Example 1. Using RU-Net

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This example demonstrates how to use a pre-trained RU-Net (Regression-U-Net) on experimental images to extrack plankton properties

NOTE:

- If you're using google colaboratory to run this notebook, please uncomment the code in the following cell to clone the repository.
- If you're running the notebook on your local machine, please skip this step to avoid cloing the repository in the current folder.

In [1]:
```
# !git clone https://github.com/softmatterlab/Quantitative-Microplankton-Tracker.git
# %cd Quantitative-Microplankton-Tracker/examples/
```

In [2]:
```
%matplotlib inline
import sys
sys.path.append("..")
```

1. Setup

Import the dependencies to run this tutorial.

In [3]:
```
import numpy as np
import tensorflow as tf
import matplotlib.pyplot as plt
from skimage.measure import label, regionprops
```

2. Load experimental holographic image

Experimental images are located in `sample-data` folder

In [4]:
```
# Load figure 1 data
exp_image1 = np.load(
    "../data/data_figure1/fig1_data.npy"
)

# Load figure 2 data
exp_image2 = np.load(
    "../data/data_figure2/Oxyrrhis_data.npy"
)[0]
```

3. Load pre-trained RU-Net model

Pre-trained models are located in `pre-trained models` folder

In [5]:
```
model = tf.keras.models.load_model(
    "../pre-trained-models/RUNet.h5",
    compile=False
)
```

4. RUNet prediction on experimental images

4.1. Example 1

Generates Fig.1b in the paper

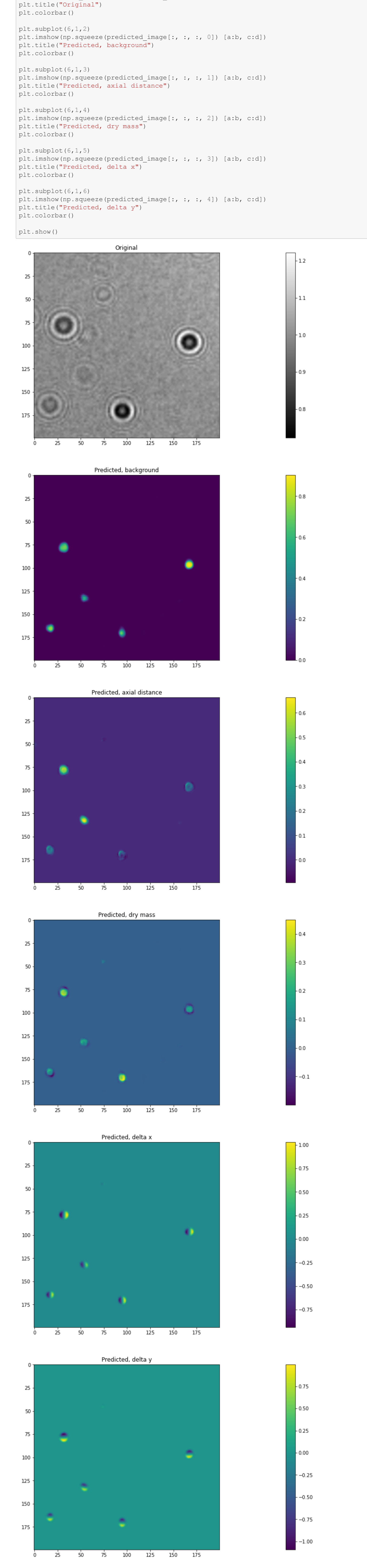
4.1.1. Normalise the experimental image

Normalise and reshape the image for RUNet prediction

In [6]:
```
img = exp_image1/np.median(exp_image1)
img = img.reshape([1,1024, 1280, 1])
predicted_image = model.predict(img)
```

4.1.2. Visualise the predictions

In [7]:
```
#predictions
fig=plt.figure(figsize=(50,50))

[a,b,c,d]=[680,880,375,575]

plt.subplot(6,1,1)
plt.imshow((exp_image1/np.median(exp_image1))[a:b, c:d] , cmap="gray")
plt.title("Original")
plt.colorbar()

plt.subplot(6,1,2)
plt.imshow(np.squeeze(predicted_image[:, :, :, 0]) [a:b, c:d])
plt.title("Predicted, background")
plt.colorbar()

plt.subplot(6,1,3)
plt.imshow(np.squeeze(predicted_image[:, :, :, 1]) [a:b, c:d])
plt.title("Predicted, axial distance")
plt.colorbar()

plt.subplot(6,1,4)
plt.imshow(np.squeeze(predicted_image[:, :, :, 2]) [a:b, c:d])
plt.title("Predicted, dry mass")
plt.colorbar()

plt.subplot(6,1,5)
plt.imshow(np.squeeze(predicted_image[:, :, :, 3]) [a:b, c:d])
plt.title("Predicted, delta x")
plt.colorbar()

plt.subplot(6,1,6)
plt.imshow(np.squeeze(predicted_image[:, :, :, 4]) [a:b, c:d])
plt.title("Predicted, delta y")
plt.colorbar()

plt.show()
```



4.2. Example 2

Generates Fig. 2a in the paper

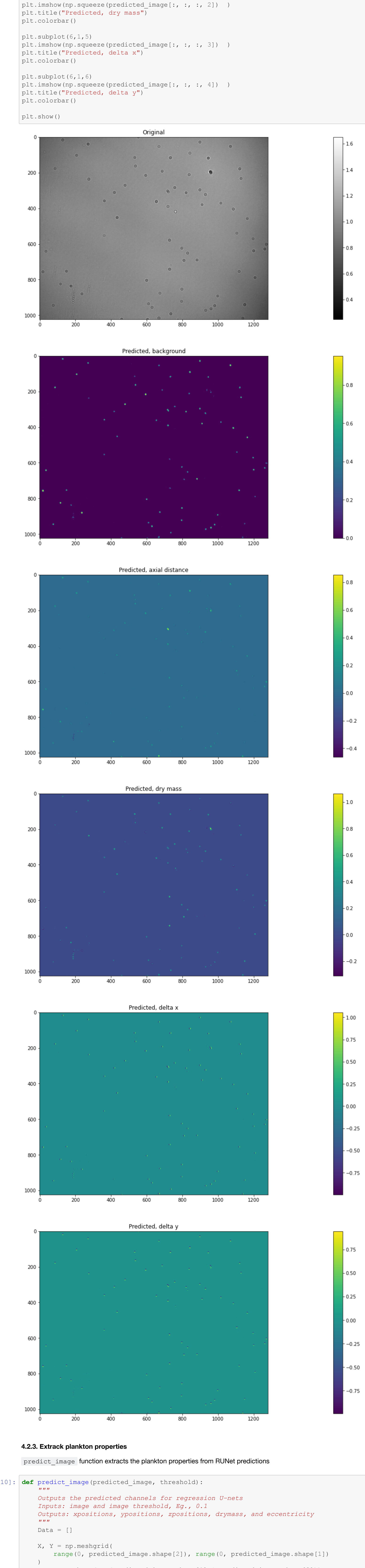
4.2.1. Normalise the experimental image

Normalise and reshape the image for RUNet prediction

In [8]:
```
img = exp_image2/np.median(exp_image2)
img = img.reshape([1,1024, 1280, 1])
predicted_image = model.predict(img)
```

4.2.2. Check predictions

In [9]:
```
#predictions
fig=plt.figure(figsize=(50,50))

plt.subplot(6,1,1)
plt.imshow(exp_image2/np.median(exp_image2) , cmap="gray")
plt.title("Original")
plt.colorbar()

plt.subplot(6,1,2)
plt.imshow(np.squeeze(predicted_image[:, :, :, 0]))
plt.title("Predicted, background")
plt.colorbar()

plt.subplot(6,1,3)
plt.imshow(np.squeeze(predicted_image[:, :, :, 1]))
plt.title("Predicted, axial distance")
plt.colorbar()

plt.subplot(6,1,4)
plt.imshow(np.squeeze(predicted_image[:, :, :, 2]))
plt.title("Predicted, dry mass")
plt.colorbar()

plt.subplot(6,1,5)
plt.imshow(np.squeeze(predicted_image[:, :, :, 3]))
plt.title("Predicted, delta x")
plt.colorbar()

plt.subplot(6,1,6)
plt.imshow(np.squeeze(predicted_image[:, :, :, 4]))
plt.title("Predicted, delta y")
plt.colorbar()

plt.show()
```



4.2.3. Extrack plankton properties

`predict_image` function extracts the plankton properties from RUNet predictions

In [10]:
```
def predict_image(predicted_image, threshold):
    """
    Outputs the predicted channels for regression U-nets
    Inputs: image and image threshold, Eg., 0.1
    Outputs: xpositions, ypositions, zpositions, drymass, and eccentricity
    """
    Data = []

    X, Y = np.meshgrid(
        range(0, predicted_image.shape[2]), range(0, predicted_image.shape[1])
    )
    X = np.reshape(X, (predicted_image.shape[1] * predicted_image.shape[2]))
    Y = np.reshape(Y, (predicted_image.shape[1] * predicted_image.shape[2]))

    for i in range(predicted_image.shape[0]):

        zpos = []
        mass = []
        xpos = []
        ypos = []
        ecc = []
        xyri = []

        predX = predicted_image[i, :, :, 3]
        predY = predicted_image[i, :, :, 4]

        gx1, gy1 = np.gradient(predX)
        gx2, gy2 = np.gradient(predY)

        I = gy1 + gx2

        I2 = np.zeros(I.shape)
        I2[I > threshold] = 1

        I3 = label(I2)
        prop = regionprops(I3)

        zs = predicted_image[i, :, :, 1]
        masses = predicted_image[i, :, :, 2]
        I3 = np.reshape(
            I3, (predicted_image.shape[2] * predicted_image.shape[1])
        )
        zs = np.reshape(
            zs, (predicted_image.shape[2] * predicted_image.shape[1])
        )
        masses = np.reshape(
            masses, (predicted_image.shape[2] * predicted_image.shape[1])
        )

        for j in range(np.amax(I3)):
            if prop[j].eccentricity < 1.2:

                ecc.append(prop[j].eccentricity)

                inds = np.where(I3 == j + 1)
                zpos.append(np.mean(zs[inds]))
                mass.append(np.mean(masses[inds]))
                xpos.append(np.mean(X[inds]))
                ypos.append(np.mean(Y[inds]))

                xyri.append(
                    [
                        np.mean(X[inds]),
                        np.mean(Y[inds]),
                        np.mean(zs[inds]),
                        np.mean(masses[inds]),
                    ]
                )

        xyri = np.array(xyri)
        Data.append(xyri)

    return Data
```

In [11]:
```
plankton_data_in_image = predict_image(predicted_image, 0.15)[0]
```

4.2.4. Highlight the planktons

In [12]:
```
fig, ax = plt.subplots(figsize=(15,15))

ax.imshow(exp_image2, cmap='gray')

X = plankton_data_in_image[:, 0]
Y = plankton_data_in_image[:, 1]

for i in range(0,len(X),1):
    x0 = X[i]
    y0 = Y[i]
    ax.plot(x0, y0,'o', ms=50, markerfacecolor="None", markeredgecolor='#e377c2', markeredgewidth=4, al
pha=0.5, label='Predator')

plt.axis("off")
plt.show()
```