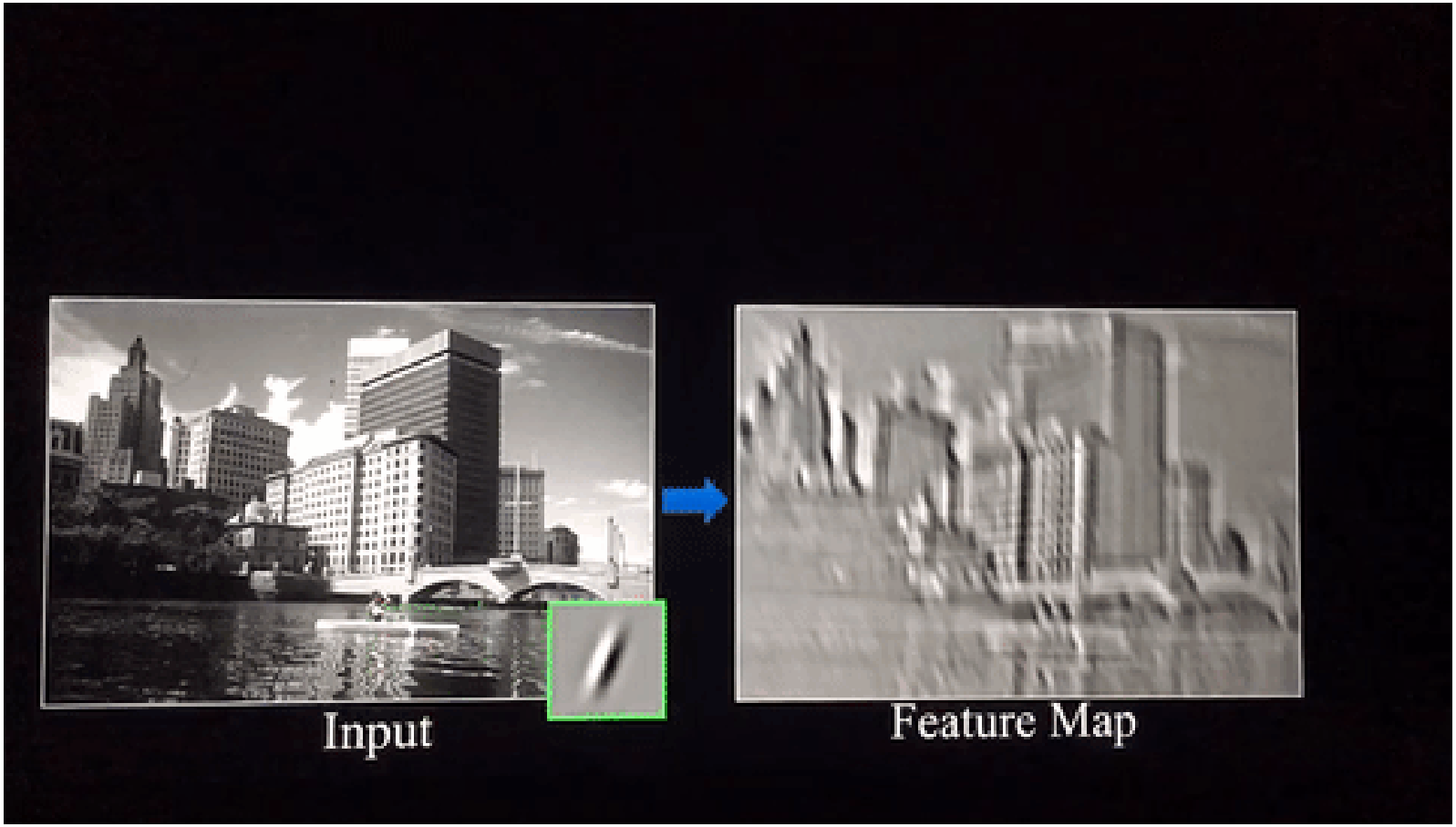
Convolution Layer



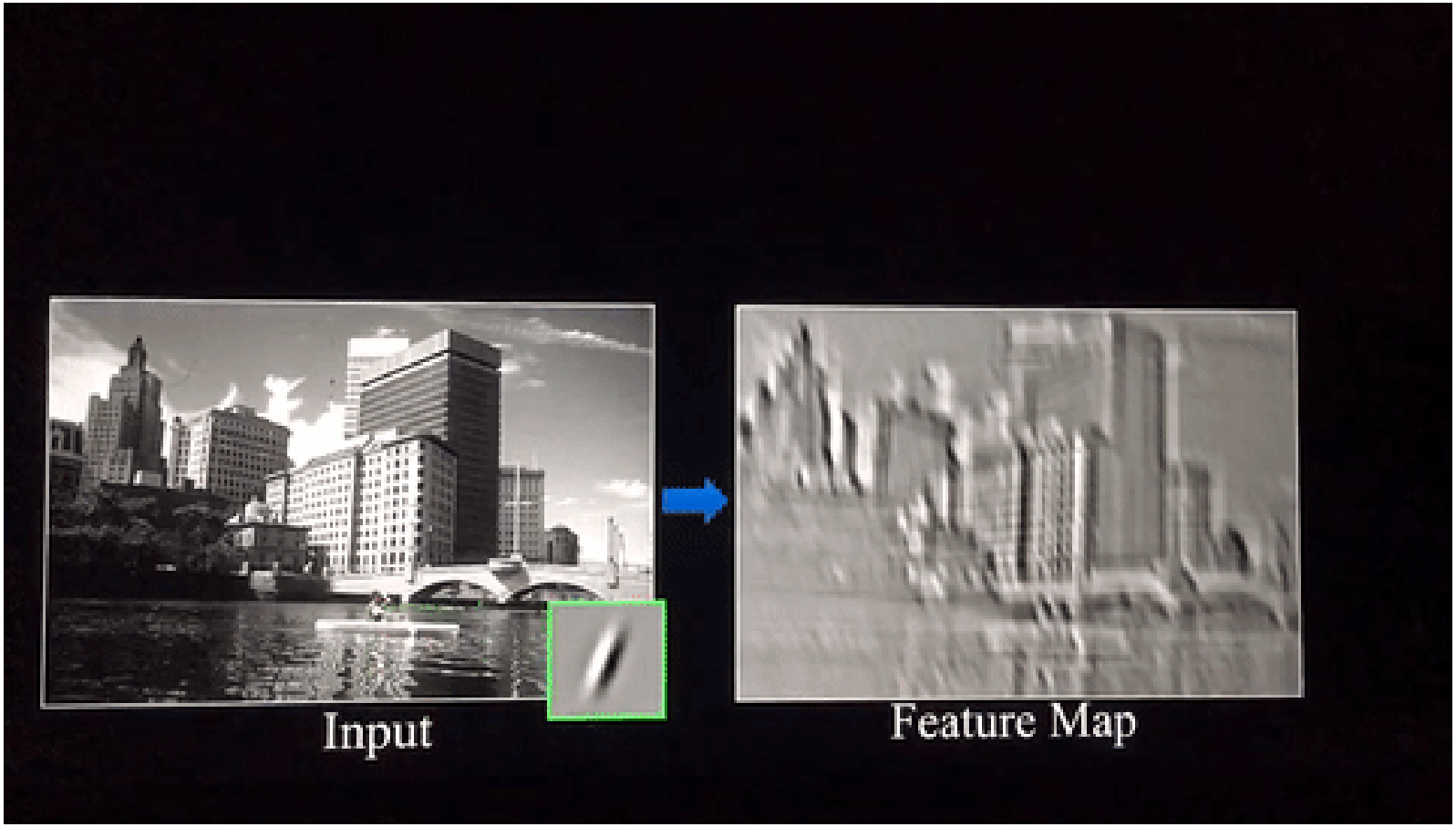
Convolution Layer



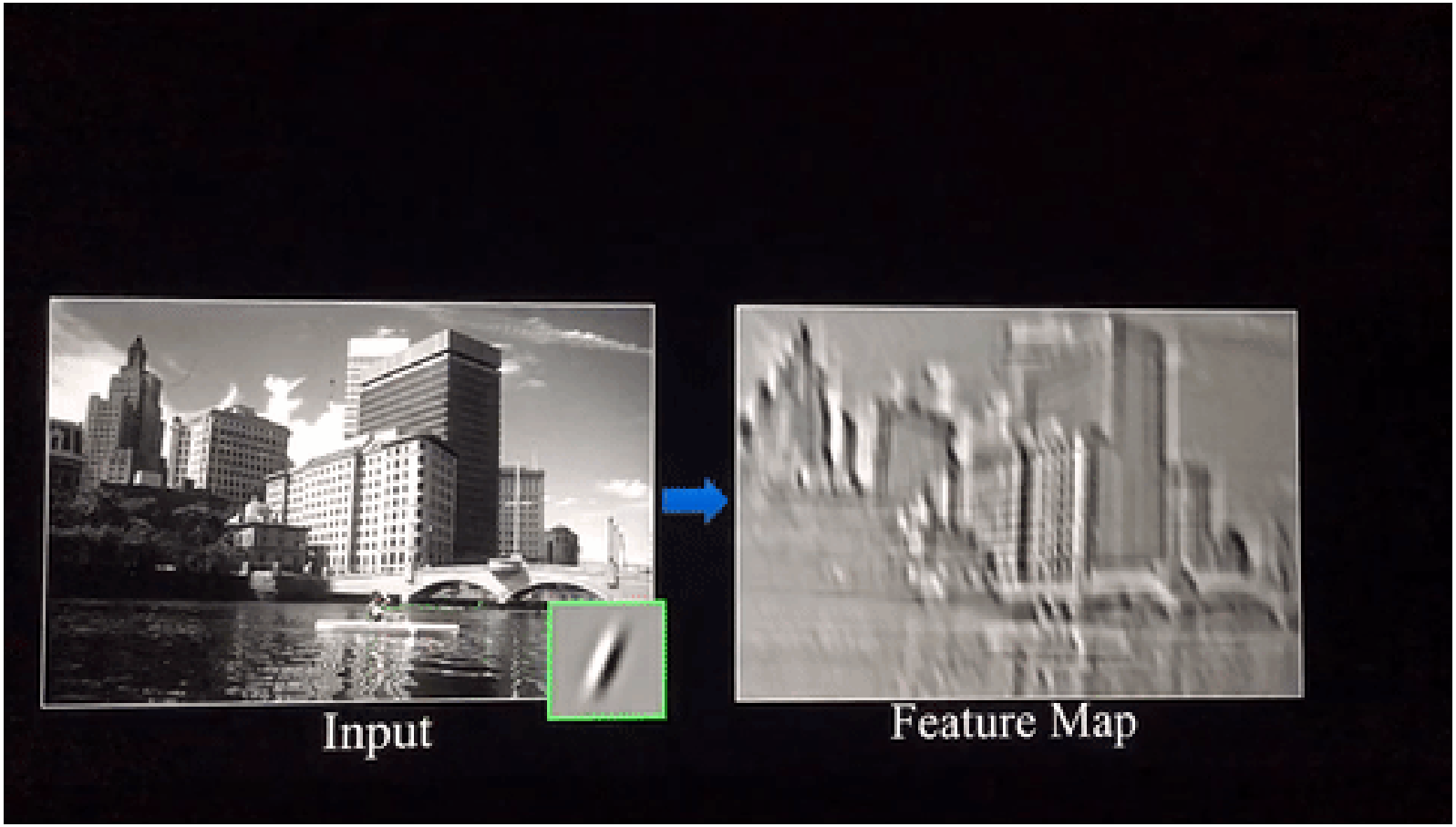
Convolution Layer



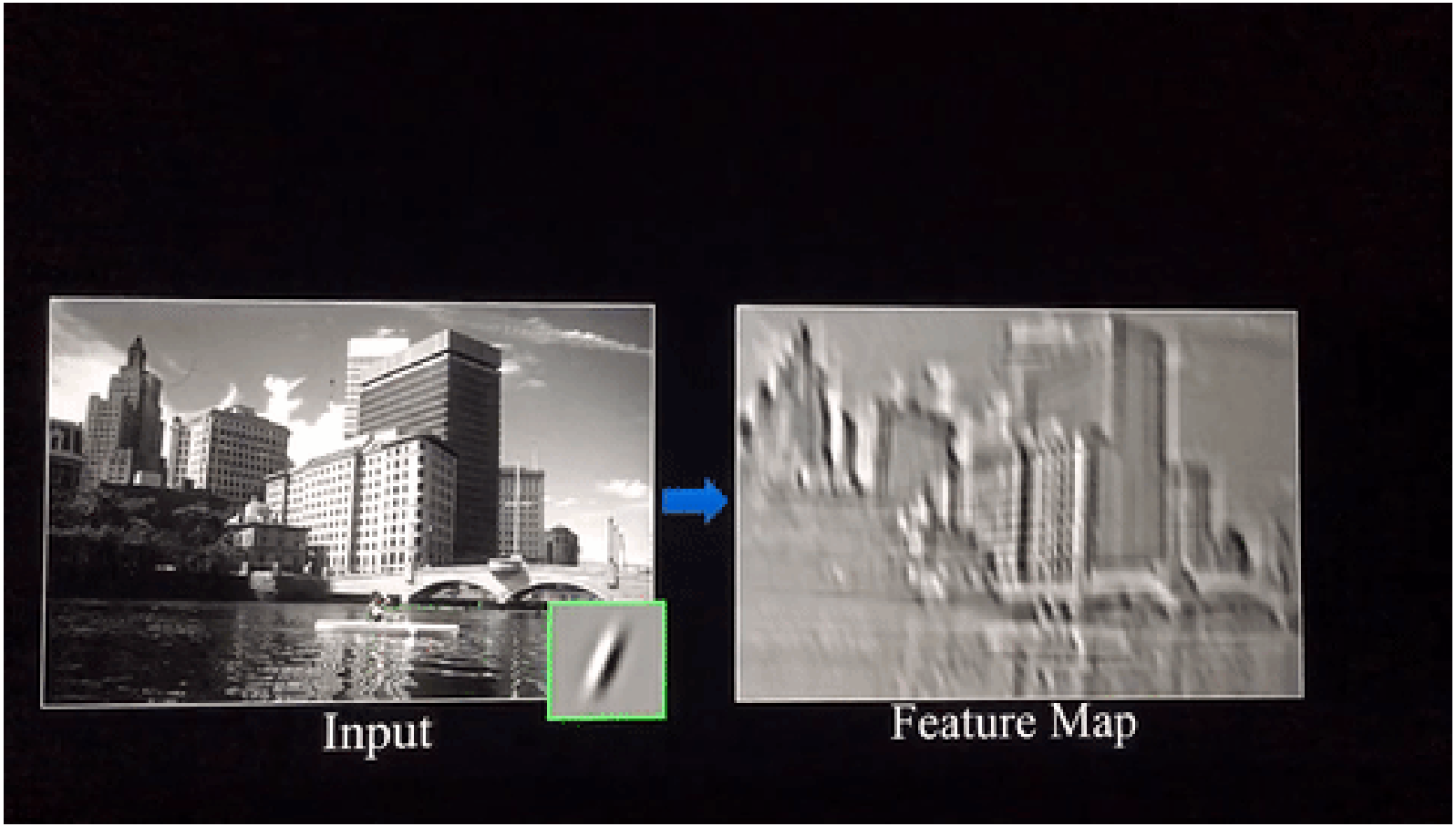
Convolution Layer



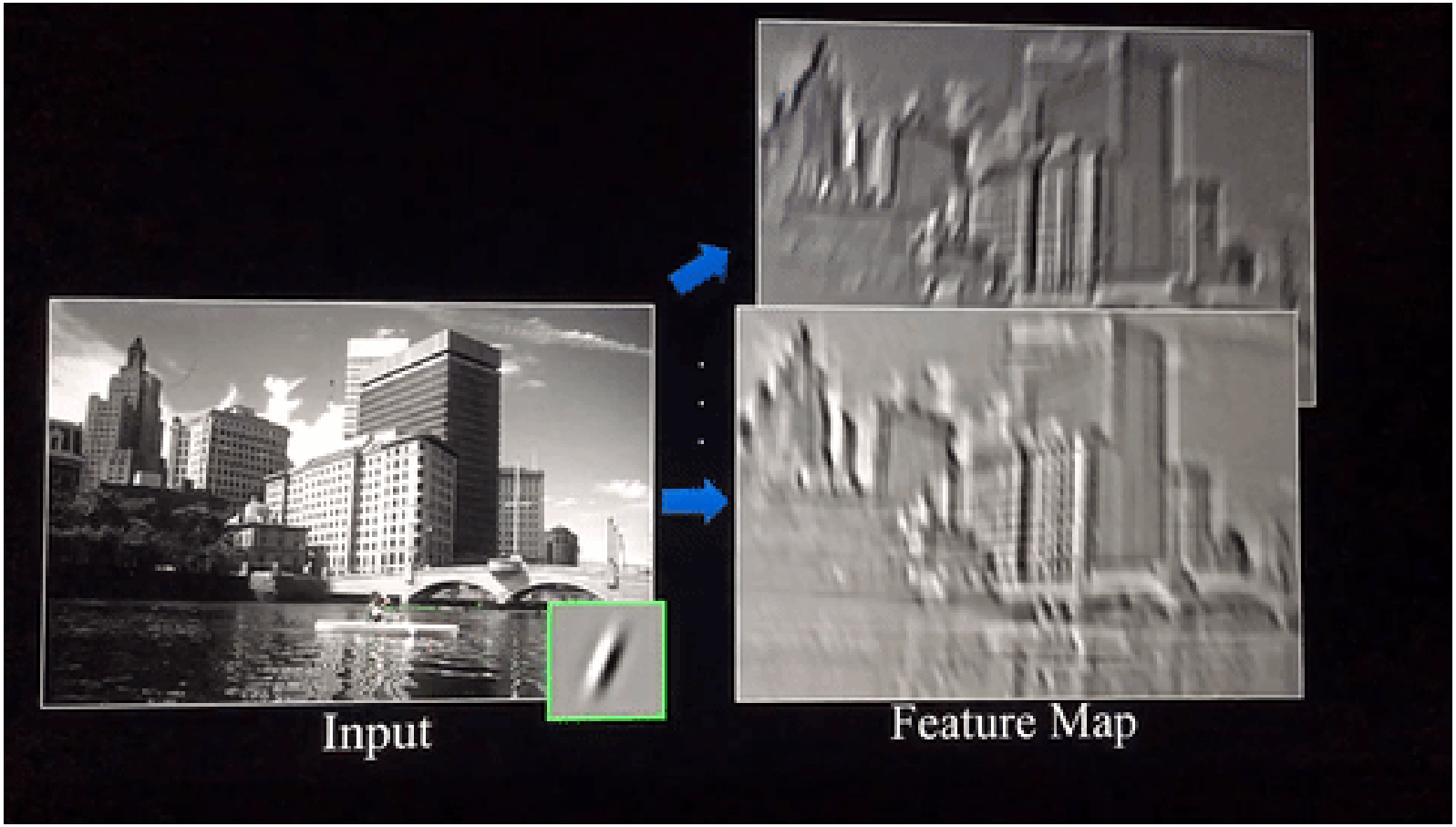
Convolution Layer



Convolution Layer



Convolution Layer



Convolution Layer

- Number of filters goes as argument.
- All different applied on image and Convolution Matrix is created.
- Different types of Filters.
  - Identity, Sobel, Edge detection, Sharpen.
- Demo of different filters applied on Image.

Pooling Layer

- Used for the reduction in dimension for each feature map.
- Retains most of the information.
- Max, Average, Sum pooling.
- **MaxPooling2D(pool_size=(2, 2), strides=None)**.

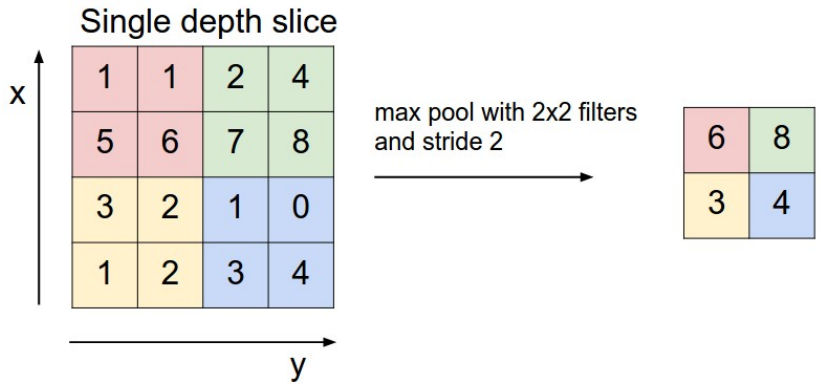


FIGURE – Max Pooling [2]

2. http ://cs231n.github.io/convolutional-networks/

ReLU Function

- ReLU stands for Rectified Linear Unit
- Used for non-linear operation.
- Operates on per pixels.
- Introduce non linearity in Convolutional Neural Network.
- Goes as an argument in Conv2D.

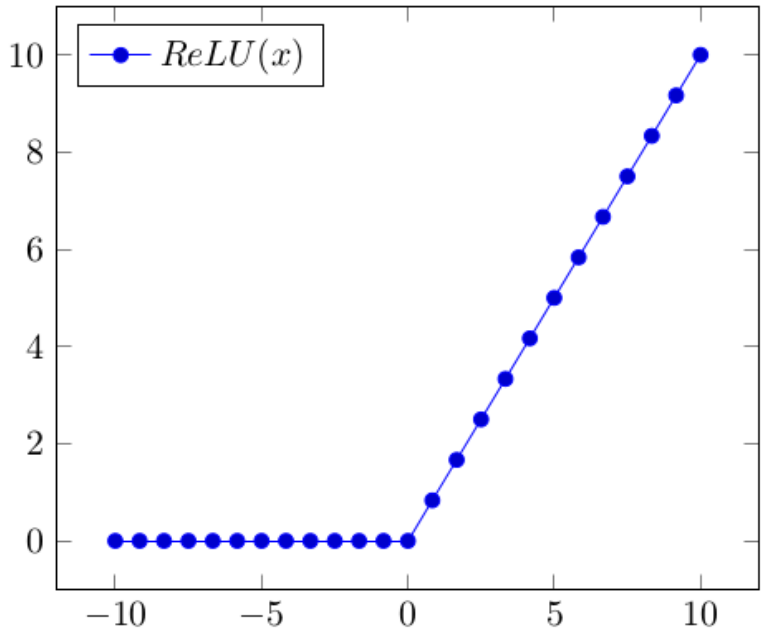


FIGURE – ReLu :=**max(0, x)**

Upsampling Layer

- It is used in context of CNN to denote reverse of Max pooling.
- A 2x2 matrix slides over image and doubles it's size.
- It is part of Deconvolution process.
- **UpSampling2D(size=(2, 2))**.

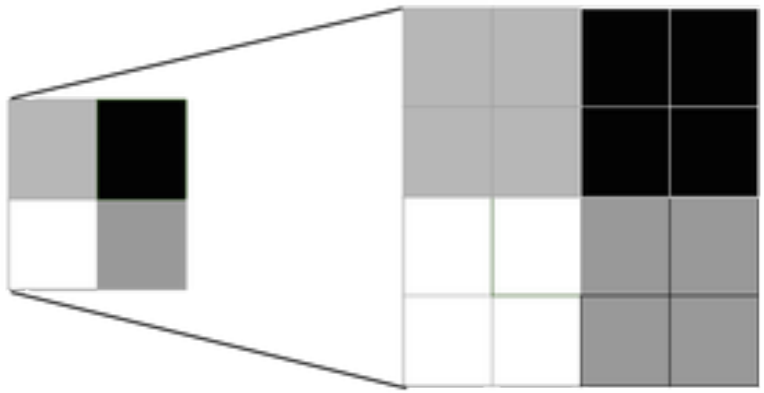


FIGURE – Upsampling [a]

a. https ://swarbrickjones.wordpress.com/2015/04/29/convolutional-autoencod

Model

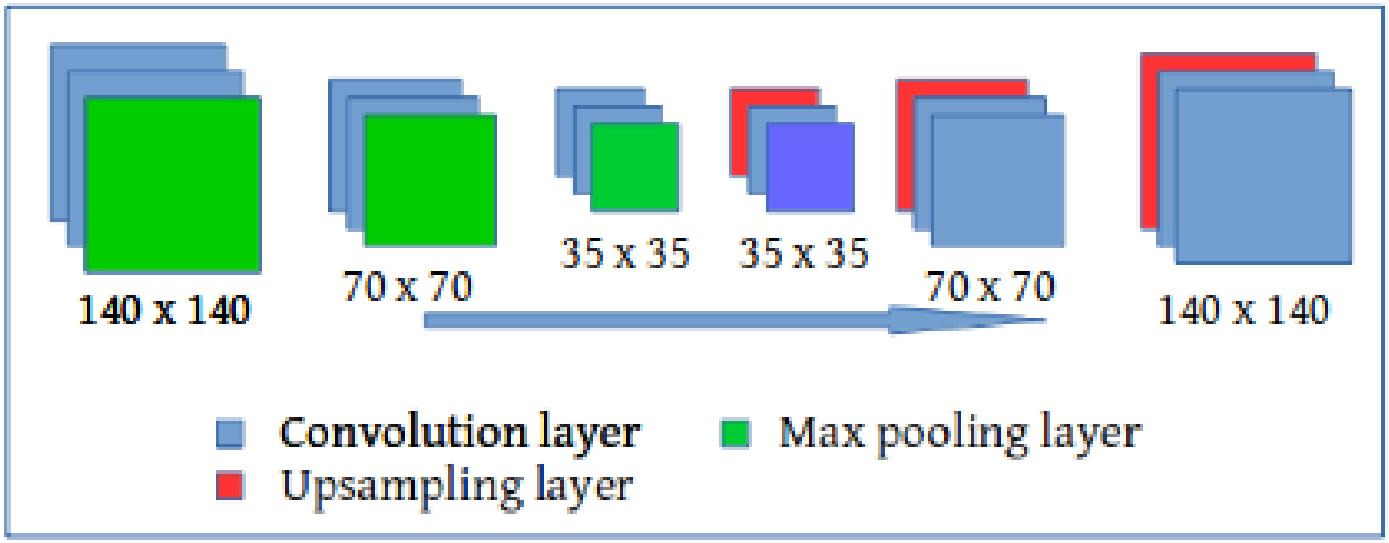


FIGURE – Basic Model

Brain tumor Segmentation

- Brain tumor segmentation seeks to separate healthy tissue from tumorous regions.
- Essential to maximize the likelihood of successful treatment.
- Manual segmentation are slow and tedious.
- High demand for computer algorithms that can do this quickly and accurately.

FIGURE – Original Image and Ground Truth [3]

3. BraTs Dataset

Brain MRI Images Dataset

- 2012 MICCAI BraTS Challenge.
- 320 3D Images (40 patients).
- Four images for a patient : T1, T2, FLAIR, T2C.
- Dimension 176x180x176.

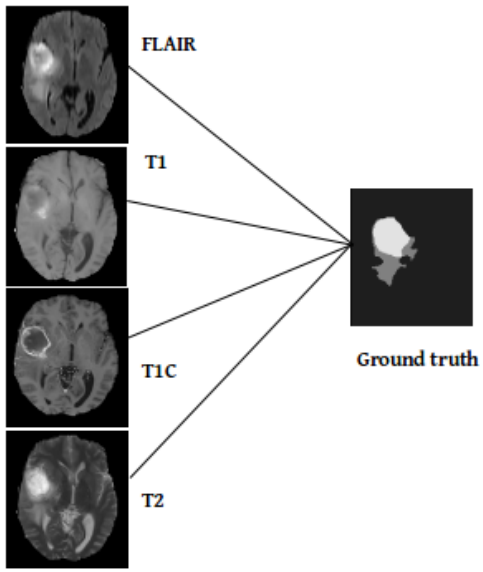


FIGURE – Different Images [4]

4. BraTs Dataset

Patch Extraction from Brain MRI Image for tumor segmentation

- Dataset is very large with 3D images.
- Depth : 176
- Most of the slices do not have tumor regions.

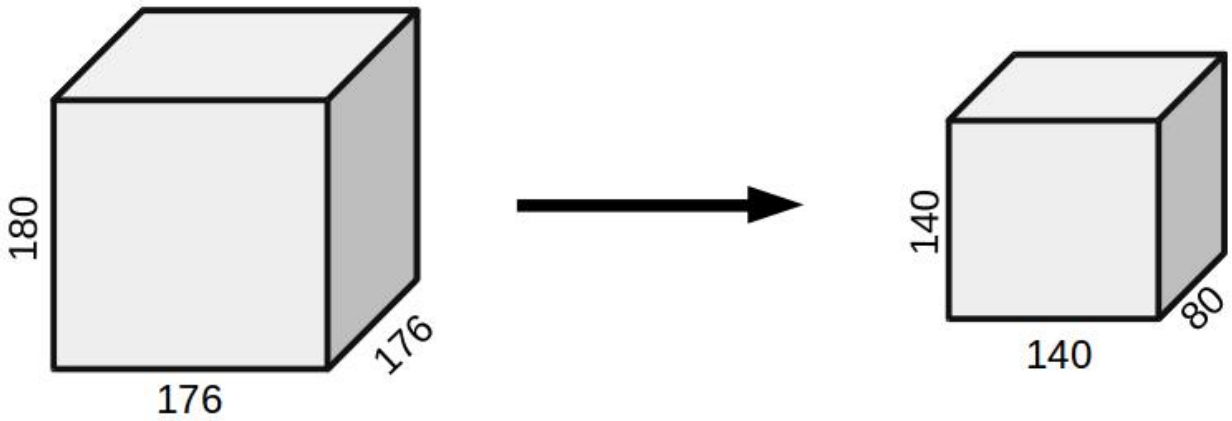


FIGURE – Patch Extraction

Result

Method	Training samples	test
Autoencoder	1-40 images	82.13%
Autoencoder	41-80 images	80.96%
Autoencoder	81-120 images	84.11%
Autoencoder	121-160 images	85.05%
Autoencoder	161-200 images	82.65%
Autoencoder	201-240 images	84.84%
Autoencoder	241-280 images	85.15%
Autoencoder	281-320 images	84.10%

- 3200 2D slices of 40 3D images are taken at a time.
- 2500 2D slices chosen for training randomly.
- 300 2D slices for validation and 400 2D slices for testing and ran for 30 epochs.

Hippocampus Segmentation

- Hippocampus segmentation is very helpful to know status of Alzheimer's disease.
- Hippocampus is responsible for converting short-term memory into long-term memory.
- Manual segmentation is slow, tedious and even expensive.
-

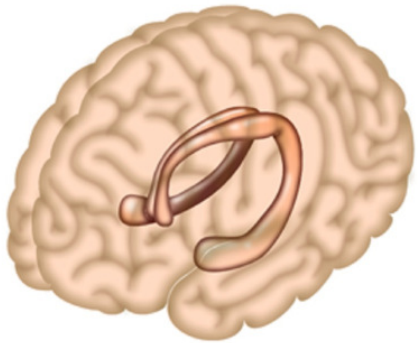


FIGURE – Original Image and Ground Truth [5]

5. OASIS Dataset

Hippocampus Images Dataset

- Open Access Series of Imaging Studies(OASIS) ; 23 3D Images.
- Alzheimer's Disease Neuroimaging Initiative(ADNI) ; 25 3D Images.
- Dimension 256x256x208.

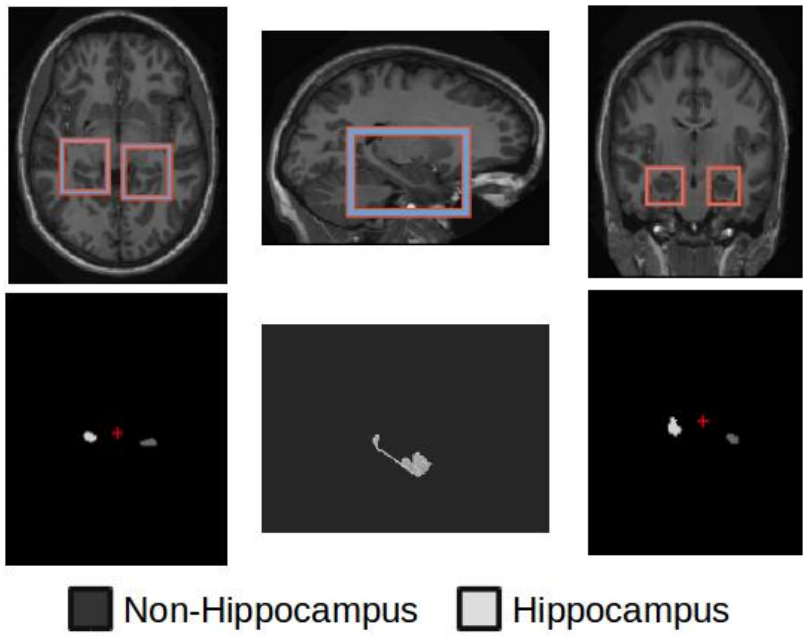


FIGURE – Original Image and Ground Truth [6]

6. OASIS Dataset using Freeview tool

Patch Extraction from Brain MRI Image for Hippocampus segmentation

- Dataset is very large with 3D images.
- Depth : 208
- Hippocampus lies in the central region of the brain .

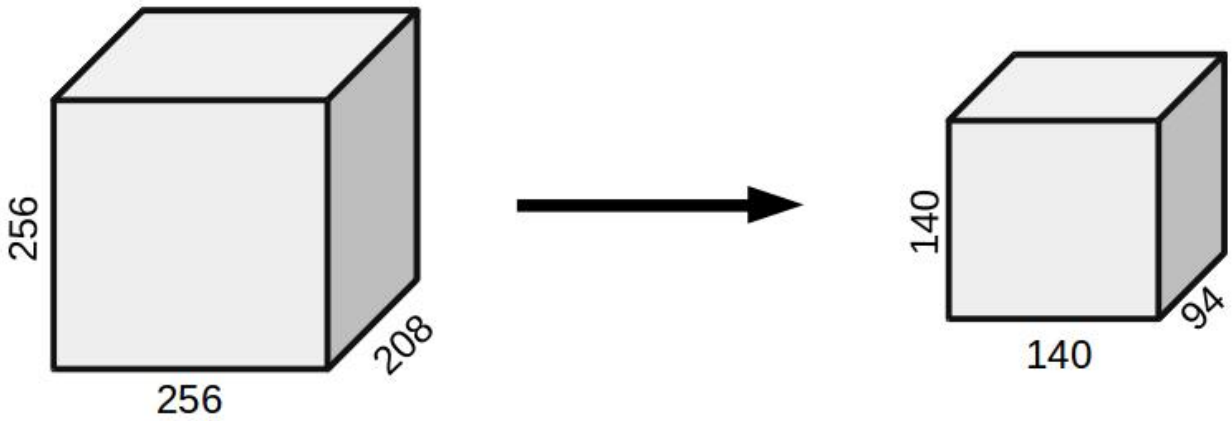


FIGURE – Patch Extraction

Result

Sr	X	Y	Z	δ	X Accuracy	Y Accuracy
1	13	5	5	5	97.11	86.23
2	13	5	5	10	97.23	87.47
3	15	5	5	5	96.43	85.39
4	15	5	5	10	96.93	86.21
5	28	10	10	5	97.27	87.11
6	28	10	10	10	97.41	87.51

X : #Training Images, Y : #Testing Images, Z : #Validation Images, δ : #Iterations ; here - # : Times, sr no. 1, 2 used OASIS dataset, and 3, 4 used ADNI dataset and in the 5, 6 both datasets are used(13 images from OASIS and 15 images from ADNI)

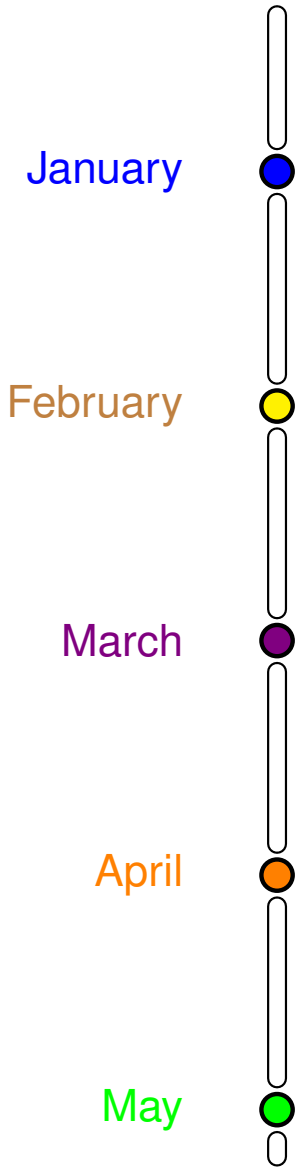
Conclusion

- Neural-network-based techniques are used successfully for the segmentation process.
- Brain tumor remains the leading cause of deaths, with the very low survival rate after diagnosis.
- Early detection of tumorous issues increases the survival rate for this disease.
- The model presented here gave significant results on OASIS, ANDI and BraTs datasets.

References

1. Vijay Badrinarayanan, Alex Kendall, and Roberto Cipolla. Segnet : A deep convolutional encoder-decoder architecture for image segmentation. arXiv preprint arXiv :1511.00561, 2015.
2. Matthew Lai. Deep learning for medical image segmentation. arXiv preprint arXiv :1505.02000, 2015.
3. Olaf Ronneberger, Philipp Fischer, and Thomas Brox. U-net : Convolutional networks for biomedical image segmentation. In International Conference on Medical Image Computing and Computer-Assisted Intervention, pages 234–241. Springer, 2015.
4. http ://cs231n.github.io/convolutional-networks/
5. https ://ujjwalkarn.me/2016/08/11/intuitive-explanation-convnets

THANK YOU !



January — **Literature survey**

February — **Problem selection & Finding Dataset**

March — **Dataset pre-processing, System requirements setting & model selection**

April — **Implementing model, testing model & Report**

May — **Final report changes and prepare presentation**