

detekcija_tock

June 2, 2025

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[1]: import cv2

import random
import math

import matplotlib.pyplot as plt
import numpy as np

import torch
import torch.nn as nn
import torch.optim as optim
import torchinfo
from torch.utils.tensorboard import SummaryWriter

from IPython.display import Image

import time

from scipy import ndimage
from skimage import transform

from os import listdir
from os.path import isfile, join

loss_diagram = SummaryWriter()
```

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[2]: #generating samples

def generate_points(center, radius, number):

    points = []

    for i in range(number):

        r = radius * math.sqrt(random.random())
        theta = random.uniform(0, 2 * math.pi)

        x = int(center[0] + r * math.cos(theta))
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        y = int(center[1] + r * math.sin(theta))

        points.append((x, y))

    return points

def points_far_enough(points, min_distance):

    for i in range(len(points) - 1):
        for j in range(i + 1, len(points)):

            distance = math.hypot(points[i][0] - points[j][0], points[i][1] -
↪points[j][1])

            if (distance < min_distance):
                return False

    return True

# https://docs.opencv.org/3.4/de/d25/imgproc\_color\_conversions.html
def lum(color):
    return (0.299 * color[0] + 0.587 * color[1] + 0.114 * color[2])

def generate_shape_color(bg_color, number, luminance_difference):

    # luminance_difference = 20 # 100
    checking_prev_colors = 4

    colors = []

    color_generated = True

    while True:

        new_color = tuple(random.randint(0, 255) for i in range(3))

        #check if bg_color and new_color have sufficiently different luminances
        if (abs(lum(bg_color) - lum(new_color)) >= luminance_difference):

            #check if new color and every color in colors[] have sufficiently
↪different luminances
            # this needs to be calculated based on neighboring colors,
↪otherwise it cant find a suitable color

            if (len(colors) >= checking_prev_colors):

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        if (abs(lum(colors[len(colors) - 1]) - lum(new_color)) <
↳luminance_difference
            or abs(lum(colors[len(colors) - 3]) - lum(new_color)) <
↳luminance_difference):
            color_generated = False

    else:
        for color in colors:
            if (abs(lum(color) - lum(new_color)) <
↳luminance_difference):
                color_generated = False

        if (color_generated == False):
            color_generated = True
            continue

        colors.append(new_color)

    if (len(colors) == number):
        return colors

def add_noise(img):

    noise = np.random.normal(0, 6, img.shape).astype(np.float32)

    noisy_image = img.astype(np.float32) + cv2.GaussianBlur(noise, (7, 7),
↳sigmaX=0)

    # Clip values to valid range [0, 255] and convert back to uint8
    noisy_image = np.clip(noisy_image, 0, 255).astype(np.uint8)

    return noisy_image

def apply_h(img, points):

    height_half = len(img) // 2
    width_half = len(img[0]) // 2

    point_distance = 10

    x = random.randint(point_distance, width_half - point_distance)
    y = random.randint(point_distance, height_half - point_distance)

    rect = np.array([[x, y], [x + width_half, y], [x + width_half, y +
↳height_half], [x, y + height_half]])

    #4 kotičke okna pomaknemo za naključne pomike v intervalu [-16, 16]

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rect_prim = np.array([[rect[0][0] + random.randint(-16, 16), rect[0][1] +
↳random.randint(-16, 16)],
                      [rect[1][0] + random.randint(-16, 16), rect[1][1] + random.
↳randint(-16, 16)],
                      [rect[2][0] + random.randint(-16, 16), rect[2][1] + random.
↳randint(-16, 16)],
                      [rect[3][0] + random.randint(-16, 16), rect[3][1] + random.
↳randint(-16, 16)]] , np.int32)

shift = random.randint(0, 3)
rect_prim = np.roll(rect_prim, shift, axis=-1)

#iz 4 kotičkov in njihovih pomikov izračunamo homografijo H
H, _ = cv2.findHomography(rect, rect_prim)

H = np.linalg.inv(H)

#inverz ocenjene homografije  $H^{-1}$  apliciramo na sliko, dobimo
↳transformirano sliko
warped_image = cv2.warpPerspective(img, H, (img.shape[1], img.shape[0]),
↳borderMode=cv2.BORDER_REPLICATE)

#project points

# Convert to numpy array in shape (H, W, 2)
points = np.array(points)

# Flatten to shape (H*W, 2)
flat_points = points.reshape(-1, 2)

# Add homogeneous coordinate (x, y) -> (x, y, 1)
ones = np.ones((flat_points.shape[0], 1))
points_homogeneous = np.hstack([flat_points, ones]) # shape (N, 3)

# Apply homography
projected = H @ points_homogeneous.T # shape (3, N)
projected = projected.T # shape (N, 3)

# Convert back to 2D
transformed_points = projected[:, :2] / projected[:, 2:3]

# Reshape to original shape (rows, cols, 2)
transformed_array = transformed_points.reshape(points.shape)

h_points_img = np.zeros(img.shape, dtype=np.uint8)

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if transformed_array.ndim == 2:
    for point in transformed_array:
        cv2.circle(h_points_img, (int(point[0]), int(point[1])), 0, 1, -1)
else:

    for line in transformed_array:
        for point in line:
            cv2.circle(h_points_img, (int(point[0]), int(point[1])), 0, 1, -1)

return warped_image, h_points_img

```

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[3]: def generate_triangle(width, height):

    center = (width // 2, height // 2)
    radius = width // 2 - 5 #staying within bounds
    min_distance = 10

    while True:
        points = generate_points(center, radius, 3)

        if points_far_enough(points, min_distance):
            break

    background_color = tuple(random.randint(0, 255) for i in range(3))

    img = np.full((height, width, 3), background_color, dtype=np.uint8)

    pts_array = np.array([points], dtype=np.int32)
    cv2.fillPoly(img, pts_array, color=generate_shape_color(background_color, 1, 100)[0])

    img_gray = cv2.cvtColor(img, cv2.COLOR_BGR2GRAY)
    final_img, points_img = apply_h(img_gray, points)
    final_img = add_noise(final_img)

    # #build the points image
    # points_img = np.zeros(img.shape)

    # for point in points:
    #     cv2.circle(points_img, point, 1, (0, 255, 0), -1)

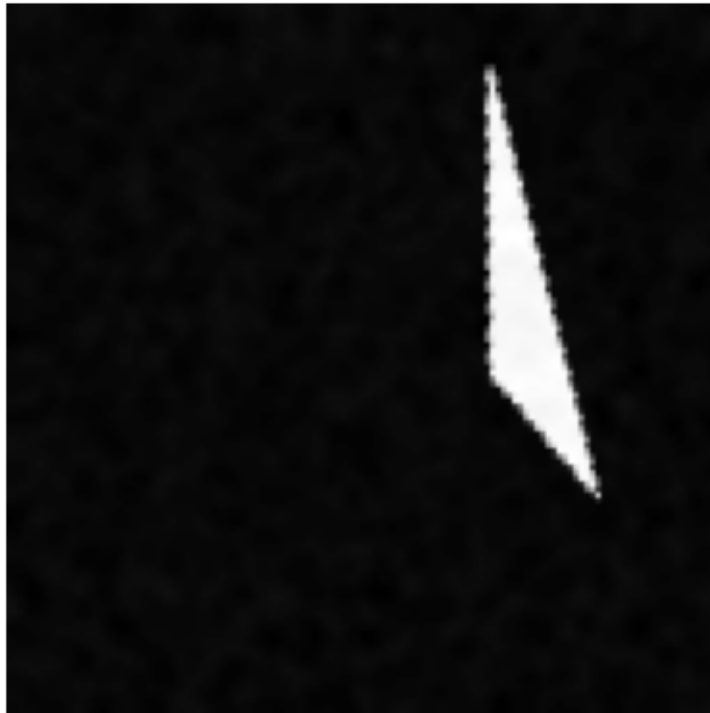
    return final_img, points_img

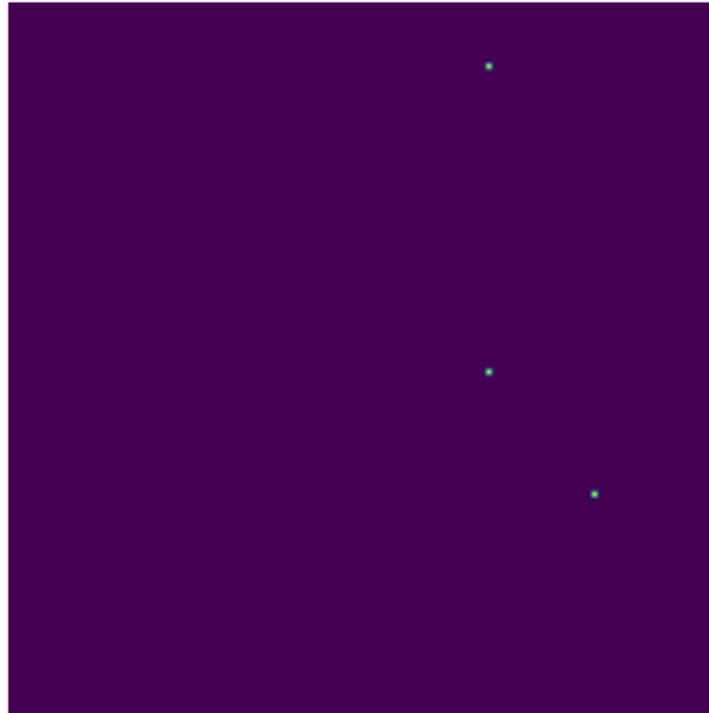
for i in range(1):
    image, points_image = generate_triangle(128, 128)

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```
plt.imshow(image, cmap='gray')  
plt.axis('off')  
plt.show()
```

```
plt.imshow(points_image)  
plt.axis('off')  
plt.show()
```





```
[4]: # https://stackoverflow.com/questions/9608148/
      ↪python-script-to-determine-if-x-y-coordinates-are-colinear-getting-some-e
def colinear_points(points):
    # check if any 3 of the generated points are colinear (prevents generating
    ↪triangle)

    for i in range(4):
        x1, y1 = points[i % 4]
        x2, y2 = points[(i + 1) % 4]
        x3, y3 = points[(i + 2) % 4]

        if (abs(((x1 * (y2 - y3)) + (x2 * (y3 - y1) + (x3 * (y1 - y2)))) / 2.0)
        ↪< 1e-2):
            return True

    return False

# https://stackoverflow.com/questions/18583214/
      ↪calculate-angle-of-triangle-python
def check_angles(points):
    # prevents square overlapping itself and colinearity

    angle_min = 10
```

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for i in range(4):
    x1, y1 = points[i % 4]
    x2, y2 = points[(i + 1) % 4]
    x3, y3 = points[(i + 2) % 4]

    dx1 = x1 - x2
    dy1 = y1 - y2

    dx2 = x3 - x2
    dy2 = y3 - y2

    numerator = dx1 * dx2 + dy1 * dy2
    denominator = math.sqrt((math.pow(dx1, 2) + math.pow(dy1, 2)) * (math.
↪ pow(dx2, 2) + math.pow(dy2, 2)))

    angle = abs(180 - math.degrees(math.acos(numerator / denominator)))

    if (angle < angle_min):
        return False

    return True

#https://stackoverflow.com/questions/3838329/
↪ how-can-i-check-if-two-segments-intersect
def ccw(p1, p2, p3):
    return (p3[1] - p1[1]) * (p2[0] - p1[0]) > (p2[1] - p1[1]) * (p3[0] - p1[0])

def is_valid_square(points):
    return ((ccw(points[0], points[1], points[3]) != ccw(points[2], points[1],
↪ points[3])
                and ccw(points[0], points[2], points[1]) != ccw(points[0],
↪ points[2], points[3])))

def sort_by_angle(points, center):

    def angle(point):
        return math.atan2(point[1] - center[1], point[0] - center[0])

    return sorted(points, key=angle)

def generate_square(width, height):

    center = (width // 2, height // 2)
    radius = width // 2 - 5 #staying within bounds
    min_distance = 10

```



```

while True:
    points = generate_points(center, radius, 4)
    points = sort_by_angle(points, center)

    if points_far_enough(points, min_distance) and is_valid_square(points)
↪and check_angles(points) and not colinear_points(points):
        break

background_color = tuple(random.randint(0, 255) for i in range(3))

img = np.full((height, width, 3), background_color, dtype=np.uint8)

pts_array = np.array([points], dtype=np.int32)
cv2.fillPoly(img, pts_array, color=generate_shape_color(background_color,
↪1, 100)[0])

img_gray = cv2.cvtColor(img, cv2.COLOR_BGR2GRAY)
final_img, points_img = apply_h(img_gray, points)
final_img = add_noise(final_img)

# points_img = np.zeros(img.shape)

# for point in points:
#     cv2.circle(points_img, point, 1, (0, 255, 0), -1)

return final_img, points_img

for i in range(1):
    image, points_image = generate_square(128, 128)
    plt.imshow(image, cmap='gray')
    plt.axis('off')
    plt.show()

    plt.imshow(points_image)
    plt.axis('off')
    plt.show()

```



```

[6]: def check_angles_star(points, center_point):
    # prevents square overlapping itself and colinearity

    angle_min = 40

    for i in range(len(points) - 1):
        for j in range(i + 1, len(points)):
            x1, y1 = points[i]
            x2, y2 = points[j]
            x3, y3 = center_point

            dx1 = x1 - x2
            dy1 = y1 - y2

            dx2 = x3 - x2
            dy2 = y3 - y2

            numerator = dx1 * dx2 + dy1 * dy2
            denominator = math.sqrt((math.pow(dx1, 2) + math.pow(dy1, 2)) *
↪(math.pow(dx2, 2) + math.pow(dy2, 2)))

            if (denominator == 0):
                return False

            angle = abs(180 - math.degrees(math.acos(numerator / denominator)))

            if (angle < angle_min):
                return False

    return True

def generate_star(width, height):

    center = (width // 2, height // 2)
    radius = width // 2 - 30
    min_distance = 15

    center_point = generate_points(center, radius, 1)

    while True:
        points = generate_points(center, radius, 5)

        if check_angles_star(points, center_point[0]):

            points.append(center_point[0])
            if points_far_enough(points, min_distance):

```

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        break

background_color = tuple(random.randint(0, 255) for i in range(3))

img = np.full((height, width, 3), background_color, dtype=np.uint8)

pts_array = np.array(points, dtype=np.int32)

color = generate_shape_color(background_color, 1, 100)[0]

for i in range(len(pts_array) - 1):
    cv2.line(img, pts_array[i], pts_array[len(pts_array) - 1], color=color,
↪thickness=2)

img_gray = cv2.cvtColor(img, cv2.COLOR_BGR2GRAY)
final_img, points_img = apply_h(img_gray, points)
final_img = add_noise(final_img)

# points_img = np.zeros(img.shape)

# for point in points:
#     cv2.circle(points_img, point, 1, (0, 255, 0), -1)

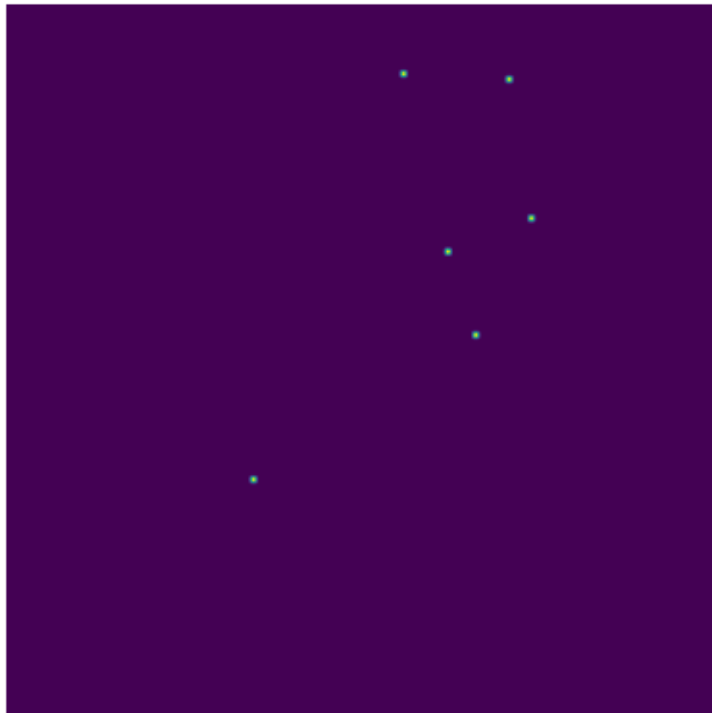
return final_img, points_img

for i in range(1):
    image, points_image = generate_star(128, 128)

    plt.imshow(image, cmap='gray')
    plt.axis('off')
    plt.show()

    plt.imshow(points_image)
    plt.axis('off')
    plt.show()

```



```

[7]: def generate_chessboard(width, height):
    rows = 3
    columns = 4

    square_dimension = width // 8

    center = (width // 2, height // 2)
    # radius = width // 2 - (square_dimension * rows // 2)
    radius = width // 2
    min_distance = 10

    while True:

        points = generate_points(center, radius, 1)

        if ((points[0][0] + (rows * square_dimension)) < width
            and (points[0][1] + (columns * square_dimension)) < height):
            break

    matrix = [[points[0]]]

    for i in range(rows + 1):

        if (i > 0):
            matrix.append([(int(matrix[i - 1][0][0] + square_dimension),
↪matrix[i - 1][0][1])])

        for j in range(1, columns + 1):

            matrix[i].append((matrix[i][j - 1][0], int(matrix[i][j - 1][1] +
↪square_dimension)))

    background_color = tuple(random.randint(0, 255) for i in range(3))
    colors = generate_shape_color(background_color, rows * columns, 25)
    color_counter = 0

    img = np.full((height, width, 3), background_color, dtype=np.uint8)

    pts_array = []

    for i in range(len(matrix) - 1):

        for j in range(len(matrix[i]) - 1):

            pts_array.append(matrix[i][j])
            pts_array.append(matrix[i][j + 1])
            pts_array.append(matrix[i + 1][j + 1])

```

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        pts_array.append(matrix[i + 1][j])

        cv2.fillPoly(img, np.array([pts_array]),
↪color=colors[color_counter])
        color_counter += 1
        pts_array = []

img_gray = cv2.cvtColor(img, cv2.COLOR_BGR2GRAY)
final_img, points_img = apply_h(img_gray, matrix)
final_img = add_noise(final_img)

#build the points image
# points_img = np.zeros(img.shape)

# for line in matrix:
#     for point in line:
#         cv2.circle(points_img, point, 1, (0, 255, 0), -1)

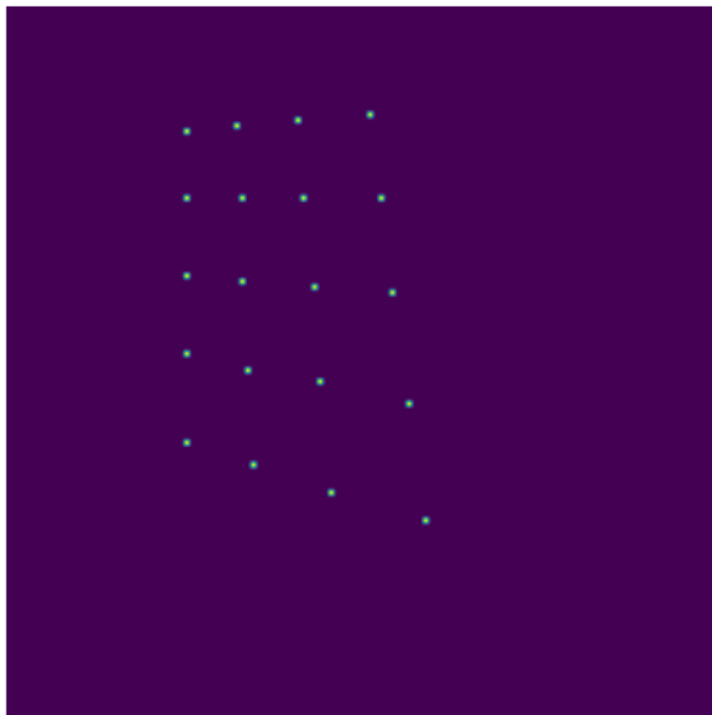
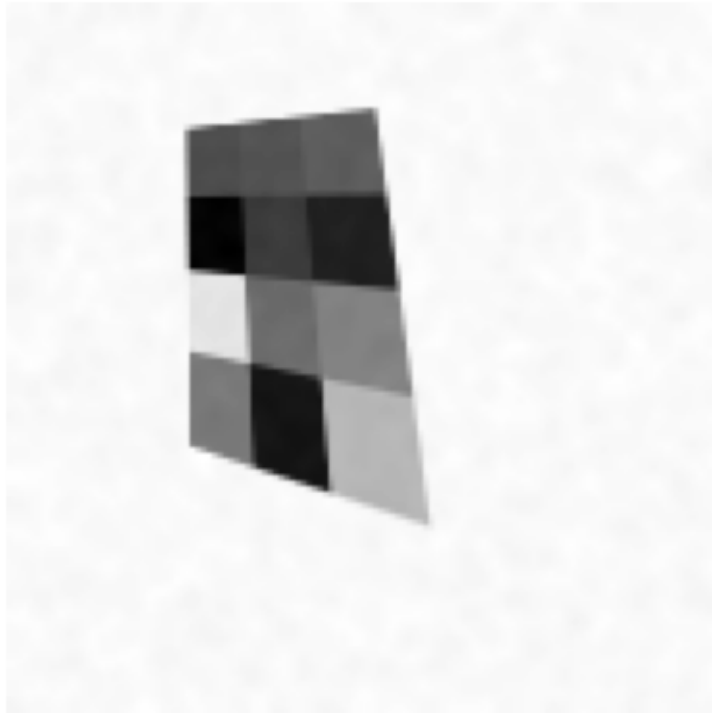
return final_img, points_img

for i in range(1):
    image, points_image = generate_chessboard(128, 128)

    plt.imshow(image, cmap='gray')
    plt.axis('off')
    plt.show()

    plt.imshow(points_image)
    plt.axis('off')
    plt.show()

```




```
[8]: class ResnetBlock(nn.Module):

    def __init__(self, in_channels, out_channels):
        super().__init__()

        self.in_channels = in_channels
        self.out_channels = out_channels

        self.conv1 = nn.Conv2d(in_channels, out_channels, 3, padding=1,
↪bias=False)
        self.conv2 = nn.Conv2d(out_channels, out_channels, 3, padding=1,
↪bias=False)
        self.conv3 = nn.Conv2d(in_channels, out_channels, 1, bias=False)

        self.bn1 = nn.BatchNorm2d(out_channels)
        self.bn2 = nn.BatchNorm2d(out_channels)

        self.relu1 = nn.ReLU()
        self.relu2 = nn.ReLU()

    def forward(self, x):

        output = self.conv1(x)
        output = self.bn1(output)
        output = self.relu1(output)
        output = self.conv2(output)
        output = self.bn2(output)

        if (self.in_channels != self.out_channels):

            tmp = self.conv3(x)
            output += tmp

        output = self.relu2(output)

        return output

class Encoder(nn.Module):

    def __init__(self):
        super().__init__()

        self.resnet1 = ResnetBlock(1, 64)
        self.resnet2 = ResnetBlock(64, 64)
        self.resnet3 = ResnetBlock(64, 64)
        self.resnet4 = ResnetBlock(64, 64)
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self.resnet5 = ResnetBlock(64, 128)
self.resnet6 = ResnetBlock(128, 128)
self.resnet7 = ResnetBlock(128, 128)
self.resnet8 = ResnetBlock(128, 128)

self.mp1 = nn.MaxPool2d(2, stride=2)
self.mp2 = nn.MaxPool2d(2, stride=2)
self.mp3 = nn.MaxPool2d(2, stride=2)
self.mp4 = nn.MaxPool2d(2, stride=2)

def forward(self, x):

    output = self.resnet1(x)
    output = self.resnet2(output)
    output = self.mp1(output)
    output = self.resnet3(output)
    output = self.resnet4(output)
    output = self.mp2(output)
    output = self.resnet5(output)
    output = self.resnet6(output)
    output = self.mp3(output)
    output = self.resnet7(output)
    output = self.resnet8(output)

    return output

class Decoder(nn.Module):

    def __init__(self):
        super().__init__()

        self.conv1 = nn.Conv2d(128, 256, 3, padding=1, bias=False)
        self.conv2 = nn.Conv2d(256, 65, 1, bias=False)

        self.bn1 = nn.BatchNorm2d(256)

        self.relu1 = nn.ReLU()

    def forward(self, x):

        output = self.conv1(x)
        output = self.bn1(output)

        output = self.relu1(output)

        output = self.conv2(output)

```

```

        return output

class Network(nn.Module):

    def __init__(self):
        super().__init__()

        self.enc = Encoder()
        self.dec = Decoder()

    def forward(self, x):

        output = self.enc(x)
        output = self.dec(output)

        return output

device = torch.device("cuda" if torch.cuda.is_available() else "cpu")

model = Network().to(device)
torchinfo.summary(model, input_size=(1,1,256,256))

```

```

[8]: =====
=====
Layer (type:depth-idx)                   Output Shape              Param #
=====
=====
Network                                  [1, 65, 32, 32]          --
  Encoder: 1-1                           [1, 128, 32, 32]         --
    ResnetBlock: 2-1                     [1, 64, 256, 256]        --
      Conv2d: 3-1                        [1, 64, 256, 256]        576
      BatchNorm2d: 3-2                  [1, 64, 256, 256]        128
      ReLU: 3-3                         [1, 64, 256, 256]        --
      Conv2d: 3-4                        [1, 64, 256, 256]        36,864
      BatchNorm2d: 3-5                  [1, 64, 256, 256]        128
      Conv2d: 3-6                        [1, 64, 256, 256]        64
      ReLU: 3-7                         [1, 64, 256, 256]        --
    ResnetBlock: 2-2                     [1, 64, 256, 256]        4,096
      Conv2d: 3-8                        [1, 64, 256, 256]        36,864
      BatchNorm2d: 3-9                  [1, 64, 256, 256]        128
      ReLU: 3-10                       [1, 64, 256, 256]        --
      Conv2d: 3-11                      [1, 64, 256, 256]        36,864
      BatchNorm2d: 3-12                 [1, 64, 256, 256]        128
      ReLU: 3-13                       [1, 64, 256, 256]        --
    MaxPool2d: 2-3                      [1, 64, 128, 128]        --
    ResnetBlock: 2-4                    [1, 64, 128, 128]        4,096

```

Conv2d: 3-14	[1, 64, 128, 128]	36,864
BatchNorm2d: 3-15	[1, 64, 128, 128]	128
ReLU: 3-16	[1, 64, 128, 128]	--
Conv2d: 3-17	[1, 64, 128, 128]	36,864
BatchNorm2d: 3-18	[1, 64, 128, 128]	128
ReLU: 3-19	[1, 64, 128, 128]	--
ResnetBlock: 2-5	[1, 64, 128, 128]	4,096
Conv2d: 3-20	[1, 64, 128, 128]	36,864
BatchNorm2d: 3-21	[1, 64, 128, 128]	128
ReLU: 3-22	[1, 64, 128, 128]	--
Conv2d: 3-23	[1, 64, 128, 128]	36,864
BatchNorm2d: 3-24	[1, 64, 128, 128]	128
ReLU: 3-25	[1, 64, 128, 128]	--
MaxPool2d: 2-6	[1, 64, 64, 64]	--
ResnetBlock: 2-7	[1, 128, 64, 64]	--
Conv2d: 3-26	[1, 128, 64, 64]	73,728
BatchNorm2d: 3-27	[1, 128, 64, 64]	256
ReLU: 3-28	[1, 128, 64, 64]	--
Conv2d: 3-29	[1, 128, 64, 64]	147,456
BatchNorm2d: 3-30	[1, 128, 64, 64]	256
Conv2d: 3-31	[1, 128, 64, 64]	8,192
ReLU: 3-32	[1, 128, 64, 64]	--
ResnetBlock: 2-8	[1, 128, 64, 64]	16,384
Conv2d: 3-33	[1, 128, 64, 64]	147,456
BatchNorm2d: 3-34	[1, 128, 64, 64]	256
ReLU: 3-35	[1, 128, 64, 64]	--
Conv2d: 3-36	[1, 128, 64, 64]	147,456
BatchNorm2d: 3-37	[1, 128, 64, 64]	256
ReLU: 3-38	[1, 128, 64, 64]	--
MaxPool2d: 2-9	[1, 128, 32, 32]	--
ResnetBlock: 2-10	[1, 128, 32, 32]	16,384
Conv2d: 3-39	[1, 128, 32, 32]	147,456
BatchNorm2d: 3-40	[1, 128, 32, 32]	256
ReLU: 3-41	[1, 128, 32, 32]	--
Conv2d: 3-42	[1, 128, 32, 32]	147,456
BatchNorm2d: 3-43	[1, 128, 32, 32]	256
ReLU: 3-44	[1, 128, 32, 32]	--
ResnetBlock: 2-11	[1, 128, 32, 32]	16,384
Conv2d: 3-45	[1, 128, 32, 32]	147,456
BatchNorm2d: 3-46	[1, 128, 32, 32]	256
ReLU: 3-47	[1, 128, 32, 32]	--
Conv2d: 3-48	[1, 128, 32, 32]	147,456
BatchNorm2d: 3-49	[1, 128, 32, 32]	256
ReLU: 3-50	[1, 128, 32, 32]	--
Decoder: 1-2	[1, 65, 32, 32]	--
Conv2d: 2-12	[1, 256, 32, 32]	294,912
BatchNorm2d: 2-13	[1, 256, 32, 32]	512

ReLU: 2-14	[1, 256, 32, 32]	--
Conv2d: 2-15	[1, 65, 32, 32]	16,640

```

=====
=====
Total params: 1,749,376
Trainable params: 1,749,376
Non-trainable params: 0
Total mult-adds (G): 12.78
=====
=====
Input size (MB): 0.26
Forward/backward pass size (MB): 419.96
Params size (MB): 6.75
Estimated Total Size (MB): 426.98
=====
=====

```

```

[17]: #priprava ucnih primerov
def generate_batch(batch_size, width, height, device):

    images = []
    point_images = []

    for i in range(batch_size):

        #0 -> triangle; 1 -> square; 2 -> star; 3 -> checkerboard
        rand_img = random.randint(0, 3)

        if (rand_img == 0):
            img, points_img = generate_triangle(width, height)
        elif (rand_img == 1):
            img, points_img = generate_square(width, height)
        elif (rand_img == 2):
            img, points_img = generate_star(width, height)
        elif (rand_img == 3):
            img, points_img = generate_chessboard(width, height)

        img = torch.tensor(img).to(device).unsqueeze(0).to(torch.float32)
        points_img = torch.tensor(points_img).to(device).unsqueeze(0).to(torch.
↪float32)

        #Reshape v velikost H/8, 8, W/8, 8
        points_img = torch.reshape(points_img, (height // 8, 8, width // 8, 8))

        #Permute kanalov v vrstni red H/8, W/8, 8, 8
        points_img = torch.permute(points_img, (0, 2, 1, 3))

```

```

#Reshape v velikost H/8, W/8, 64
points_img = torch.reshape(points_img, (height // 8, width // 8, 64))

#Dodamo kanal 65
points_img_new = torch.zeros((height // 8, width // 8, 1))
points_img = torch.cat((points_img, points_img_new), 2)

#Za vsak izmed H/8, 8, W/8 pikslov preverimo, da je nastavljena ena
↪ izmed 65 točk
for j in range(0, len(points_img)):
    for k in range(0, len(points_img[0])):
        found_points = []

        for l in range(len(points_img[j][k])):
            if (points_img[j][k][l] == 1):
                found_points.append(l)

        if (len(found_points) == 0):
            #kjer ni nastavljena nobena nastavimo kanal 65
            points_img[j][k][64] = 1

        elif (len(found_points) > 1):
            #kjer je nastavljenih več ohranimo eno naključno

            keep_rand = random.randint(0, len(found_points) - 1)

            for l in range(len(found_points)):
                if (keep_rand == l):
                    continue

            points_img[j][k][found_points[0]] = 0

points_img = torch.permute(points_img, (2, 0, 1))

images.append(img)
point_images.append(points_img)

return torch.stack(images), torch.stack(point_images)
# generate_batch(1, 256, 256, device)

```

```

[ ]: # import sys
     # np.set_printoptions(threshold=sys.maxsize)

```

```

[14]: image, point_image = generate_batch(1, 128, 128, device)

```

```

[15]: device = torch.device("cuda" if torch.cuda.is_available() else "cpu")

```

```

model = Network().to(device)

iterations = 1 #1000
batch_size = 1
epochs = 100 #10

loss_function = nn.CrossEntropyLoss()
optimizer = optim.Adam(model.parameters(), 1e-3)

steps_train = 0
steps_val = 0

for epoch in range(epochs):

    train_loss = 0
    val_loss = 0

    start_time = 0

    #train

    model.train()

    for iteration in range(iterations):

        optimizer.zero_grad()

        outputs = model(image)
        loss = loss_function(outputs, point_image)

        loss.backward()
        optimizer.step()

        train_loss += loss.item()
        steps_train += 1

    print("Epoch done: ", str(epoch + 1), " (training). Loss: ", train_loss /
↪ iterations)

    #validate

    with torch.no_grad():
        model.eval()

        for iteration in range(iterations):

            outputs = model(image)

```

```

        loss = loss_function(outputs, point_image)

        val_loss += loss.item()
        steps_val += 1

    print("Epoch: ", str(epoch + 1), " (validating). Loss: ", val_loss /
↪iterations)

```

```

Epoch done: 1 (training). Loss: 4.0841755867004395
Epoch: 1 (validating). Loss: 4.1583733558654785
Epoch done: 2 (training). Loss: 3.8184568881988525
Epoch: 2 (validating). Loss: 4.117103576660156
Epoch done: 3 (training). Loss: 3.5323801040649414
Epoch: 3 (validating). Loss: 4.054582118988037
Epoch done: 4 (training). Loss: 3.1867599487304688
Epoch: 4 (validating). Loss: 3.984454393386841
Epoch done: 5 (training). Loss: 2.8472490310668945
Epoch: 5 (validating). Loss: 3.9032199382781982
Epoch done: 6 (training). Loss: 2.554046869277954
Epoch: 6 (validating). Loss: 3.8493564128875732
Epoch done: 7 (training). Loss: 2.296175718307495
Epoch: 7 (validating). Loss: 3.7438199520111084
Epoch done: 8 (training). Loss: 2.0507984161376953
Epoch: 8 (validating). Loss: 3.5413694381713867
Epoch done: 9 (training). Loss: 1.8305491209030151
Epoch: 9 (validating). Loss: 3.2093992233276367
Epoch done: 10 (training). Loss: 1.6276065111160278
Epoch: 10 (validating). Loss: 2.9780216217041016
Epoch done: 11 (training). Loss: 1.4426217079162598
Epoch: 11 (validating). Loss: 2.7503838539123535
Epoch done: 12 (training). Loss: 1.2755956649780273
Epoch: 12 (validating). Loss: 2.386049270629883
Epoch done: 13 (training). Loss: 1.1233842372894287
Epoch: 13 (validating). Loss: 2.0353822708129883
Epoch done: 14 (training). Loss: 0.9839590191841125
Epoch: 14 (validating). Loss: 1.8458869457244873
Epoch done: 15 (training). Loss: 0.8581812381744385
Epoch: 15 (validating). Loss: 1.6422412395477295
Epoch done: 16 (training). Loss: 0.7452664375305176
Epoch: 16 (validating). Loss: 1.3957420587539673
Epoch done: 17 (training). Loss: 0.6434639096260071
Epoch: 17 (validating). Loss: 1.1443485021591187
Epoch done: 18 (training). Loss: 0.5550420880317688
Epoch: 18 (validating). Loss: 0.9680818915367126
Epoch done: 19 (training). Loss: 0.4770165681838989
Epoch: 19 (validating). Loss: 0.9525731205940247
Epoch done: 20 (training). Loss: 0.4096740782260895
Epoch: 20 (validating). Loss: 0.6999013423919678

```


Epoch done: 21 (training). Loss: 0.35183680057525635
Epoch: 21 (validating). Loss: 0.4252578616142273
Epoch done: 22 (training). Loss: 0.30248090624809265
Epoch: 22 (validating). Loss: 0.34055355191230774
Epoch done: 23 (training). Loss: 0.26053285598754883
Epoch: 23 (validating). Loss: 0.29113075137138367
Epoch done: 24 (training). Loss: 0.22512242197990417
Epoch: 24 (validating). Loss: 0.25082752108573914
Epoch done: 25 (training). Loss: 0.1952367126941681
Epoch: 25 (validating). Loss: 0.21974320709705353
Epoch done: 26 (training). Loss: 0.16982293128967285
Epoch: 26 (validating). Loss: 0.19077320396900177
Epoch done: 27 (training). Loss: 0.14851415157318115
Epoch: 27 (validating). Loss: 0.16751526296138763
Epoch done: 28 (training). Loss: 0.13049183785915375
Epoch: 28 (validating). Loss: 0.147809237241745
Epoch done: 29 (training). Loss: 0.11503102630376816
Epoch: 29 (validating). Loss: 0.12842980027198792
Epoch done: 30 (training). Loss: 0.10197168588638306
Epoch: 30 (validating). Loss: 0.10943365842103958
Epoch done: 31 (training). Loss: 0.09080441296100616
Epoch: 31 (validating). Loss: 0.09250738471746445
Epoch done: 32 (training). Loss: 0.08131113648414612
Epoch: 32 (validating). Loss: 0.07802760601043701
Epoch done: 33 (training). Loss: 0.0731702595949173
Epoch: 33 (validating). Loss: 0.06648527085781097
Epoch done: 34 (training). Loss: 0.06612753868103027
Epoch: 34 (validating). Loss: 0.05717872083187103
Epoch done: 35 (training). Loss: 0.0600917711853981
Epoch: 35 (validating). Loss: 0.04955727234482765
Epoch done: 36 (training). Loss: 0.05486239120364189
Epoch: 36 (validating). Loss: 0.043364886194467545
Epoch done: 37 (training). Loss: 0.05030905827879906
Epoch: 37 (validating). Loss: 0.03856273740530014
Epoch done: 38 (training). Loss: 0.04634307697415352
Epoch: 38 (validating). Loss: 0.0349244624376297
Epoch done: 39 (training). Loss: 0.04286237806081772
Epoch: 39 (validating). Loss: 0.032068535685539246
Epoch done: 40 (training). Loss: 0.03981362283229828
Epoch: 40 (validating). Loss: 0.029734011739492416
Epoch done: 41 (training). Loss: 0.03714175522327423
Epoch: 41 (validating). Loss: 0.027716755867004395
Epoch done: 42 (training). Loss: 0.03476613387465477
Epoch: 42 (validating). Loss: 0.025878511369228363
Epoch done: 43 (training). Loss: 0.03264352306723595
Epoch: 43 (validating). Loss: 0.02422848716378212
Epoch done: 44 (training). Loss: 0.030756842344999313
Epoch: 44 (validating). Loss: 0.02281446009874344

Epoch done: 45 (training). Loss: 0.02907460927963257
Epoch: 45 (validating). Loss: 0.02167087234556675
Epoch done: 46 (training). Loss: 0.027561357244849205
Epoch: 46 (validating). Loss: 0.020778577774763107
Epoch done: 47 (training). Loss: 0.026199834421277046
Epoch: 47 (validating). Loss: 0.02008778229355812
Epoch done: 48 (training). Loss: 0.02497464045882225
Epoch: 48 (validating). Loss: 0.019544851034879684
Epoch done: 49 (training). Loss: 0.02386399731040001
Epoch: 49 (validating). Loss: 0.01909082755446434
Epoch done: 50 (training). Loss: 0.022853044793009758
Epoch: 50 (validating). Loss: 0.01869601011276245
Epoch done: 51 (training). Loss: 0.021932493895292282
Epoch: 51 (validating). Loss: 0.01834098808467388
Epoch done: 52 (training). Loss: 0.021093130111694336
Epoch: 52 (validating). Loss: 0.018011368811130524
Epoch done: 53 (training). Loss: 0.020324859768152237
Epoch: 53 (validating). Loss: 0.017687790095806122
Epoch done: 54 (training). Loss: 0.019618427380919456
Epoch: 54 (validating). Loss: 0.0173509381711483
Epoch done: 55 (training). Loss: 0.018967701122164726
Epoch: 55 (validating). Loss: 0.016989264637231827
Epoch done: 56 (training). Loss: 0.018366528674960136
Epoch: 56 (validating). Loss: 0.016604043543338776
Epoch done: 57 (training). Loss: 0.017809562385082245
Epoch: 57 (validating). Loss: 0.016220832243561745
Epoch done: 58 (training). Loss: 0.017293332144618034
Epoch: 58 (validating). Loss: 0.015871454030275345
Epoch done: 59 (training). Loss: 0.01681383326649666
Epoch: 59 (validating). Loss: 0.015575464814901352
Epoch done: 60 (training). Loss: 0.01636638306081295
Epoch: 60 (validating). Loss: 0.015339707024395466
Epoch done: 61 (training). Loss: 0.015947051346302032
Epoch: 61 (validating). Loss: 0.015156455338001251
Epoch done: 62 (training). Loss: 0.015553843230009079
Epoch: 62 (validating). Loss: 0.015008452348411083
Epoch done: 63 (training). Loss: 0.015185341238975525
Epoch: 63 (validating). Loss: 0.014865415170788765
Epoch done: 64 (training). Loss: 0.014839209616184235
Epoch: 64 (validating). Loss: 0.014699254184961319
Epoch done: 65 (training). Loss: 0.014512891881167889
Epoch: 65 (validating). Loss: 0.014496617950499058
Epoch done: 66 (training). Loss: 0.014204644598066807
Epoch: 66 (validating). Loss: 0.014259380288422108
Epoch done: 67 (training). Loss: 0.013912982307374477
Epoch: 67 (validating). Loss: 0.013999875634908676
Epoch done: 68 (training). Loss: 0.013636220246553421
Epoch: 68 (validating). Loss: 0.013738354668021202

Epoch done: 69 (training). Loss: 0.013372855260968208
Epoch: 69 (validating). Loss: 0.013494455255568027
Epoch done: 70 (training). Loss: 0.013122009113430977
Epoch: 70 (validating). Loss: 0.013281872496008873
Epoch done: 71 (training). Loss: 0.012882944196462631
Epoch: 71 (validating). Loss: 0.013105697929859161
Epoch done: 72 (training). Loss: 0.012654771097004414
Epoch: 72 (validating). Loss: 0.012962288223206997
Epoch done: 73 (training). Loss: 0.01243650447577238
Epoch: 73 (validating). Loss: 0.012842326425015926
Epoch done: 74 (training). Loss: 0.012227335013449192
Epoch: 74 (validating). Loss: 0.012732954695820808
Epoch done: 75 (training). Loss: 0.012026607990264893
Epoch: 75 (validating). Loss: 0.012625849805772305
Epoch done: 76 (training). Loss: 0.011833634227514267
Epoch: 76 (validating). Loss: 0.012515608221292496
Epoch done: 77 (training). Loss: 0.011647802777588367
Epoch: 77 (validating). Loss: 0.012400135397911072
Epoch done: 78 (training). Loss: 0.011468632146716118
Epoch: 78 (validating). Loss: 0.012281166389584541
Epoch done: 79 (training). Loss: 0.01129584014415741
Epoch: 79 (validating). Loss: 0.012160951271653175
Epoch done: 80 (training). Loss: 0.011129113845527172
Epoch: 80 (validating). Loss: 0.012039821594953537
Epoch done: 81 (training). Loss: 0.010967935435473919
Epoch: 81 (validating). Loss: 0.011916186660528183
Epoch done: 82 (training). Loss: 0.010811822488904
Epoch: 82 (validating). Loss: 0.011789718642830849
Epoch done: 83 (training). Loss: 0.010660496540367603
Epoch: 83 (validating). Loss: 0.011658762581646442
Epoch done: 84 (training). Loss: 0.010513762943446636
Epoch: 84 (validating). Loss: 0.011524975299835205
Epoch done: 85 (training). Loss: 0.01037132740020752
Epoch: 85 (validating). Loss: 0.011388944461941719
Epoch done: 86 (training). Loss: 0.01023288443684578
Epoch: 86 (validating). Loss: 0.011251921765506268
Epoch done: 87 (training). Loss: 0.010098189115524292
Epoch: 87 (validating). Loss: 0.01111737173050642
Epoch done: 88 (training). Loss: 0.009967061690986156
Epoch: 88 (validating). Loss: 0.010988189838826656
Epoch done: 89 (training). Loss: 0.009839341044425964
Epoch: 89 (validating). Loss: 0.01086657028645277
Epoch done: 90 (training). Loss: 0.009714895859360695
Epoch: 90 (validating). Loss: 0.010752849280834198
Epoch done: 91 (training). Loss: 0.009593553841114044
Epoch: 91 (validating). Loss: 0.010645067319273949
Epoch done: 92 (training). Loss: 0.009475141763687134
Epoch: 92 (validating). Loss: 0.010540495626628399

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Epoch done: 93 (training). Loss: 0.009359538555145264
Epoch: 93 (validating). Loss: 0.010435700416564941
Epoch done: 94 (training). Loss: 0.009246603585779667
Epoch: 94 (validating). Loss: 0.010328459553420544
Epoch done: 95 (training). Loss: 0.009136219508945942
Epoch: 95 (validating). Loss: 0.010218141600489616
Epoch done: 96 (training). Loss: 0.00902824942022562
Epoch: 96 (validating). Loss: 0.010106056928634644
Epoch done: 97 (training). Loss: 0.008922592736780643
Epoch: 97 (validating). Loss: 0.009993158280849457
Epoch done: 98 (training). Loss: 0.008819153532385826
Epoch: 98 (validating). Loss: 0.009880969300866127
Epoch done: 99 (training). Loss: 0.008717851713299751
Epoch: 99 (validating). Loss: 0.009770284406840801
Epoch done: 100 (training). Loss: 0.0086186109110713
Epoch: 100 (validating). Loss: 0.009661532007157803

```

```

[12]: def reshape_to_original_size(pred):

    #Reshape v velikost H/8, W/8, 8, 8
    pred = torch.permute(pred, (1, 2, 0)) # [16, 16, 65]
    pred = pred[:, :, :-1] # [16, 16, 64]
    pred = torch.reshape(pred, (pred.shape[0], pred.shape[1], 8, 8)) # [16, 16, 8, 8]

    #Permute kanalov v vrstni red H/8, 8, W/8, 8
    pred = torch.permute(pred, (0, 2, 1, 3)) # [16, 8, 16, 8]

    #Reshape v velikost H, W
    pred = torch.reshape(pred, (pred.shape[0] * 8, pred.shape[2] * 8)) # [128, 128]

    return pred

```

```

[16]: device = torch.device("cuda" if torch.cuda.is_available() else "cpu")

# pretvori cilj
target = reshape_to_original_size(point_image[0])
py_tar, px_tar = np.where(target>0)

plt.imshow(image[0][0], cmap='gray')
plt.axis('off')
plt.show()

plt.plot(px_tar, py_tar, 'go', label='cilji')
plt.imshow(target)
plt.axis('off')

```

```

plt.show()

pred = model(image)
soft = nn.Softmax(0)
pred = soft(pred[0])
pred = reshape_to_original_size(pred)
pred = pred.detach().numpy()

# # najdi lokalne maksimume predikcije, vecje od minimalne vrednosti
local_max = (pred==ndimage.grey_dilation(pred, size=3))*pred>0.3
py_est, px_est = np.where(local_max)

plt.plot(px_est, py_est, 'rx', label='napovedi')
plt.imshow(pred)
plt.axis('off')
plt.show()

```





```

[29]: device = torch.device("cuda" if torch.cuda.is_available() else "cpu")

model = Network().to(device)

iterations = 10
batch_size = 8
epochs = 1000

loss_function = nn.CrossEntropyLoss()
optimizer = optim.Adam(model.parameters(), 1e-3)

steps_train = 0
steps_val = 0

for epoch in range(epochs):

    train_loss = 0
    val_loss = 0

    start_time = 0

    #train

    model.train()

    for iteration in range(iterations):

        images, point_images = generate_batch(batch_size, 128, 128, device)

        optimizer.zero_grad()

        outputs = model(images)
        loss = loss_function(outputs, point_images)

        loss.backward()
        optimizer.step()

        train_loss += loss.item()
        loss_diagram.add_scalar("Loss/train/det", loss.item(), steps_train)
        steps_train += 1

    print("Epoch done: ", str(epoch + 1), " (training). Loss: ", train_loss /
↵iterations)

    #validate

    with torch.no_grad():

```

```

model.eval()

for iteration in range(iterations):

    images, point_images = generate_batch(batch_size, 128, 128, device)

    outputs = model(images)
    loss = loss_function(outputs, point_images)

    val_loss += loss.item()
    loss_diagram.add_scalar("Loss/test/det", loss.item(), steps_val)
    steps_val += 1

    print("Epoch: ", str(epoch + 1), " (validating). Loss: ", val_loss /
↪iterations)

    loss_diagram.flush()

torch.save(model, ("save_detection.pt"))

```

```

Epoch done: 1 (training). Loss: 3.004988598823547
Epoch: 1 (validating). Loss: 3.361141037940979
Epoch done: 2 (training). Loss: 1.1854448795318604
Epoch: 2 (validating). Loss: 1.0480110049247742
Epoch done: 3 (training). Loss: 0.46863395273685454
Epoch: 3 (validating). Loss: 0.5336500406265259
Epoch done: 4 (training). Loss: 0.29433100372552873
Epoch: 4 (validating). Loss: 0.2846026197075844
Epoch done: 5 (training). Loss: 0.24772001802921295
Epoch: 5 (validating). Loss: 0.2991391524672508
Epoch done: 6 (training). Loss: 0.2472882926464081
Epoch: 6 (validating). Loss: 0.24778223633766175
Epoch done: 7 (training). Loss: 0.23014751672744752
Epoch: 7 (validating). Loss: 0.22799151986837388
Epoch done: 8 (training). Loss: 0.24208882600069045
Epoch: 8 (validating). Loss: 0.21622908264398574
Epoch done: 9 (training). Loss: 0.24667733162641525
Epoch: 9 (validating). Loss: 0.2197430431842804
Epoch done: 10 (training). Loss: 0.25488186776638033
Epoch: 10 (validating). Loss: 0.27108432054519654
Epoch done: 11 (training). Loss: 0.23564811646938325
Epoch: 11 (validating). Loss: 0.24977402687072753
Epoch done: 12 (training). Loss: 0.21081662476062774
Epoch: 12 (validating). Loss: 0.2457079291343689
Epoch done: 13 (training). Loss: 0.2095161572098732
Epoch: 13 (validating). Loss: 0.23872412741184235
Epoch done: 14 (training). Loss: 0.20729168504476547
Epoch: 14 (validating). Loss: 0.22983990758657455

```


Epoch done: 15 (training). Loss: 0.22679151594638824
Epoch: 15 (validating). Loss: 0.20322632193565368
Epoch done: 16 (training). Loss: 0.23516547083854675
Epoch: 16 (validating). Loss: 0.2418278157711029
Epoch done: 17 (training). Loss: 0.23452878892421722
Epoch: 17 (validating). Loss: 0.24292128086090087
Epoch done: 18 (training). Loss: 0.21640573292970658
Epoch: 18 (validating). Loss: 0.19876976311206818
Epoch done: 19 (training). Loss: 0.21711573451757432
Epoch: 19 (validating). Loss: 0.2274477332830429
Epoch done: 20 (training). Loss: 0.22182178050279616
Epoch: 20 (validating). Loss: 0.24596045762300492
Epoch done: 21 (training). Loss: 0.2082040473818779
Epoch: 21 (validating). Loss: 0.22415565699338913
Epoch done: 22 (training). Loss: 0.19201046526432036
Epoch: 22 (validating). Loss: 0.22821066975593568
Epoch done: 23 (training). Loss: 0.20865005850791932
Epoch: 23 (validating). Loss: 0.2226639710366726
Epoch done: 24 (training). Loss: 0.22739994823932647
Epoch: 24 (validating). Loss: 0.23404911831021308
Epoch done: 25 (training). Loss: 0.20349781215190887
Epoch: 25 (validating). Loss: 0.23369759321212769
Epoch done: 26 (training). Loss: 0.21223628968000413
Epoch: 26 (validating). Loss: 0.1973541796207428
Epoch done: 27 (training). Loss: 0.21828893572092056
Epoch: 27 (validating). Loss: 0.26223505437374117
Epoch done: 28 (training). Loss: 0.2481669083237648
Epoch: 28 (validating). Loss: 0.22174171954393387
Epoch done: 29 (training). Loss: 0.21528032273054123
Epoch: 29 (validating). Loss: 0.22932229191064835
Epoch done: 30 (training). Loss: 0.22482053190469742
Epoch: 30 (validating). Loss: 0.25545835196971894
Epoch done: 31 (training). Loss: 0.20304316356778146
Epoch: 31 (validating). Loss: 0.22222791463136674
Epoch done: 32 (training). Loss: 0.24759840220212936
Epoch: 32 (validating). Loss: 0.2146539032459259
Epoch done: 33 (training). Loss: 0.2365198940038681
Epoch: 33 (validating). Loss: 0.16239308044314385
Epoch done: 34 (training). Loss: 0.19750136882066727
Epoch: 34 (validating). Loss: 0.20299517959356309
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Epoch done: 975 (training). Loss: 0.04062792900949717
 Epoch: 975 (validating). Loss: 0.037215388007462026
 Epoch done: 976 (training). Loss: 0.038299037516117095
 Epoch: 976 (validating). Loss: 0.040471011959016326
 Epoch done: 977 (training). Loss: 0.03744971472769976
 Epoch: 977 (validating). Loss: 0.032560087740421295
 Epoch done: 978 (training). Loss: 0.04629984796047211
 Epoch: 978 (validating). Loss: 0.03753322958946228
 Epoch done: 979 (training). Loss: 0.03525787219405174
 Epoch: 979 (validating). Loss: 0.03647070378065109
 Epoch done: 980 (training). Loss: 0.03501058518886566
 Epoch: 980 (validating). Loss: 0.04411294423043728
 Epoch done: 981 (training). Loss: 0.034631673339754344
 Epoch: 981 (validating). Loss: 0.04108754862099886
 Epoch done: 982 (training). Loss: 0.04270148798823357
 Epoch: 982 (validating). Loss: 0.04018029067665339
 Epoch done: 983 (training). Loss: 0.03433273341506719
 Epoch: 983 (validating). Loss: 0.0399421151727438
 Epoch done: 984 (training). Loss: 0.03647543862462044
 Epoch: 984 (validating). Loss: 0.03440648708492518
 Epoch done: 985 (training). Loss: 0.030938507989048958
 Epoch: 985 (validating). Loss: 0.03506754972040653
 Epoch done: 986 (training). Loss: 0.02996939541772008
 Epoch: 986 (validating). Loss: 0.03991986382752657
 Epoch done: 987 (training). Loss: 0.041107113286852834
 Epoch: 987 (validating). Loss: 0.03719141837209463
 Epoch done: 988 (training). Loss: 0.0338398726657033
 Epoch: 988 (validating). Loss: 0.03815895356237888
 Epoch done: 989 (training). Loss: 0.040832786820828915
 Epoch: 989 (validating). Loss: 0.03857847526669502
 Epoch done: 990 (training). Loss: 0.03285514563322067
 Epoch: 990 (validating). Loss: 0.03846258632838726
 Epoch done: 991 (training). Loss: 0.035710076615214345
 Epoch: 991 (validating). Loss: 0.04131731893867254
 Epoch done: 992 (training). Loss: 0.032396286725997925
 Epoch: 992 (validating). Loss: 0.0379116190597415
 Epoch done: 993 (training). Loss: 0.039104977250099184
 Epoch: 993 (validating). Loss: 0.039677122980356215
 Epoch done: 994 (training). Loss: 0.03610248323529959
 Epoch: 994 (validating). Loss: 0.038551211915910245
 Epoch done: 995 (training). Loss: 0.03743304703384638
 Epoch: 995 (validating). Loss: 0.03636530600488186
 Epoch done: 996 (training). Loss: 0.037875952944159505
 Epoch: 996 (validating). Loss: 0.04404582493007183
 Epoch done: 997 (training). Loss: 0.03915467094630003
 Epoch: 997 (validating). Loss: 0.033660198003053664
 Epoch done: 998 (training). Loss: 0.047058578208088876
 Epoch: 998 (validating). Loss: 0.03879191130399704

Epoch done: 999 (training). Loss: 0.0397196426987648
 Epoch: 999 (validating). Loss: 0.039254814572632316
 Epoch done: 1000 (training). Loss: 0.04199779275804758
 Epoch: 1000 (validating). Loss: 0.03584388941526413

```
[57]: device = torch.device("cuda" if torch.cuda.is_available() else "cpu")

model = torch.load("save_detection.pt", device)

for i in range(10):

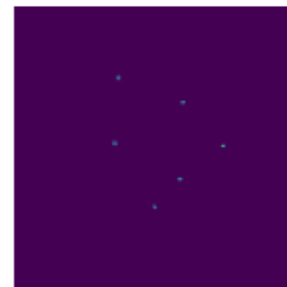
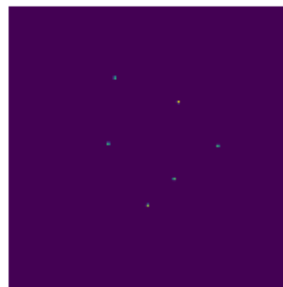
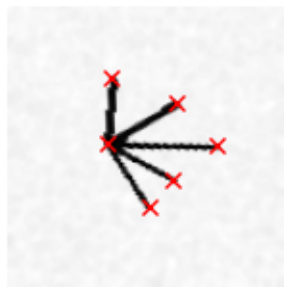
    image, point_image = generate_batch(1, 128, 128, device)

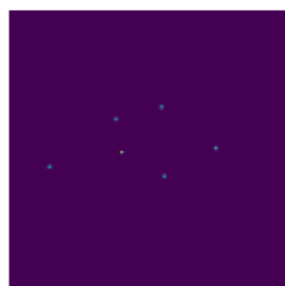
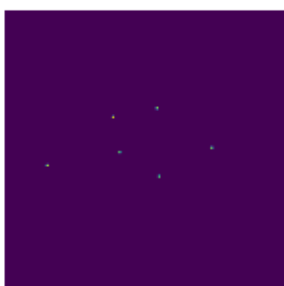
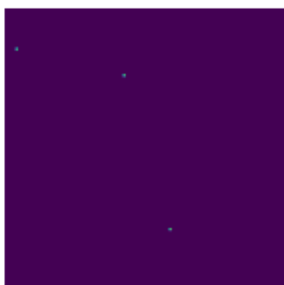
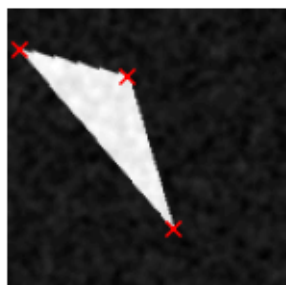
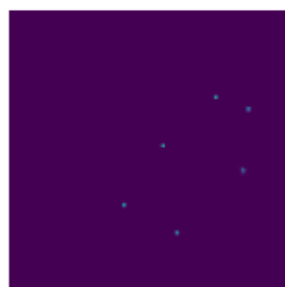
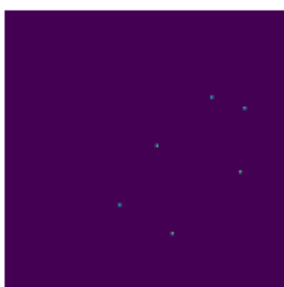
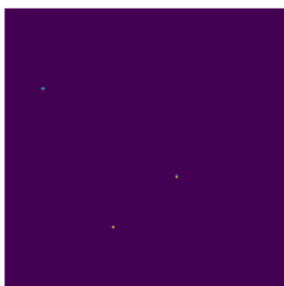
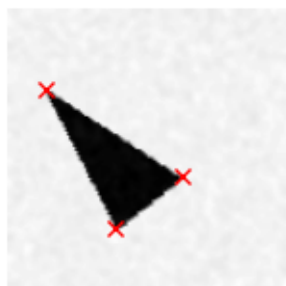
    # pretvori cilj
    target = reshape_to_original_size(point_image[0])
    # py_tar, px_tar = np.where(target>0)

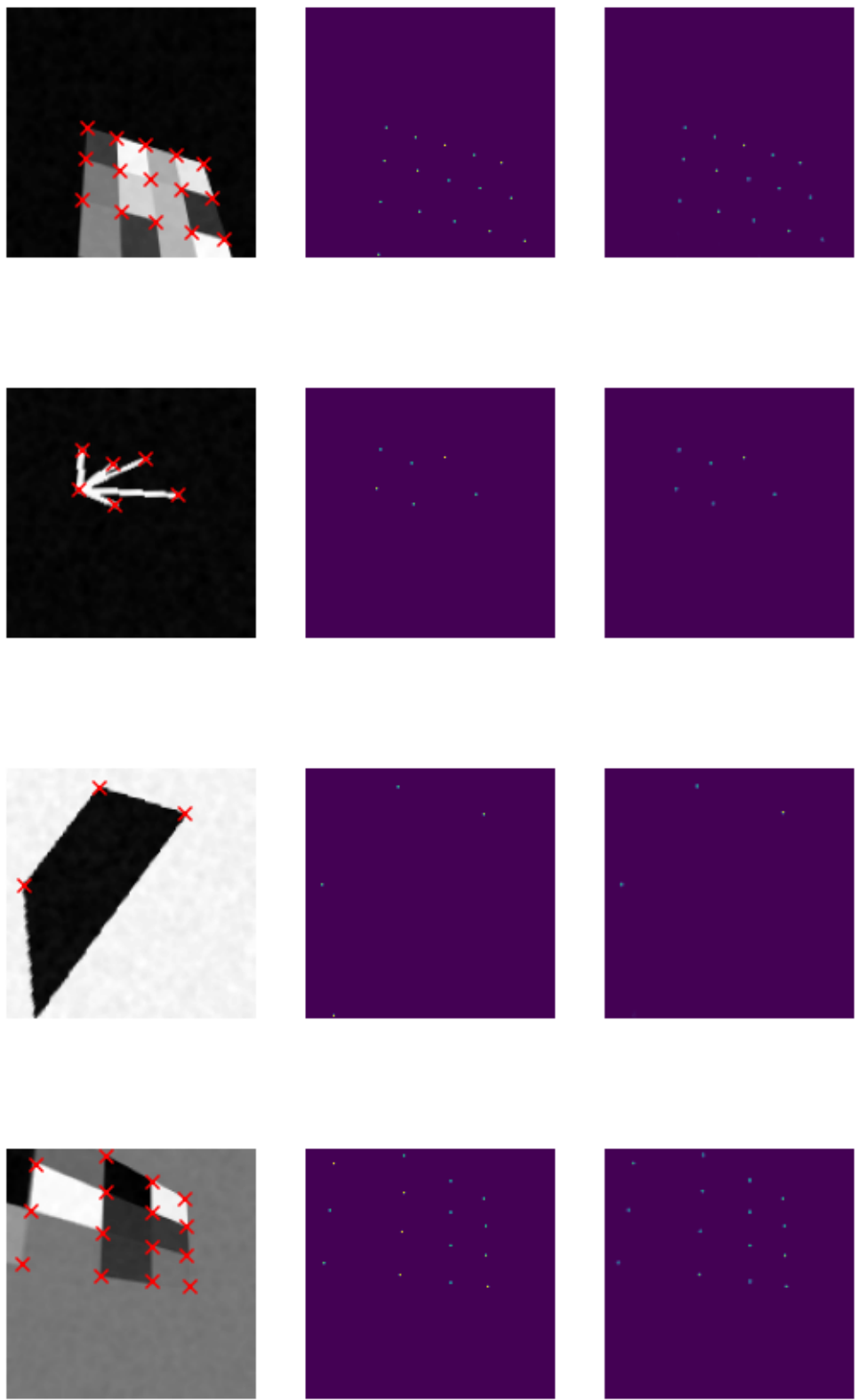
    pred = model(image)
    soft = nn.Softmax(0)
    pred = soft(pred[0])
    pred = reshape_to_original_size(pred)
    pred = pred.detach().numpy()

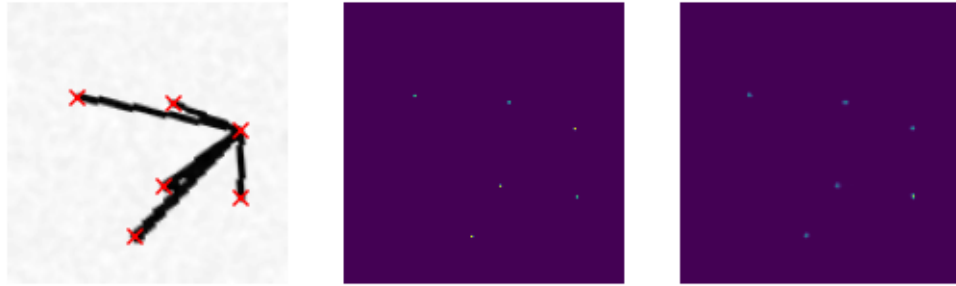
    # najdi lokalne maksimume predikcije, vecje od minimalne vrednosti
    local_max = (pred==ndimage.grey_dilation(pred, size=3))*pred>0.2
    py_est, px_est = np.where(local_max)

    fig, ax = plt.subplots(1, 3)
    ax[0].imshow(image[0][0], cmap='gray')
    ax[0].plot(px_est, py_est, 'rx', label='napovedi')
    ax[0].set_axis_off()
    ax[1].imshow(target)
    ax[1].set_axis_off()
    ax[2].imshow(pred)
    ax[2].set_axis_off()
```



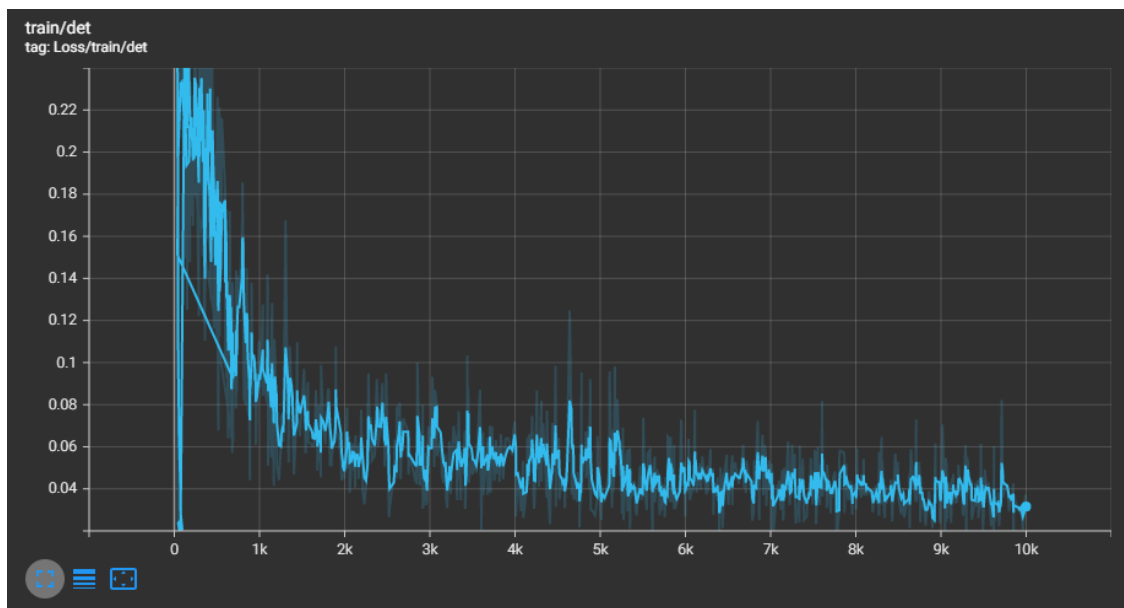






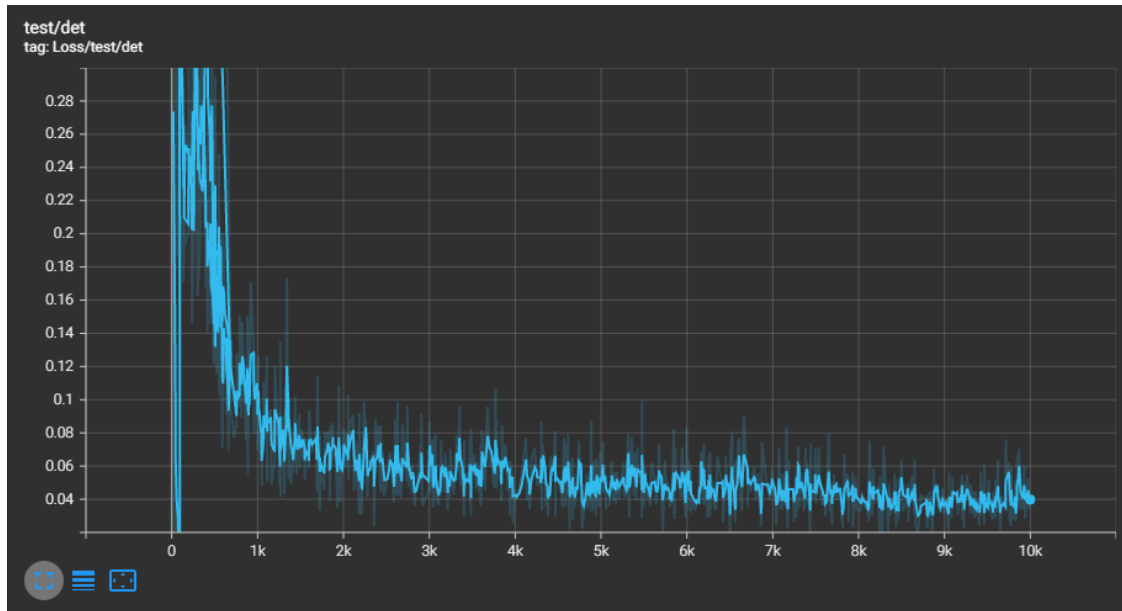
```
[64]: Image(filename='train_det.png')
```

```
[64]:
```



```
[66]: Image(filename='test_det.png')
```

```
[66]:
```



```
[63]: def apply_h_image(img):

    height_half = len(img) // 2
    width_half = len(img[0]) // 2

    point_distance = 10

    x = random.randint(point_distance, width_half - point_distance)
    y = random.randint(point_distance, height_half - point_distance)

    rect = np.array([[x, y], [x + width_half, y], [x + width_half, y +
↪height_half], [x, y + height_half]])

    #4 koticke okna pomaknemo za naključne pomike v intervalu [-16, 16]

    rect_prim = np.array([[rect[0][0] + random.randint(-16, 16), rect[0][1] +
↪random.randint(-16, 16)],
        [rect[1][0] + random.randint(-16, 16), rect[1][1] + random.
↪randint(-16, 16)],
        [rect[2][0] + random.randint(-16, 16), rect[2][1] + random.
↪randint(-16, 16)],
        [rect[3][0] + random.randint(-16, 16), rect[3][1] + random.
↪randint(-16, 16)]] , np.int32)

    #iz 4 koticfov in njihovih pomikov izračunamo homografijo H
    H, _ = cv2.findHomography(rect, rect_prim)
```

```

H = np.linalg.inv(H)

#inverz ocenjene homografije  $H^{-1}$  apliciramo na sliko, dobimo
↪transformirano sliko
warped_image = cv2.warpPerspective(img, H, (img.shape[1], img.shape[0]),
↪borderMode=cv2.BORDER_REPLICATE)

return warped_image, H

def inverse_h(pred, H):

    #inverz ocenjene homografije  $H^{-1}$  apliciramo na sliko, dobimo
    ↪transformirano sliko
    return cv2.warpPerspective(img, np.linalg.inv(H), (img.shape[1], img.
    ↪shape[0]), borderMode=cv2.BORDER_REPLICATE)

model = torch.load("save_detection.pt", device)

path = "train"
files = [f for f in listdir(path) if isfile(join(path, f))]

for n in range(10):

    img = cv2.imread(join(path, files[random.randint(0, len(files) - 1)]))
    img = cv2.resize(img, (128, 128))
    img = cv2.cvtColor(img, cv2.COLOR_BGR2GRAY)

    img_tensor = torch.tensor(img).to(device).unsqueeze(0).to(torch.float32)

    # prva detekcija, brez homografske adaptacije
    pred = model(torch.stack([img_tensor]))
    pred = soft(pred[0])
    pred = reshape_to_original_size(pred)
    pred = pred.detach().numpy()

    pred_cum = pred.copy()
    pred_no_ha = pred_cum.copy()

    for i in range(99):
        # ostale detekcije, vsaka z homografsko adaptacijo - naključno
        ↪homografsko transformacijo

        # transformacija slike, pridobitev transformacijske matrike
        img_ha, H = apply_h_image(img)

        img_ha = torch.tensor(img_ha).to(device).unsqueeze(0).to(torch.float32)

```

```

pred = model(torch.stack([img_ha]))
pred = soft(pred[0])
pred = reshape_to_original_size(pred)
pred = pred.detach().numpy()

# poravnava predikcije z originalno sliko
pred_inv = inverse_h(pred, H)

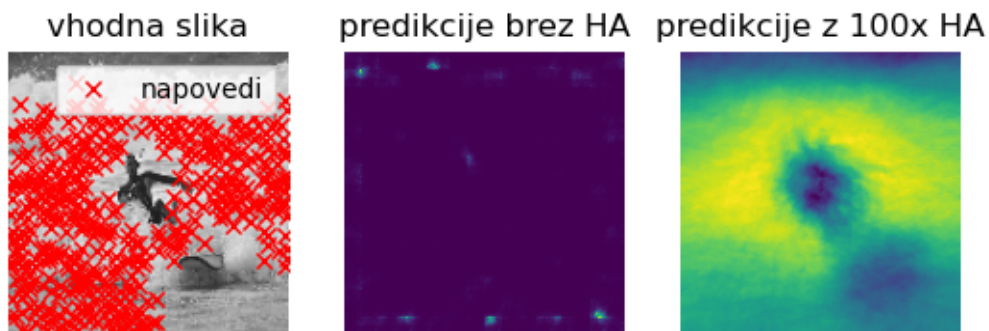
# akumulacija predikcij
pred_cum += pred_inv

# odstranimo morebitne nan vrednosti, normaliziramo
pred = np.nan_to_num(pred_cum)
pred /= pred.max()

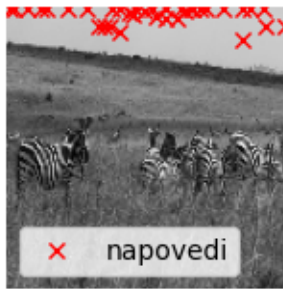
# najdi lokalne maksimume predikcije, vecje od ročno izbranega minimalnega
↳pragu
local_max = (pred==ndimage.grey_dilation(pred, size=3))*pred>0.8
py_est, px_est = np.where(local_max)

fig, ax = plt.subplots(1, 3)
ax[0].imshow(img, cmap='gray')
ax[0].plot(px_est, py_est, 'rx', label='napovedi')
ax[0].set_axis_off()
ax[0].set_title('vhodna slika')
ax[0].legend()
ax[1].imshow(pred_no_ha)
ax[1].set_title('predikcije brez HA')
ax[1].set_axis_off()
ax[2].imshow(pred)
ax[2].set_title('predikcije z 100x HA')
ax[2].set_axis_off()

```



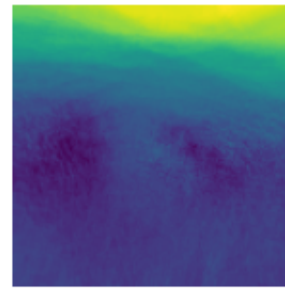
vhodna slika



predikcije brez HA



predikcije z 100x HA



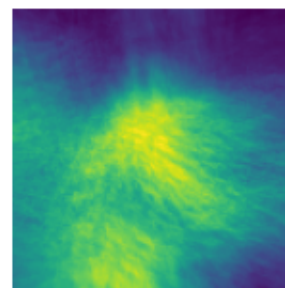
vhodna slika



predikcije brez HA



predikcije z 100x HA



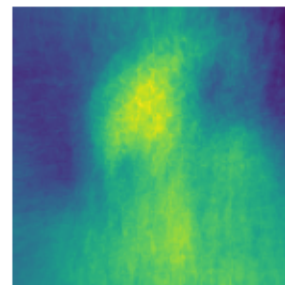
vhodna slika



predikcije brez HA



predikcije z 100x HA



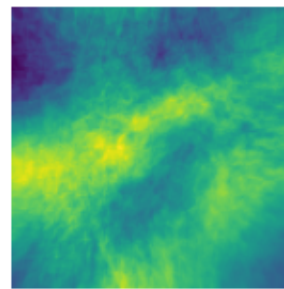
vhodna slika



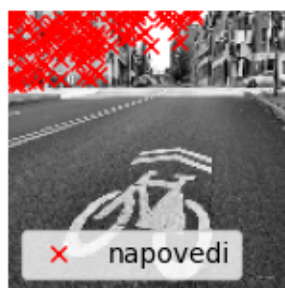
predikcije brez HA



predikcije z 100x HA



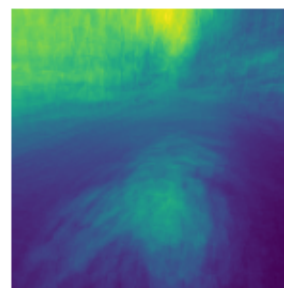
vhodna slika



predikcije brez HA



predikcije z 100x HA



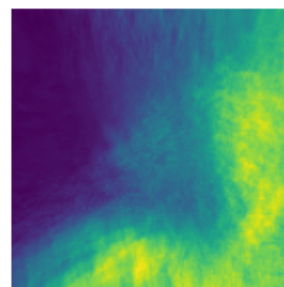
vhodna slika



predikcije brez HA



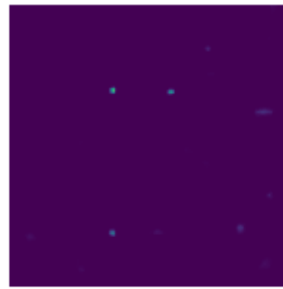
predikcije z 100x HA



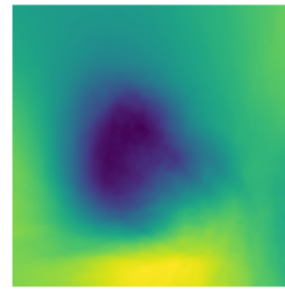
vhodna slika



predikcije brez HA



predikcije z 100x HA



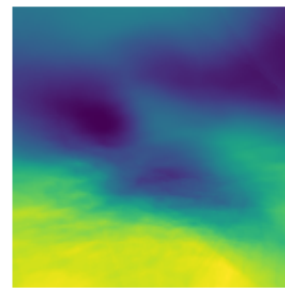
vhodna slika



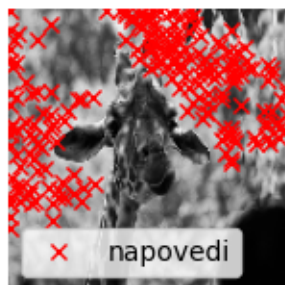
predikcije brez HA



predikcije z 100x HA



vhodna slika



predikcije brez HA



predikcije z 100x HA

