TFM_LauraRivera_objetivo2_similares

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<img src="http://www.uoc.edu/portal/_resources/common/imatges/marca_UOC/UOC_Masterbrand.jpg", align="left">

Identificación de huellas de calzado a partir de imágenes con redes neuronales convolucionales

MU Ingeniería Computacional y Matemática / Área de Inteligencia Artificial

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1 Objetivo 2: Búsqueda de huellas similares para la identificación de individuos

El objetivo de este cuaderno es crear una red neuronal siamesa para obtener imágenes similares a la de entrada.

Para ello se utiliza el conjunto de datos disponible en: https://fid.dmi.unibas.ch/

Dispone de dos tipos de imágenes: las de referencia (muestras tomadas a personas) y las "tracks" (recogidas en escenas de crimen), de éstas últimas se dispone también de su versión recortada (cropped), que es la que se utilizará también en los experimentos.

[2]:
```
#librerias necesarias:
import pandas as pd
import numpy as np
from zipfile import ZipFile
import matplotlib.pyplot as plt
from PIL import Image
import os
import cv2
import random
import skimage
```

[3]:
```
#En caso de utilizar google colab:
#from google.colab import drive
#drive.mount('/content/gdrive')
```

1.1 Lectura y análisis de los conjuntos de datos FD-300

[4]:
```
def get_images_to_jpeg(imgPath):
  dir_list = os.listdir("./"+imgPath)
  result = []

  for f in dir_list:

    im = Image.open("./"+imgPath+"/"+f)
    im2=im.resize((400,912))
    im3 = im2.crop((40,40,320,872)) #Quitar marco medidor
    im3.save("./"+imgPath+"/"+f[0:-4]+'jpeg')

    result.append(f[0:-4]+'jpeg')
    os.remove("./"+imgPath+"/"+f)

  print('Nº files:',len(result))
  return result

def get_images(imgPath):
  dir_list = os.listdir("./"+imgPath)
  result = []
  for f in dir_list:
    result.append(f)


  print('Nº files:',len(result))
  return result
```

[5]:
```
with ZipFile('data/FID300/images.zip', 'r') as zipObj:
  zipObj.extractall('fid300')
```

[6]:
```
#Lectura de la tabla de resultados
df_fid300 = pd.read_csv('data/FID300/label_table.csv', delimiter=',')
```

En este caso, las imágenes estan divididas en 3 carpetas:

- *tracks_original*: Conteine las 300 imágenes originales extraidas de la escena del crimen, incluyendo la plantilla de medición.
- *tracks_cropped*: Contiene las imágenes originales pero ya recortadas.
- *references*: Contiene las 1175 imágenes de las huellas de referencia, obtenidas de diferentes calzados.

Para el proyecto se decide utilizar las dos últimas categorias, guardandolas en 2 datasets diferenciados: *fid300ref* y *fid300crop*.

1.1.1 Análisis de los datos

[7]:
```
fid300ref = get_images("fid300/references")
fid300crop = get_images("fid300/tracks_cropped")

print(len(df_fid300)) #lineas en el csv
print(fid300ref[0])
```

```
Nº files: 1175
Nº files: 300
300
00481.png
```

[8]:
```
X_files = df_fid300['X'].values.tolist()
y = df_fid300['y'].values.tolist()

values_y, counts_y = np.unique(y, return_counts=True)

print('Nº of references: %d' %len(values_y))

dfref = pd.DataFrame({'x':values_y, 'y':counts_y})
dfref = dfref.sort_values('y', ascending = False)
dfref.head(10) # coger los 5 primeros
```

```
Nº of references: 130
```

[8]:

	x	y
32	37	7
19	22	6
2	3	6
4	5	6
44	49	6
12	14	6
89	1055	6
79	1041	5
55	60	5
9	11	5

1.1.2 Visualización de imágenes

Se ha creado la función *plot_image* que permite la visualización de las imágenes de cualquiera de las dos bases de datos.

Parámetros:
imgPath: carpeta donde estan las imágenes
fileNames: array con los nombres de los ficheros a mostrar

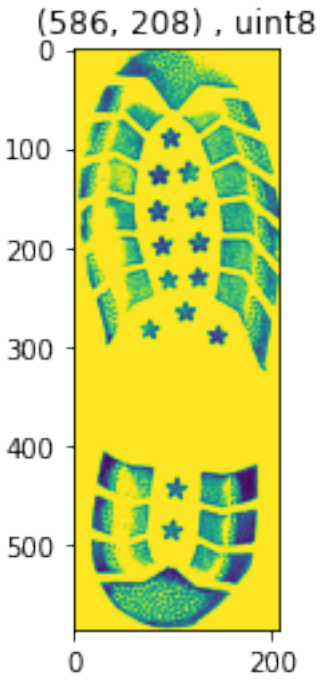
[9]:
```
import skimage
def plot_image(imgPath, fileNames):
  for i in range(len(fileNames)):
```

```
    filename = fileNames[i]
    img = skimage.io.imread(imgPath+filename)

    plt.figure()
    plt.title(str(img.shape)+" , "+str(img.dtype))
    plt.imshow(img)
  print(fileNames)
  plt.show()

def plot_image2(img):

    plt.figure()
    plt.title(str(img.shape)+" , "+str(img.dtype))
    plt.imshow(img)

    plt.show()
def plot_image_grey(img):

    plt.figure()
    plt.title(str(img.shape)+" , "+str(img.dtype))
    plt.imshow(img, cmap='gray')

    plt.show()
```

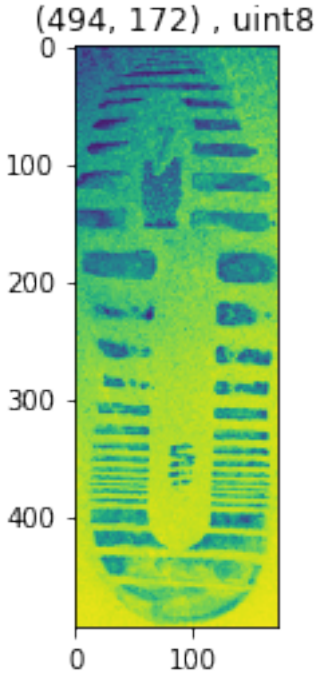
A continuación, se muestra una imagen aleatória de cada uno de los 3 datasets del proyecto:

[10]:
```
plot_image("fid300/references/",random.choices(fid300ref,k=1))
plot_image("fid300/tracks_cropped/",random.choices(fid300crop,k=1))
```

```
['00478.png']
```


(586, 208) , uint8
0
100
200
300
400
500
0
200

['00168.jpg']


(494, 172) , uint8
0
100
200
300
400
0
100

1.1.3 División de los datos

En este caso, no es necesaria la división de datos, ya que se va a utilizar todas las imágenes de referencia para codificar sus características en la red neuronal, representando las imágenes que podría la polícia tener en su base de datos (de personas conocidas).

1.2 Red neuronal siamesa

Red neuronal siamesa para la búsqueda de imágenes similares.

[13]:
```
from tensorflow.keras.preprocessing.image import ImageDataGenerator, load_img,␣
↪img_to_array, array_to_img
from tensorflow.keras.models import Model, load_model
from tensorflow.keras.layers import Flatten, Conv2D, Conv2DTranspose,␣
↪LeakyReLU, BatchNormalization, Input, Dense, Reshape, Activation
from tensorflow.keras.optimizers import Adam
from tensorflow.keras.callbacks import ModelCheckpoint
import tensorflow.keras.backend as K
import numpy as np
import matplotlib.pyplot as plt
from tqdm import tqdm_notebook as tqdm
import pickle
import pandas as pd
import tensorflow as tf

# Load images
img_height = 586
img_width = 156
channels = 1 #3
batch_size = 16

def my_preprocessing_function(img):

    #Combines all the transformations
    #img = cv.imread('fid300/'+filename)
    #img = rgb2gray(img)
    test_binary_high,img = cv.threshold(img,0, 255, cv2.THRESH_BINARY)
    #img = crop_image(img)
    #img = cv2.resize(img, (img_height, img_width), interpolation = cv2.
↪INTER_AREA)
    img = np.expand_dims(img,-1)
   # img = gray2rgb(img)
    return img



train_datagen = ImageDataGenerator(preprocessing_function␣
↪=my_preprocessing_function, rescale=1./255,
```

```
                                    validation_split=0.2)

#añadir funcion preprocessing_function para pasar a gris y binary
training_set = train_datagen.flow_from_directory(
    'fid300/',
     target_size = (img_height, img_width),
     batch_size = batch_size,
     classes=['references'],
     class_mode = 'input',
     subset = 'training',
     color_mode='grayscale',
     shuffle=True)

validation_set = train_datagen.flow_from_directory(
    'fid300/',
     target_size = (img_height, img_width),
     batch_size = batch_size,
     classes=['references'],
     subset = 'validation',
     class_mode = 'input',
     color_mode='grayscale',
     shuffle=False)

#Única clase porque no tengo classes / labels por imagen.
```

```
Found 940 images belonging to 1 classes.
Found 235 images belonging to 1 classes.
```

[18]:
```
# Define the autoencoder
input_model = Input(shape=(img_height, img_width, channels))

print(input_model.shape)
# Encoder layers
encoder = Conv2D(32, (3,3), padding='same',␣
 ↪kernel_initializer='normal')(input_model)
encoder = LeakyReLU()(encoder)
encoder = BatchNormalization(axis=-1)(encoder)

encoder = Conv2D(64, (3,3), padding='same',␣
 ↪kernel_initializer='normal')(encoder)
encoder = LeakyReLU()(encoder)
encoder = BatchNormalization(axis=-1)(encoder)

encoder = Conv2D(64, (3,3), padding='same',␣
 ↪kernel_initializer='normal')(input_model)
encoder = LeakyReLU()(encoder)
encoder = BatchNormalization(axis=-1)(encoder)
```

```
encoder_dim = K.int_shape(encoder)
encoder = Flatten()(encoder)

# Latent Space
latent_space = Dense(16, name='latent_space')(encoder)

# Decoder Layers
decoder = Dense(np.prod(encoder_dim[1:]))(latent_space)
decoder = Reshape((encoder_dim[1], encoder_dim[2], encoder_dim[3]))(decoder)

decoder = Conv2DTranspose(64, (3,3), padding='same',␣
 ↪kernel_initializer='normal')(decoder)
decoder = LeakyReLU()(decoder)
decoder = BatchNormalization(axis=-1)(decoder)

decoder = Conv2DTranspose(64, (3,3), padding='same',␣
 ↪kernel_initializer='normal')(decoder)
decoder = LeakyReLU()(decoder)
decoder = BatchNormalization(axis=-1)(decoder)

decoder = Conv2DTranspose(32, (3,3), padding='same',␣
 ↪kernel_initializer='normal')(decoder)
decoder = LeakyReLU()(decoder)
decoder = BatchNormalization(axis=-1)(decoder)

decoder = Conv2DTranspose(1, (3, 3), padding="same")(decoder)
output = Activation('sigmoid', name='decoder')(decoder)

print(output.shape)
```

```
(None, 586, 156, 1)
(None, 586, 156, 1)
```

[19]:
```
# Create model object
autoencoder = Model(input_model, output, name='autoencoder')
autoencoder.summary()
```

```
Model: "autoencoder"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 input_2 (InputLayer)        [(None, 586, 156, 1)]     0

 conv2d_5 (Conv2D)           (None, 586, 156, 64)      640

 leaky_re_lu_8 (LeakyReLU)   (None, 586, 156, 64)      0
```

```
batch_normalization_8 (Batc  (None, 586, 156, 64)     256
hNormalization)

flatten_1 (Flatten)          (None, 5850624)          0

latent_space (Dense)         (None, 16)               93610000

dense_1 (Dense)              (None, 5850624)          99460608

reshape_1 (Reshape)          (None, 586, 156, 64)     0

conv2d_transpose_4 (Conv2DT  (None, 586, 156, 64)     36928
ranspose)

leaky_re_lu_9 (LeakyReLU)    (None, 586, 156, 64)     0

batch_normalization_9 (Batc  (None, 586, 156, 64)     256
hNormalization)

conv2d_transpose_5 (Conv2DT  (None, 586, 156, 64)     36928
ranspose)

leaky_re_lu_10 (LeakyReLU)   (None, 586, 156, 64)     0

batch_normalization_10 (Bat  (None, 586, 156, 64)     256
chNormalization)

conv2d_transpose_6 (Conv2DT  (None, 586, 156, 32)     18464
ranspose)

leaky_re_lu_11 (LeakyReLU)   (None, 586, 156, 32)     0

batch_normalization_11 (Bat  (None, 586, 156, 32)     128
chNormalization)

conv2d_transpose_7 (Conv2DT  (None, 586, 156, 1)      289
ranspose)

decoder (Activation)         (None, 586, 156, 1)      0

=================================================================
Total params: 193,164,753
Trainable params: 193,164,305
Non-trainable params: 448
_________________________________________________________________
```

[20]:
```
!pip install opencv-contrib-python==4.4.0.44
```

```
Requirement already satisfied: opencv-contrib-python==4.4.0.44 in
/Library/Frameworks/Python.framework/Versions/3.8/lib/python3.8/site-packages
(4.4.0.44)
Requirement already satisfied: numpy>=1.17.3 in
/Library/Frameworks/Python.framework/Versions/3.8/lib/python3.8/site-packages
(from opencv-contrib-python==4.4.0.44) (1.23.4)

[notice] A new release of pip is
available: 23.0.1 -> 23.1.2
[notice] To update, run:
pip install --upgrade pip
```

[22]:
```
# Compile the model
autoencoder.compile(loss="mse", optimizer= Adam(learning_rate=1e-3),␣
 ↪metrics=['accuracy'])
#autoencoder.compile(optimizer='adam',
#               loss=tf.keras.losses.
 ↪SparseCategoricalCrossentropy(from_logits=True),
#               metrics=['accuracy'])
# Fit the model
history = autoencoder.fit(
          training_set,
          steps_per_epoch=training_set.n // batch_size,
          epochs=25,
          validation_data=validation_set,
          validation_steps=validation_set.n // batch_size,
          callbacks = [ModelCheckpoint('models/image_autoencoder_2.h5',
                                       monitor='val_loss',
                                       verbose=0,
                                       save_best_only=True,
                                       save_weights_only=False)])
```

```
Epoch 1/25
58/58 [==============================] - 643s 11s/step - loss: 0.1348 -
accuracy: 0.8717 - val_loss: 0.9292 - val_accuracy: 0.0597
Epoch 2/25
58/58 [==============================] - 601s 10s/step - loss: 0.0996 -
accuracy: 0.9018 - val_loss: 0.7845 - val_accuracy: 0.1832
Epoch 3/25
58/58 [==============================] - 603s 10s/step - loss: 0.0924 -
accuracy: 0.9069 - val_loss: 0.1121 - val_accuracy: 0.8877
Epoch 4/25
58/58 [==============================] - 603s 10s/step - loss: 0.0646 -
accuracy: 0.9353 - val_loss: 0.0610 - val_accuracy: 0.9374
Epoch 5/25
58/58 [==============================] - 601s 10s/step - loss: 0.0386 -
accuracy: 0.9614 - val_loss: 0.0103 - val_accuracy: 0.9911
Epoch 6/25
```

```
58/58 [==============================] - 604s 10s/step - loss: 0.0223 -
accuracy: 0.9779 - val_loss: 0.0097 - val_accuracy: 0.9911
Epoch 7/25
58/58 [==============================] - 609s 11s/step - loss: 0.0129 -
accuracy: 0.9868 - val_loss: 0.0091 - val_accuracy: 0.9911
Epoch 8/25
58/58 [==============================] - 603s 10s/step - loss: 0.0126 -
accuracy: 0.9868 - val_loss: 0.0089 - val_accuracy: 0.9911
Epoch 9/25
58/58 [==============================] - 601s 10s/step - loss: 0.0126 -
accuracy: 0.9867 - val_loss: 0.0088 - val_accuracy: 0.9909
Epoch 10/25
58/58 [==============================] - 594s 10s/step - loss: 0.0124 -
accuracy: 0.9870 - val_loss: 0.0086 - val_accuracy: 0.9910
Epoch 11/25
58/58 [==============================] - 600s 10s/step - loss: 0.0125 -
accuracy: 0.9869 - val_loss: 0.0087 - val_accuracy: 0.9909
Epoch 12/25
58/58 [==============================] - 575s 10s/step - loss: 0.0123 -
accuracy: 0.9871 - val_loss: 0.0088 - val_accuracy: 0.9903
Epoch 13/25
58/58 [==============================] - 592s 10s/step - loss: 0.0125 -
accuracy: 0.9868 - val_loss: 0.0091 - val_accuracy: 0.9900
Epoch 14/25
58/58 [==============================] - 581s 10s/step - loss: 0.0124 -
accuracy: 0.9870 - val_loss: 0.0093 - val_accuracy: 0.9894
Epoch 15/25
58/58 [==============================] - 577s 10s/step - loss: 0.0124 -
accuracy: 0.9869 - val_loss: 0.0097 - val_accuracy: 0.9884
Epoch 16/25
58/58 [==============================] - 572s 10s/step - loss: 0.0124 -
accuracy: 0.9870 - val_loss: 0.0113 - val_accuracy: 0.9863
Epoch 17/25
58/58 [==============================] - 575s 10s/step - loss: 0.0124 -
accuracy: 0.9869 - val_loss: 0.0088 - val_accuracy: 0.9908
Epoch 18/25
58/58 [==============================] - 581s 10s/step - loss: 0.0124 -
accuracy: 0.9869 - val_loss: 0.0109 - val_accuracy: 0.9870
Epoch 19/25
58/58 [==============================] - 576s 10s/step - loss: 0.0124 -
accuracy: 0.9869 - val_loss: 0.0111 - val_accuracy: 0.9867
Epoch 20/25
58/58 [==============================] - 580s 10s/step - loss: 0.0122 -
accuracy: 0.9871 - val_loss: 0.0111 - val_accuracy: 0.9866
Epoch 21/25
58/58 [==============================] - 577s 10s/step - loss: 0.0121 -
accuracy: 0.9872 - val_loss: 0.0098 - val_accuracy: 0.9886
Epoch 22/25
```

```
58/58 [==============================] - 571s 10s/step - loss: 0.0120 -
accuracy: 0.9874 - val_loss: 0.0103 - val_accuracy: 0.9880
Epoch 23/25
58/58 [==============================] - 574s 10s/step - loss: 0.0120 -
accuracy: 0.9873 - val_loss: 0.0108 - val_accuracy: 0.9872
Epoch 24/25
58/58 [==============================] - 571s 10s/step - loss: 0.0121 -
accuracy: 0.9872 - val_loss: 0.0109 - val_accuracy: 0.9871
Epoch 25/25
58/58 [==============================] - 575s 10s/step - loss: 0.0122 -
accuracy: 0.9871 - val_loss: 0.0095 - val_accuracy: 0.9892
```

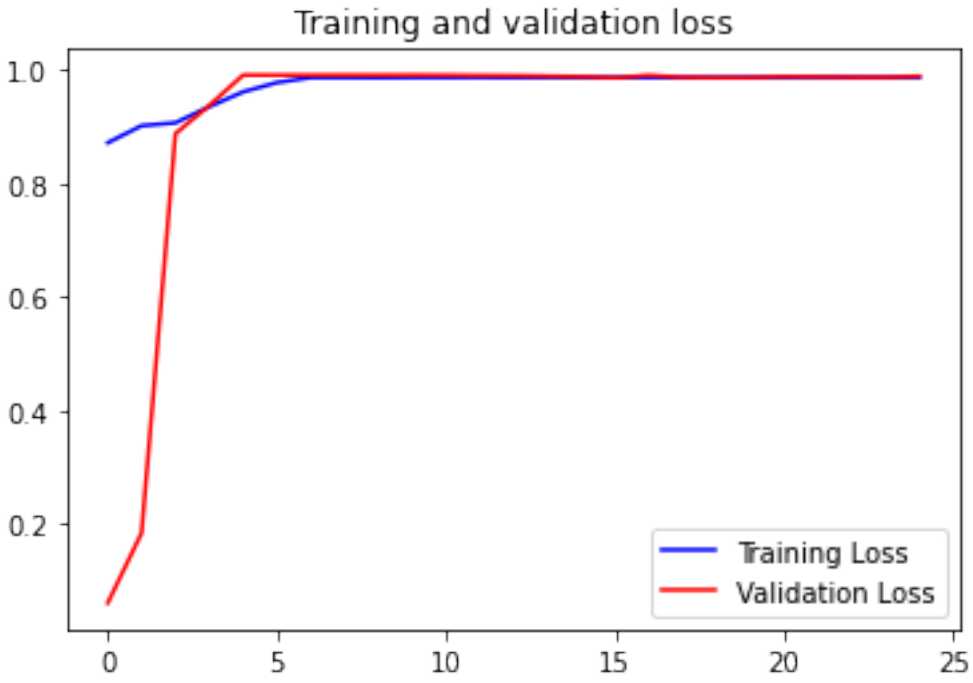
[23]:
```python
# Plot Accuracy and Loss
loss = history.history['accuracy']
val_loss = history.history['val_accuracy']

epochs = range(len(loss))

plt.figure()

plt.plot(epochs, loss, 'b', label='Training Acc')
plt.plot(epochs, val_loss, 'r', label='Validation Acc')
plt.title('Training and validation accuracy')
plt.legend()

plt.show()
```



[14]:
```
# Predict image function
def predict_image(image_dir, autoencoder):
  raw_image = load_img(image_dir, target_size=(img_height, img_width),␣
 ↪color_mode = "grayscale")
  image = img_to_array(raw_image)
  image = np.expand_dims(image, axis=0)
  image = image / 255.0
  pred = autoencoder.predict(image)
  pred = pred * 255.0
  pred = np.reshape(pred, (img_height, img_width, 1))
  pred = array_to_img(pred)

  return raw_image, pred
```

[ ]:
```
# Predict 3 images from training set
train_imgs = training_set.filepaths[0:3]

for i in train_imgs:
  raw_image, pred_image = predict_image(i, autoencoder)

  # Show original image
  plt.imshow(raw_image)
  plt.show()

  # Show predicted image
  plt.imshow(pred_image)
  plt.show()
```

[ ]:
```
autoencoder.save('models/image_autoencoder_2.h5')
```

[16]:
```
import os
import cv2 as cv
#Latent space:

autoencoder = load_model('models/image_autoencoder_2.h5', compile=False)
latent_space_model = Model(autoencoder.input, autoencoder.
 ↪get_layer('latent_space').output)

#
# Load all images and predict them with the latent space model
X = []
indices = []

for i in tqdm(range(len(os.listdir('./fid300/references')))):
  try:
```

```
    img_name = os.listdir('./fid300/references')[i]
    img = load_img('./fid300/references/{}'.format(img_name),
                   target_size = (img_height, img_width), color_mode =␣
↪"grayscale")
    img = img_to_array(img) / 255.0
    test_binary_high,img = cv.threshold(img,0, 255, cv2.THRESH_BINARY)
    #img = crop_image(img)
    #img = cv2.resize(img, (img_height, img_width), interpolation = cv2.
↪INTER_AREA)
    #img = np.expand_dims(img,-1)

    #img = cv2.resize(img, (img_height, img_width), interpolation = cv2.
↪INTER_AREA)
    img = np.expand_dims(img, axis=0)
    pred = latent_space_model.predict(img)
    pred = np.resize(pred, (16))
    X.append(pred)
    indices.append(img_name)

  except Exception as e:
    print(img_name)
    print(e)

    # Export the embeddings
embeddings = {'indices': indices, 'features': np.array(X)}
pickle.dump(embeddings,
            open('./fid300/image_embeddings.pickle', 'wb'))
#
def eucledian_distance(x,y):
  eucl_dist = np.linalg.norm(x - y)
  return eucl_dist
```

```
<ipython-input-16-2083651edf6d>:13: TqdmDeprecationWarning: This function will
be removed in tqdm==5.0.0
Please use `tqdm.notebook.tqdm` instead of `tqdm.tqdm_notebook`
  for i in tqdm(range(len(os.listdir('./fid300/references')))):
```

```
HBox(children=(FloatProgress(value=0.0, max=1175.0), HTML(value='')))
```

```
1/1 [==============================] - 0s 276ms/step
1/1 [==============================] - 0s 60ms/step
1/1 [==============================] - 0s 59ms/step
1/1 [==============================] - 0s 60ms/step
1/1 [==============================] - 0s 59ms/step
1/1 [==============================] - 0s 61ms/step
1/1 [==============================] - 0s 60ms/step
1/1 [==============================] - 0s 67ms/step
```

```
1/1 [==============================] - 0s 66ms/step
1/1 [==============================] - 0s 64ms/step
1/1 [==============================] - 0s 65ms/step
1/1 [==============================] - 0s 58ms/step
1/1 [==============================] - 0s 64ms/step
1/1 [==============================] - 0s 63ms/step
1/1 [==============================] - 0s 59ms/step
1/1 [==============================] - 0s 58ms/step
1/1 [==============================] - 0s 59ms/step
1/1 [==============================] - 0s 59ms/step
1/1 [==============================] - 0s 59ms/step
1/1 [==============================] - 0s 60ms/step
1/1 [==============================] - 0s 60ms/step
1/1 [==============================] - 0s 58ms/step
1/1 [==============================] - 0s 63ms/step
1/1 [==============================] - 0s 63ms/step
1/1 [==============================] - 0s 60ms/step
1/1 [==============================] - 0s 58ms/step
1/1 [==============================] - 0s 60ms/step
1/1 [==============================] - 0s 58ms/step
1/1 [==============================] - 0s 59ms/step
1/1 [==============================] - 0s 59ms/step
1/1 [==============================] - 0s 59ms/step
1/1 [==============================] - 0s 58ms/step
1/1 [==============================] - 0s 60ms/step
1/1 [==============================] - 0s 60ms/step
1/1 [==============================] - 0s 59ms/step
1/1 [==============================] - 0s 60ms/step
1/1 [==============================] - 0s 59ms/step
1/1 [==============================] - 0s 58ms/step
1/1 [==============================] - 0s 58ms/step
1/1 [==============================] - 0s 58ms/step
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```
1/1 [==============================] - 0s 60ms/step
1/1 [==============================] - 0s 59ms/step
1/1 [==============================] - 0s 62ms/step
1/1 [==============================] - 0s 60ms/step
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1/1 [==============================] - 0s 62ms/step
1/1 [==============================] - 0s 60ms/step
1/1 [==============================] - 0s 59ms/step
1/1 [==============================] - 0s 62ms/step
```

[17]:
```python
# Load embeddings
embeddings = pickle.load(open('./fid300/image_embeddings.pickle', 'rb'))

# Load images metadata
metadata = pd.read_csv('data/FID300/label_table.csv')
```

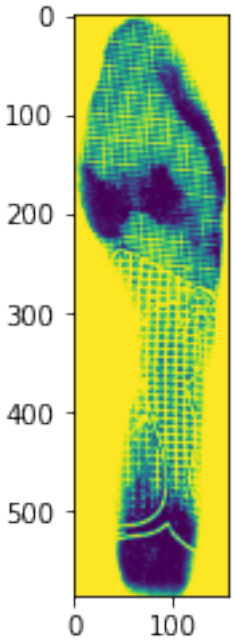
[60]:
```python
def getTop3Similars(img):
    # Calculate eucledian distance
    img_similarity = []
    #cat_similarity = []

    # Get actual image embedding
    img = img_to_array(img) / 255.0
    test_binary_high,img = cv2.threshold(img,0, 255, cv2.THRESH_BINARY)
    img = np.expand_dims(img, axis=0)

    pred = latent_space_model.predict(img)
    pred = np.resize(pred, (16))

    for i in range(len(embeddings['indices'])):
      img_name = embeddings['indices'][i]

      # Calculate vectors distances
      dist = eucledian_distance(pred,embeddings['features'][i])
      img_similarity.append(dist)


    imgs_result = pd.DataFrame({'img': embeddings['indices'],
                                'euclidean_distance': img_similarity})
```

```
    imgs_result = imgs_result.query('euclidean_distance > 0').
↪sort_values(by='euclidean_distance', ascending=True).reset_index(drop=True)

    print("Most similar images")
    fig = plt.figure(figsize=(10, 7))
    fig.tight_layout(pad=50.0)

    # Show 3 most similar images
    for i in range(3):
      image = load_img('./fid300/references/{}'.format(imgs_result['img'].
↪values[i]))

      # Show image
      fig.add_subplot(1, 3, i+1)
      plt.imshow(image)
      plt.title('{}'.format(imgs_result['img'].values[i])+"\n"+'Dist: {}'.
↪format(imgs_result['euclidean_distance'].values[i]))


    plt.show()
    print("Less similar images")
    fig = plt.figure(figsize=(10, 7))
    fig.tight_layout(pad=50.0)

    # Show 3 less similar images
    less = imgs_result.tail(3)
    for i in range(3):
        image = load_img('./fid300/references/{}'.format(less['img'].values[i]))

        # Show image
        fig.add_subplot(1, 3, i+1)
        plt.imshow(image)
        plt.title('{}'.format(less['img'].values[i])+"\n"+'Dist: {}'.
↪format(less['euclidean_distance'].values[i]))
    plt.show()
```

1.2.1 Experimentos con las imágenes de referencia

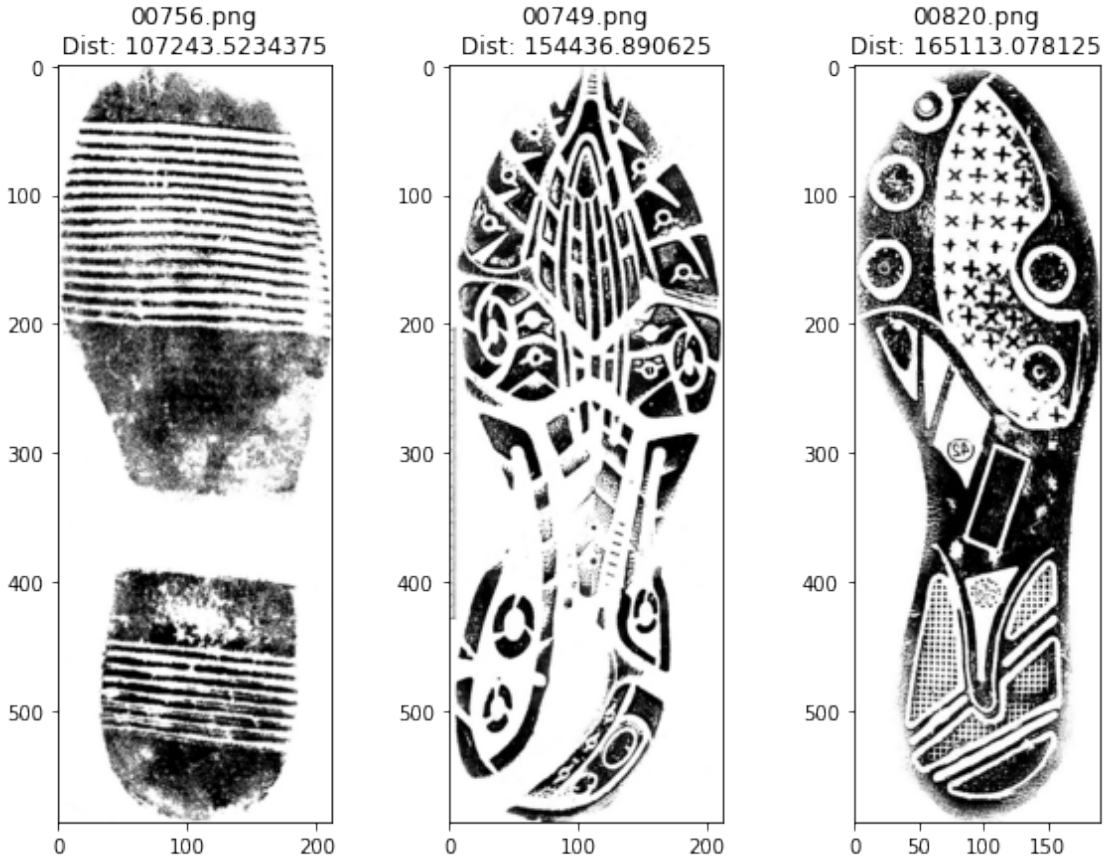
[61]:
```
# Get random image name
img_name = os.listdir('./fid300/references')[random.randint(0, 299)]
test1 = load_img('./fid300/references/{}'.format(img_name),
                 target_size = (img_height, img_width),␣
 ↪color_mode='grayscale')

#my_preprocessing_function(img)

plt.imshow(test1)
```

[61]:
```
<matplotlib.image.AxesImage at 0x7fca62b934f0>
```

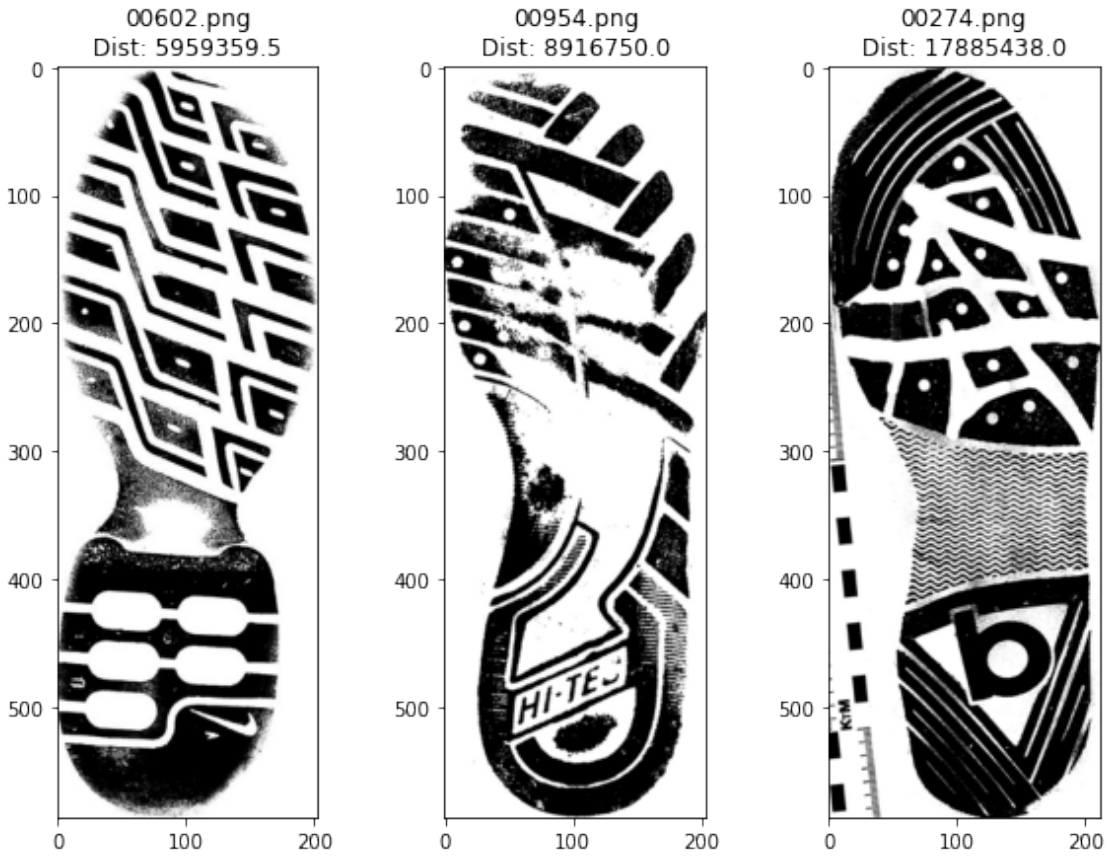


[62]:
```
getTop3Similars(test1)
```

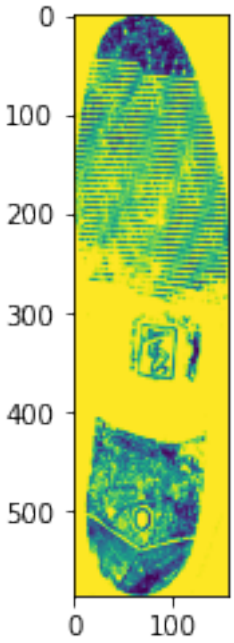
```
1/1 [==============================] - 0s 75ms/step
Most similar images
```



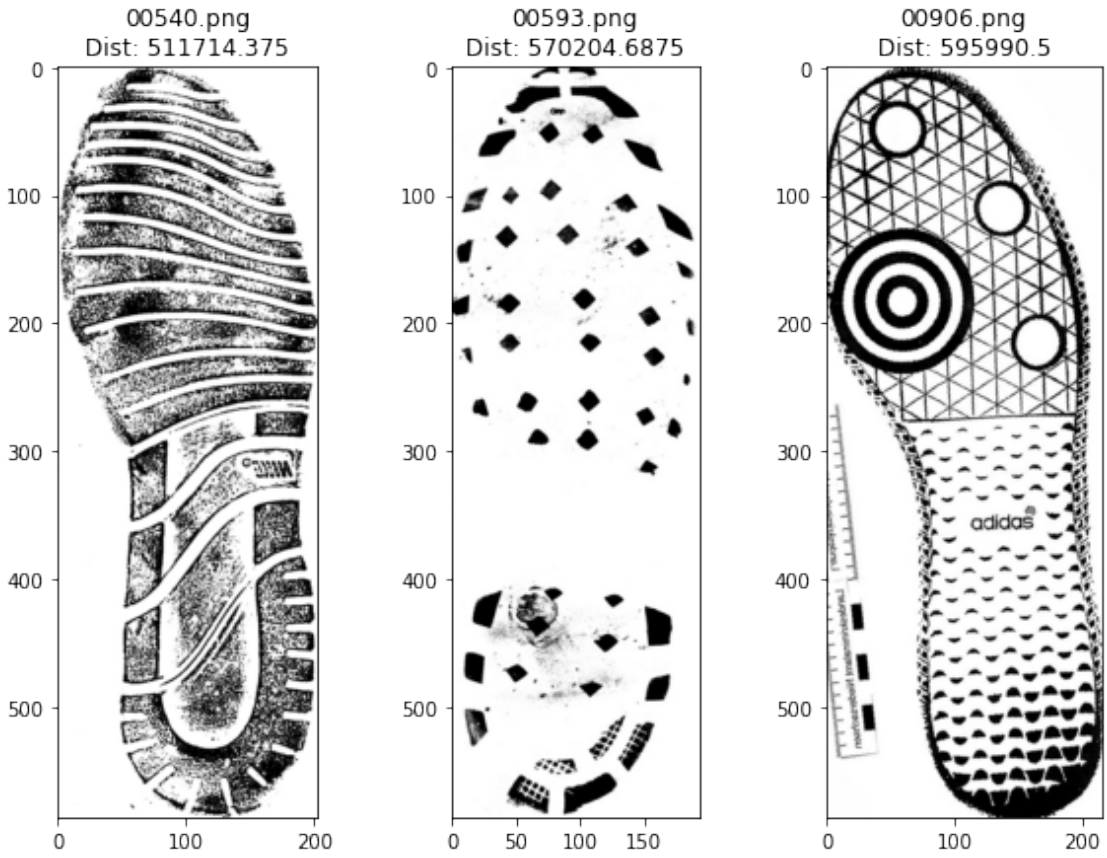
Less similar images



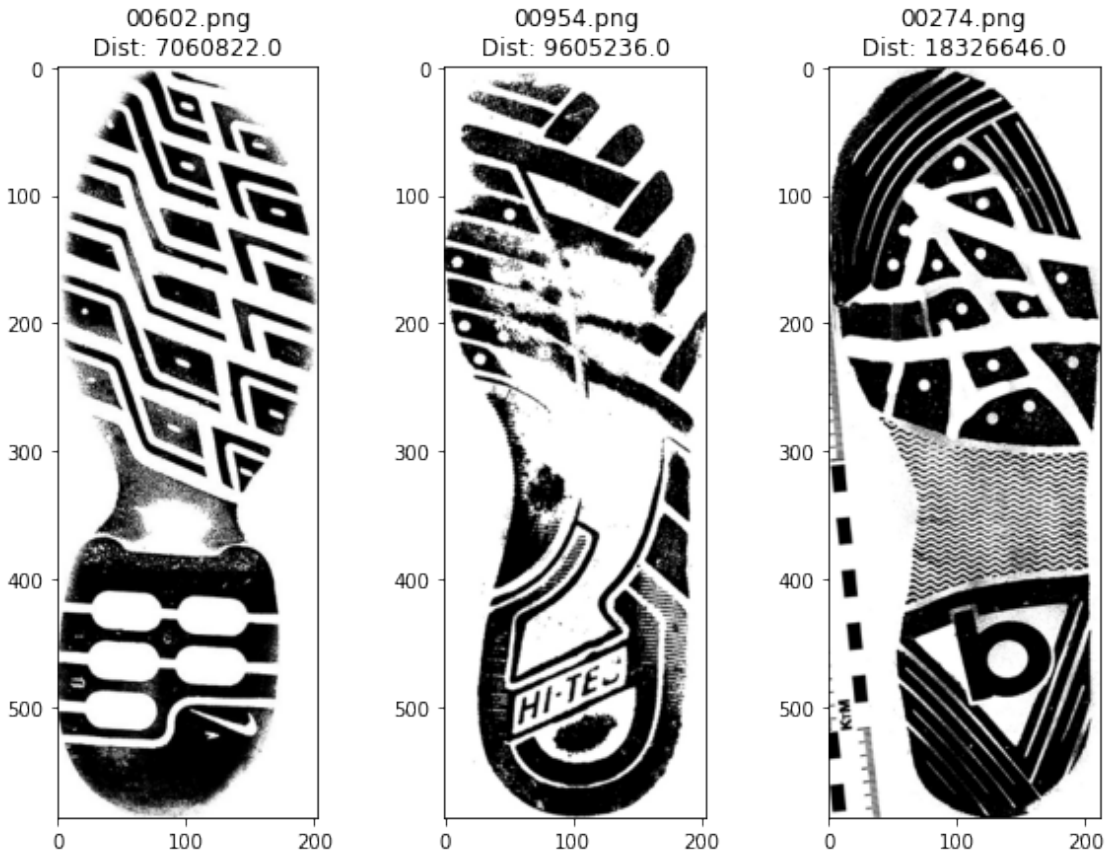
[63]:
```
#Test 00755.png
test00755= load_img('./fid300/references/{}'.format("00755.png"),
                    target_size = (img_height, img_width),␣
 ↪color_mode='grayscale')

plt.imshow(test00755)
plt.show()
getTop3Similars(test00755)
```



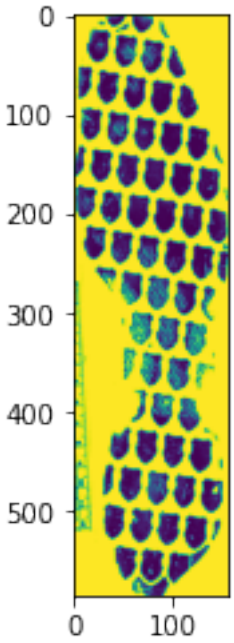

```
1/1 [==============================] - 0s 80ms/step
Most similar images
```



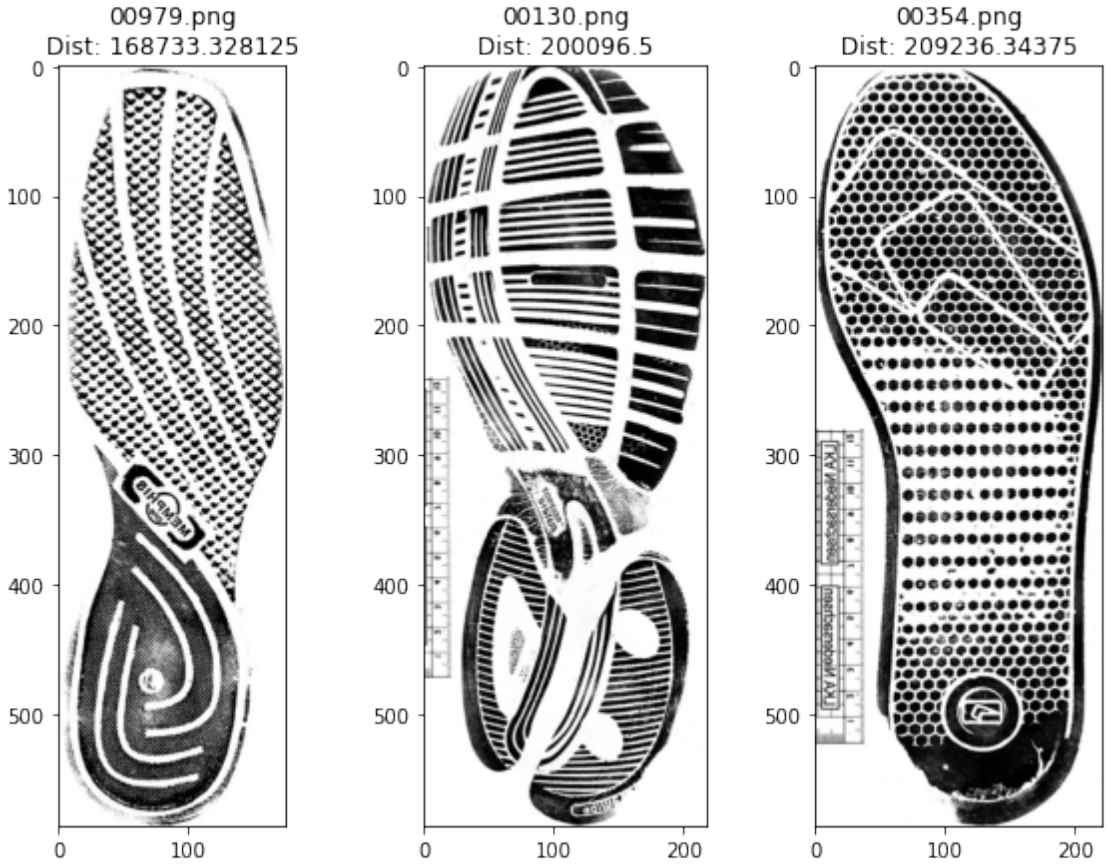
Less similar images



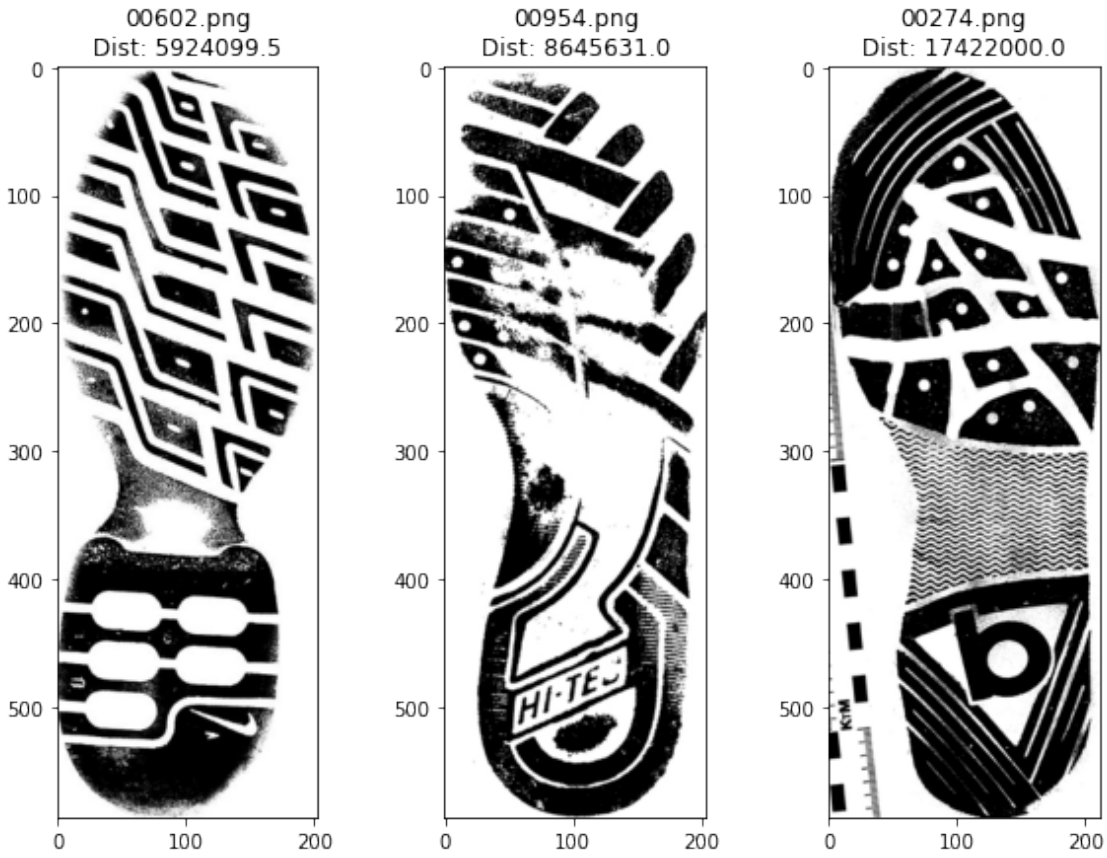
[64]:
```
#Test 00403.png

test00403= load_img('./fid300/references/{}'.format("00403.png"),
                    target_size = (img_height, img_width),␣
 ↪color_mode='grayscale')

plt.imshow(test00403)
plt.show()
getTop3Similars(test00403)
```



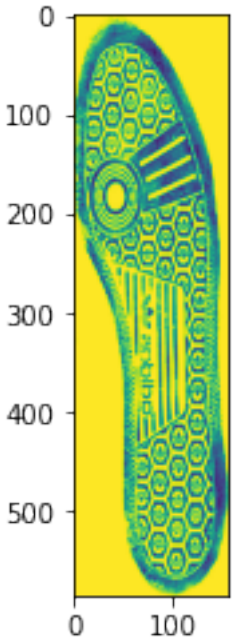

```
1/1 [==============================] - 0s 75ms/step
Most similar images
```



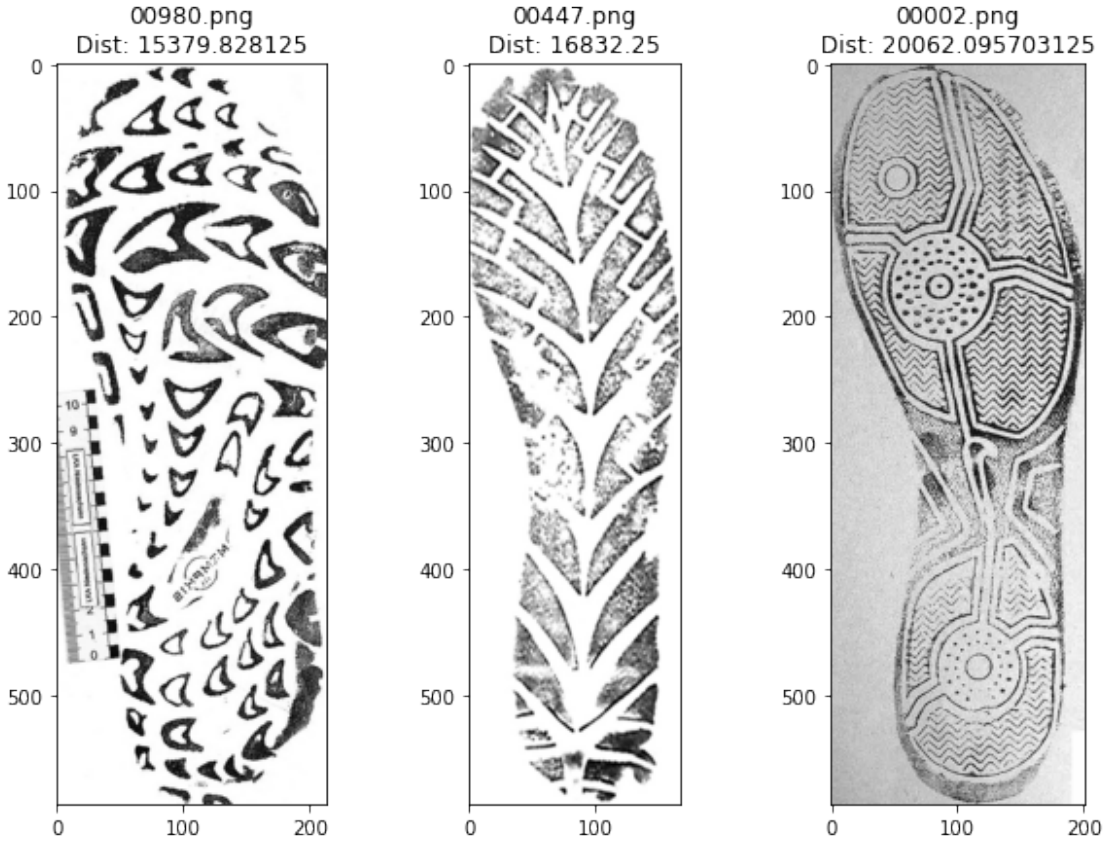
Less similar images



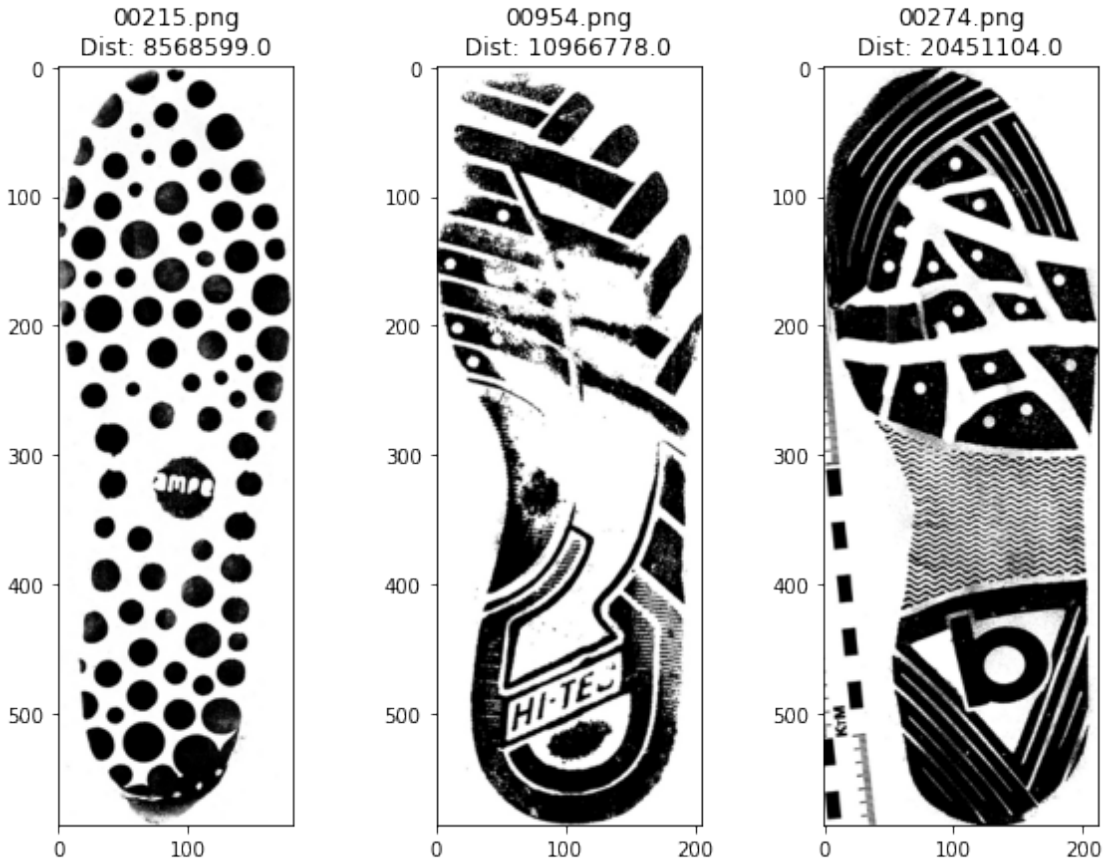
[65]:
```
#Test 00109.png

test00109= load_img('./fid300/references/{}'.format("00109.png"),
                    target_size = (img_height, img_width),␣
 ↪color_mode='grayscale')

plt.imshow(test00109)
plt.show()
getTop3Similars(test00109)
```



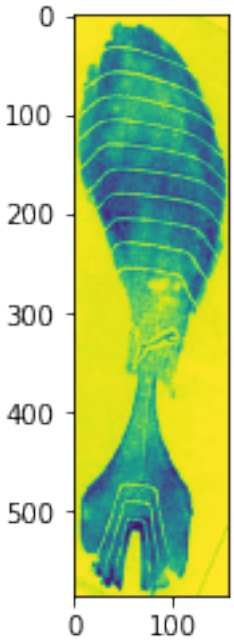

```
1/1 [==============================] - 0s 73ms/step
Most similar images
```



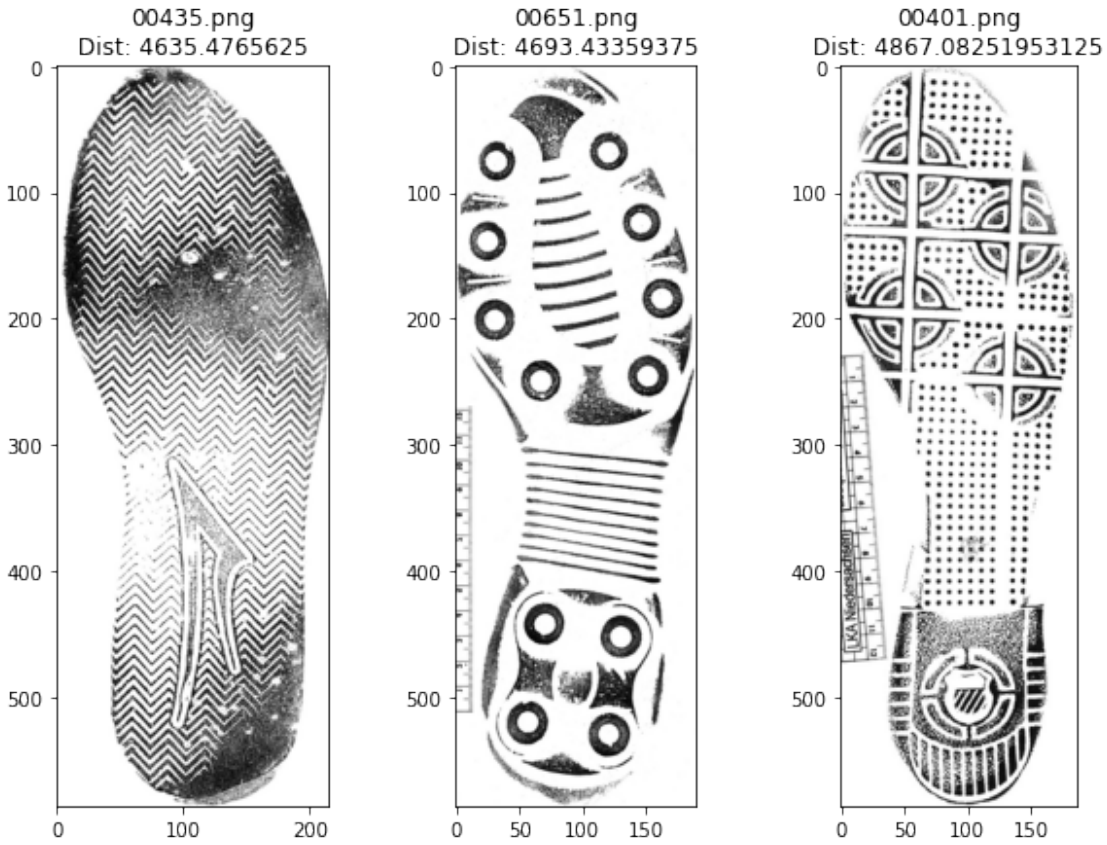
Less similar images



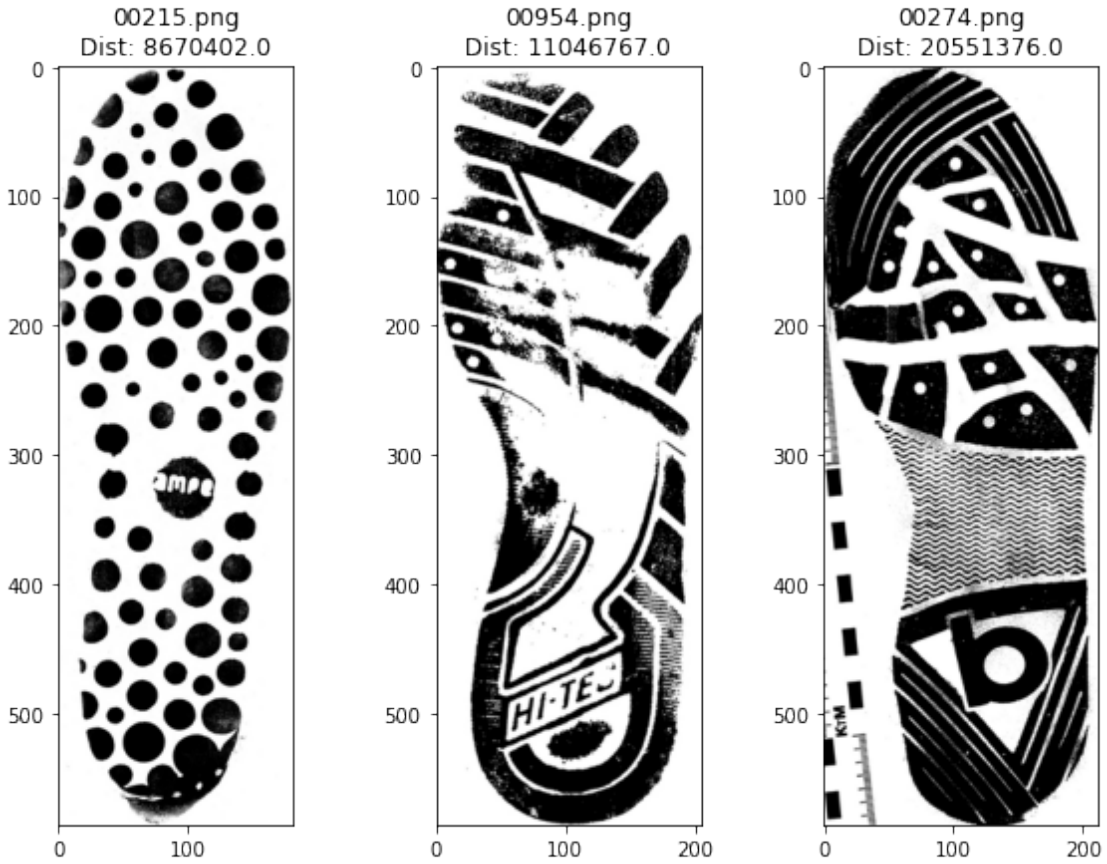
[66]:
```
#Test 00033.png
test00033= load_img('./fid300/references/{}'.format("00033.png"),
                    target_size = (img_height, img_width),␣
 ↪color_mode='grayscale')

plt.imshow(test00033)
plt.show()
getTop3Similars(test00033)
```



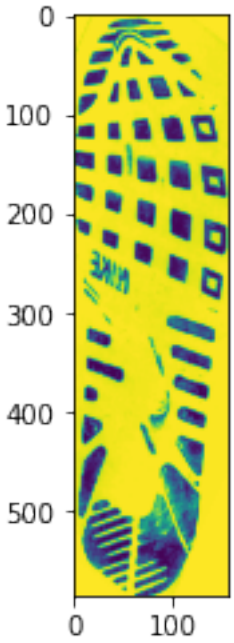

```
1/1 [==============================] - 0s 69ms/step
Most similar images
```



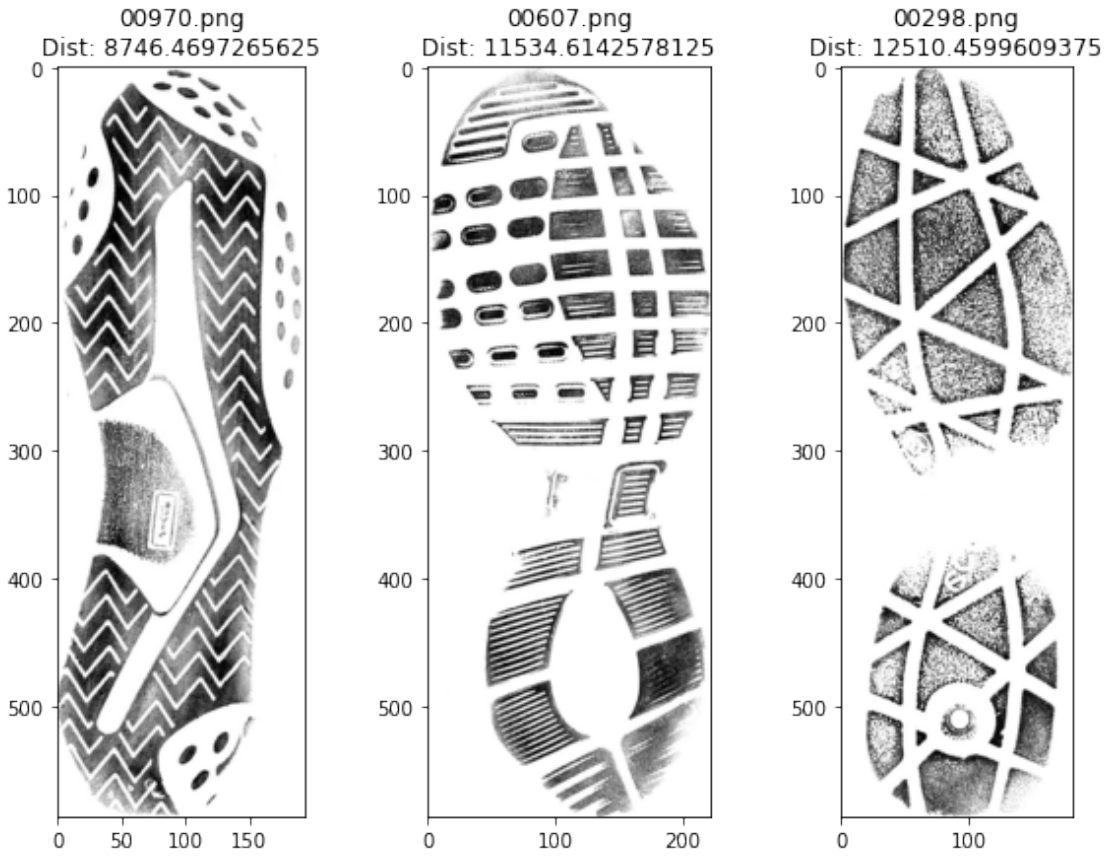
Less similar images



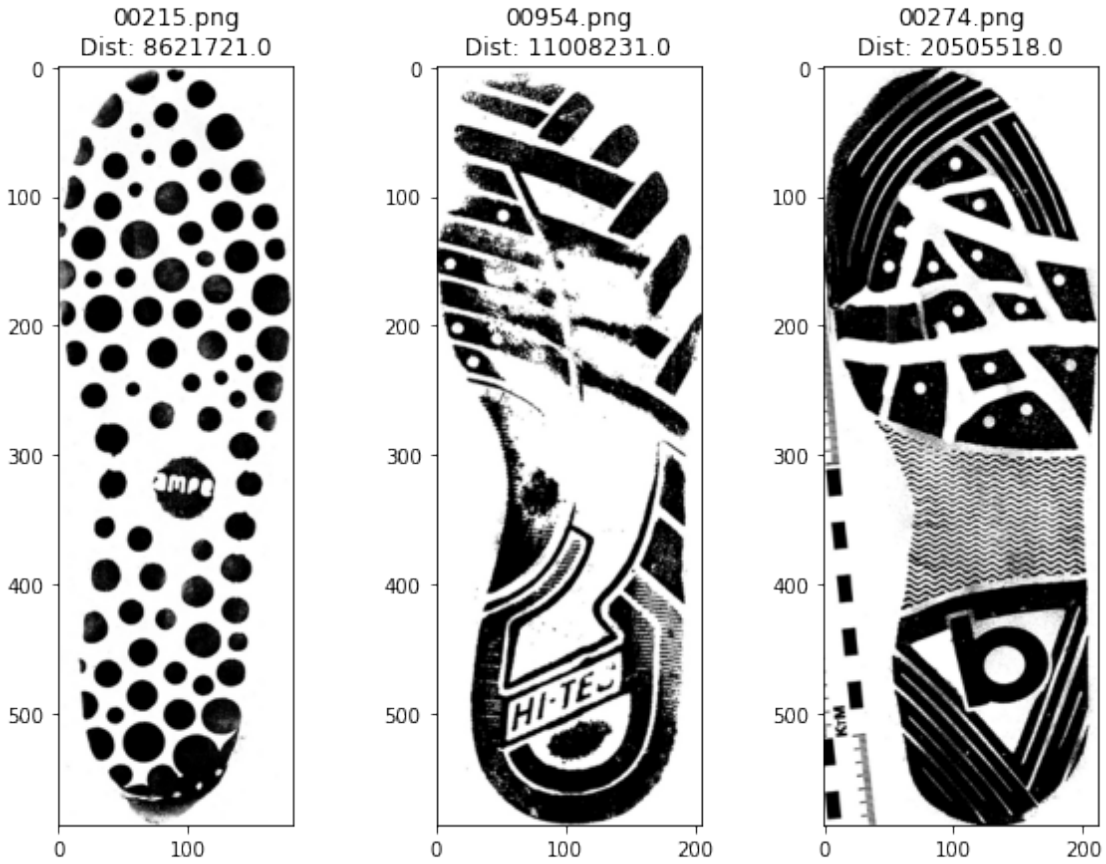
[67]:
```
#Test 00011.png
test00011= load_img('./fid300/references/{}'.format("00011.png"),
                    target_size = (img_height, img_width),␣
 ↪color_mode='grayscale')

plt.imshow(test00011)
plt.show()
getTop3Similars(test00011)
```




```
1/1 [==============================] - 0s 68ms/step
Most similar images
```



Less similar images

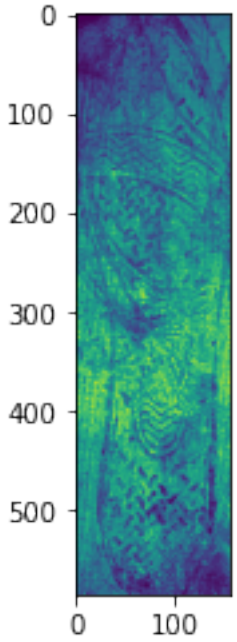


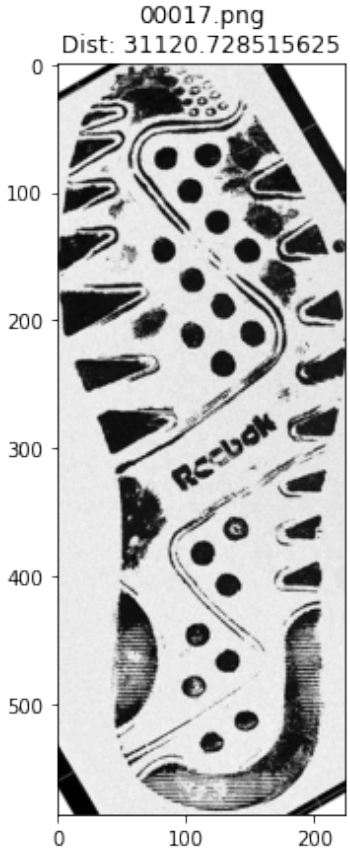
1.2.2 Experimentos con imágenes de huellas reales

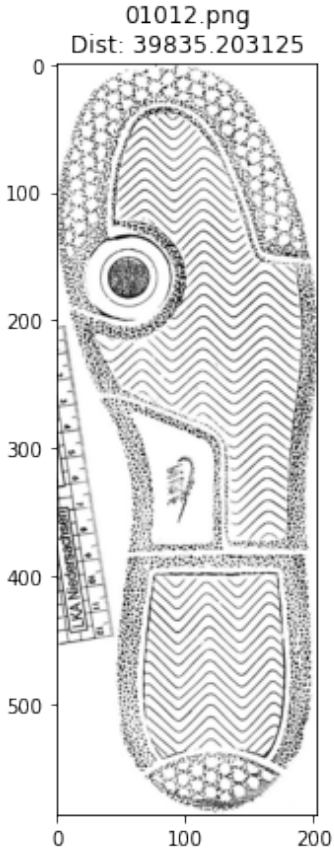
[73]:
```
import re
# Get image name
img_name = os.listdir('./fid300/tracks_cropped')[random.randint(0, 299)]
test2 = load_img('./fid300/tracks_cropped/{}'.format(img_name),
                 target_size = (img_height, img_width),␣
 ↪color_mode='grayscale')

plt.imshow(test2)
code = re.sub("^0+(?!$)","",img_name[0:5])

solution = df_fid300[df_fid300.X == int(code)]
print ("Testing image: "+ code + " Suggested solution: "+str(solution['y'].
 ↪iloc[0]))

getTop3Similars(test2)
```

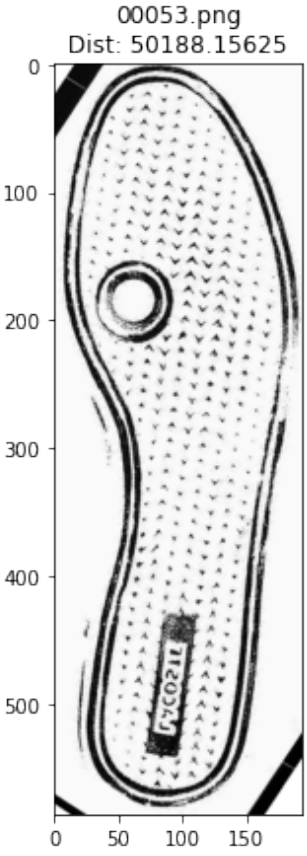
```
Testing image: 67 Suggested solution: 45
1/1 [==============================] - 0s 72ms/step
```

Most similar images

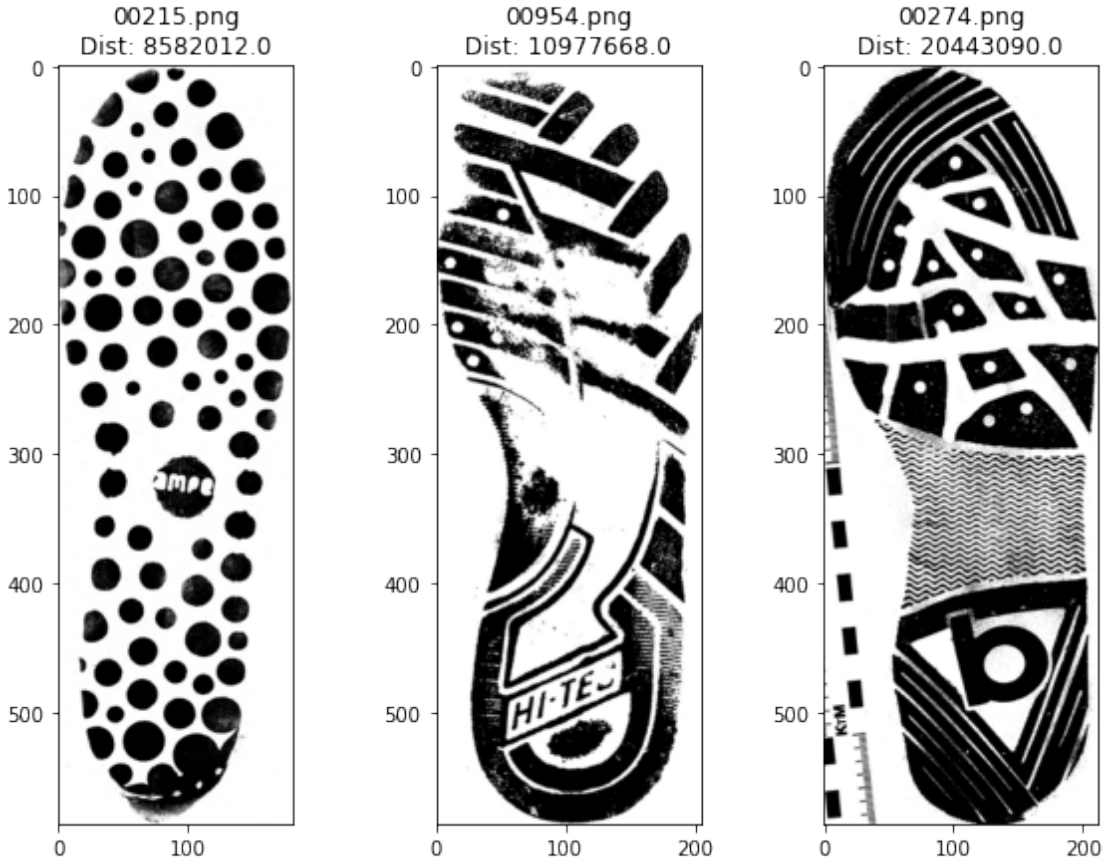




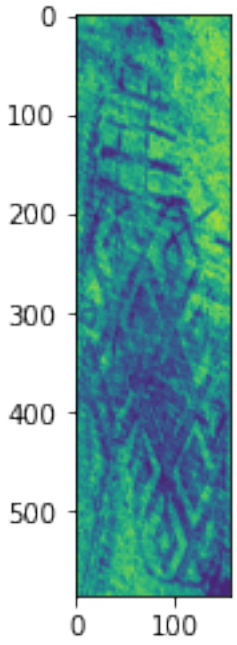




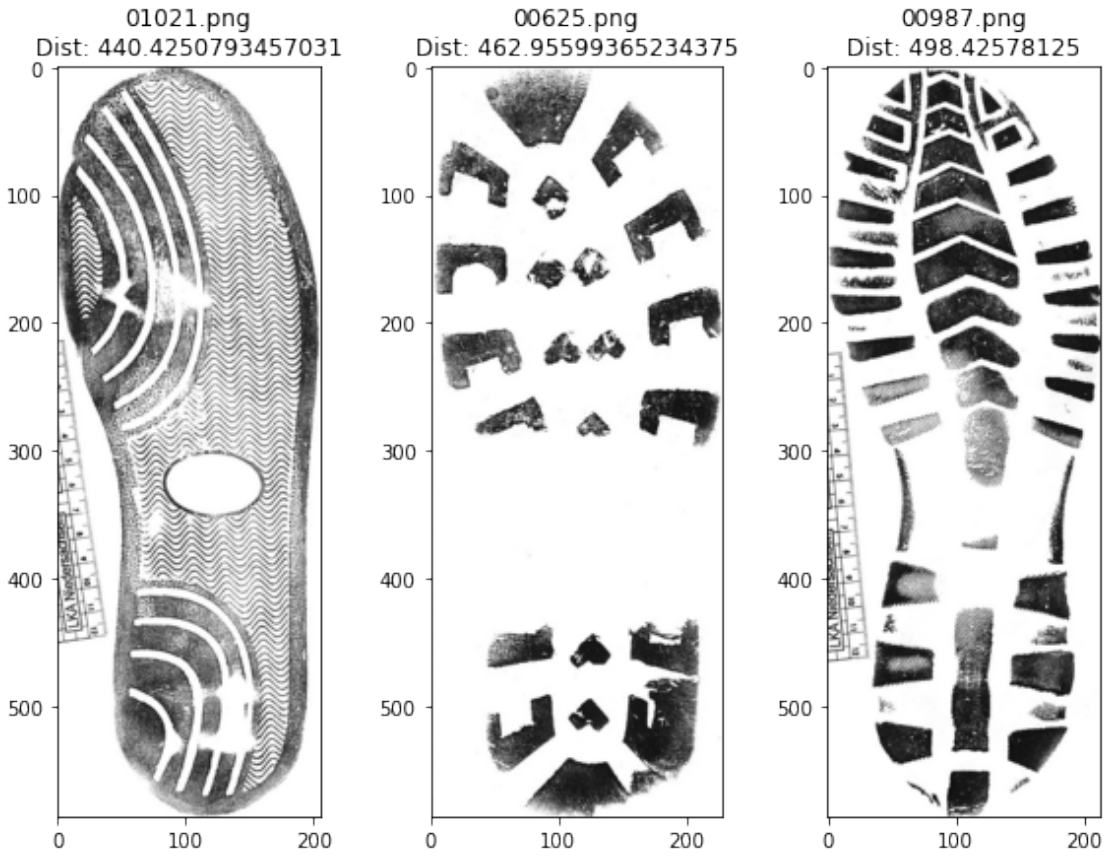
Less similar images



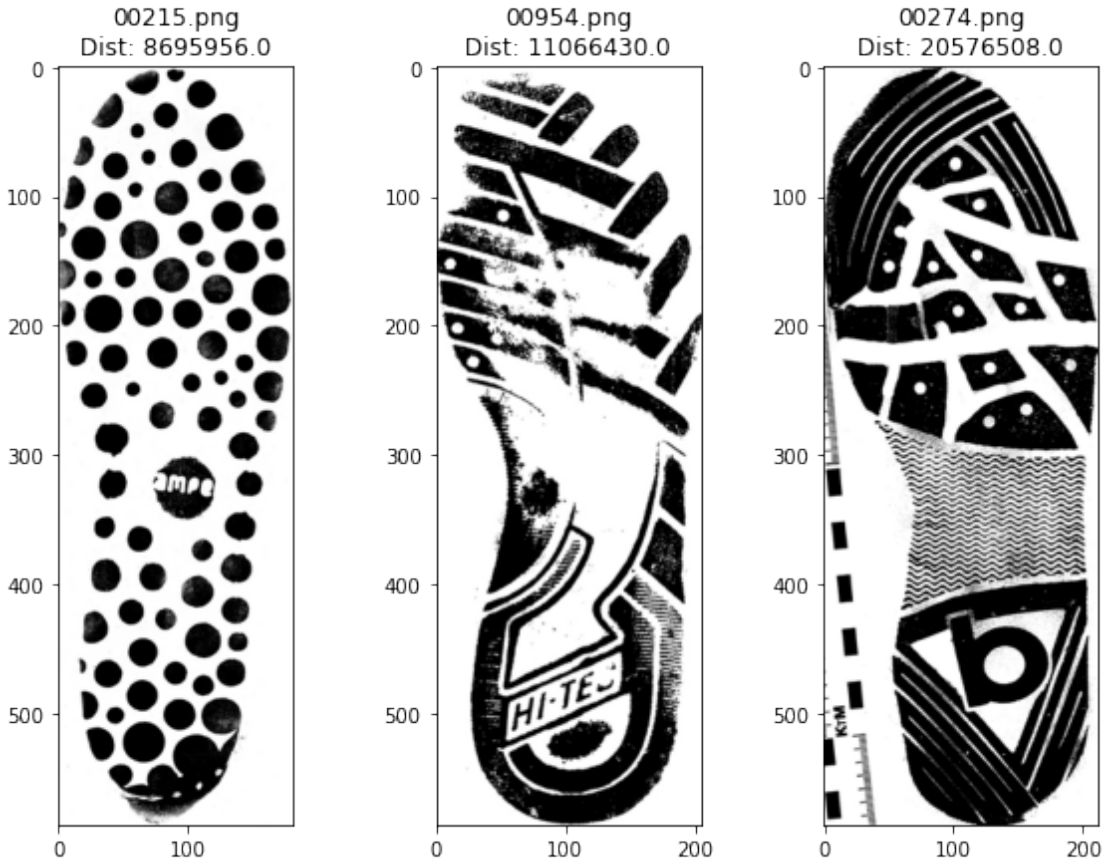
[69]:
```
#Test test0001 (converse)
test0001 = load_img('./fid300/tracks_cropped/{}'.format("00001.jpg"),
                    target_size = (img_height, img_width),␣
 ↪color_mode='grayscale')

plt.imshow(test0001)
plt.show()
getTop3Similars(test0001)
```



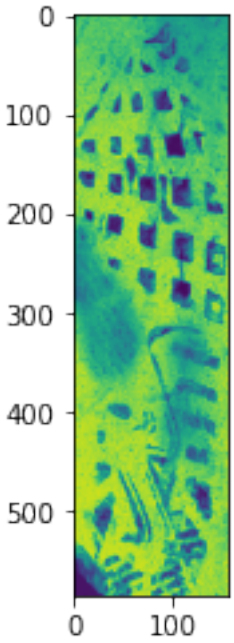

```
1/1 [==============================] - 0s 74ms/step
Most similar images
```



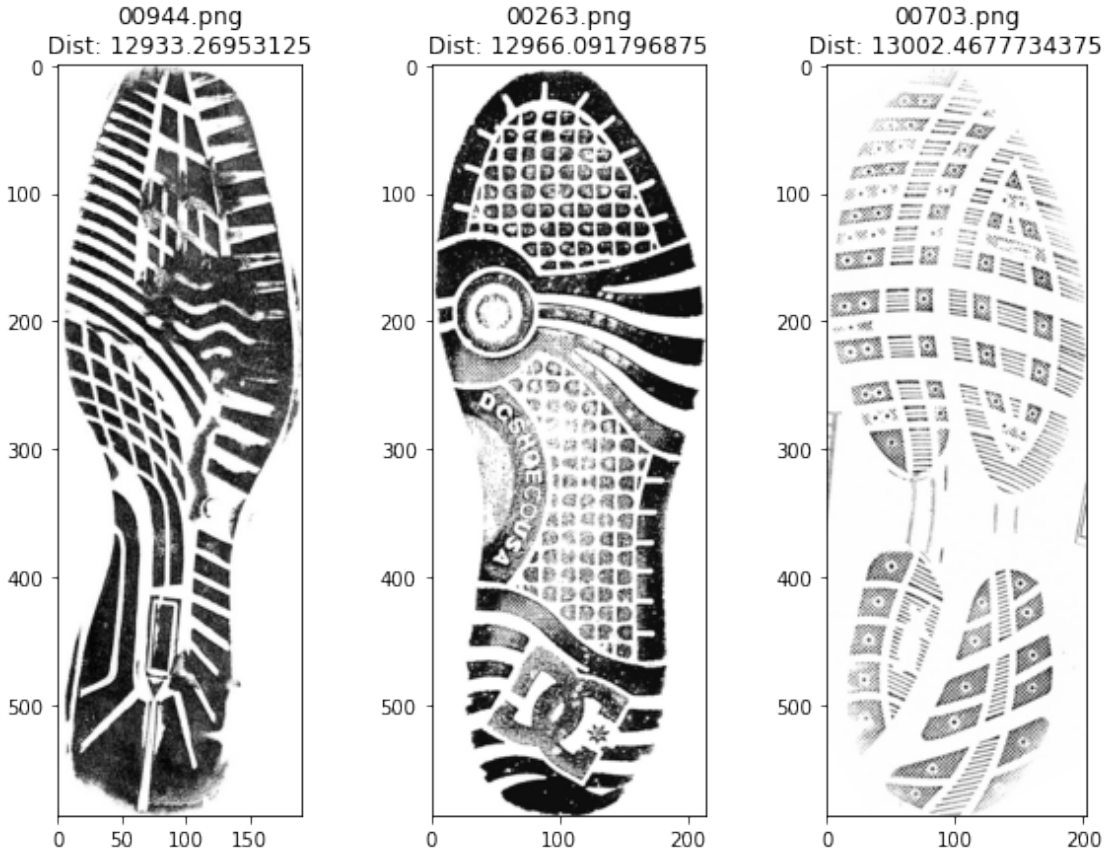
Less similar images



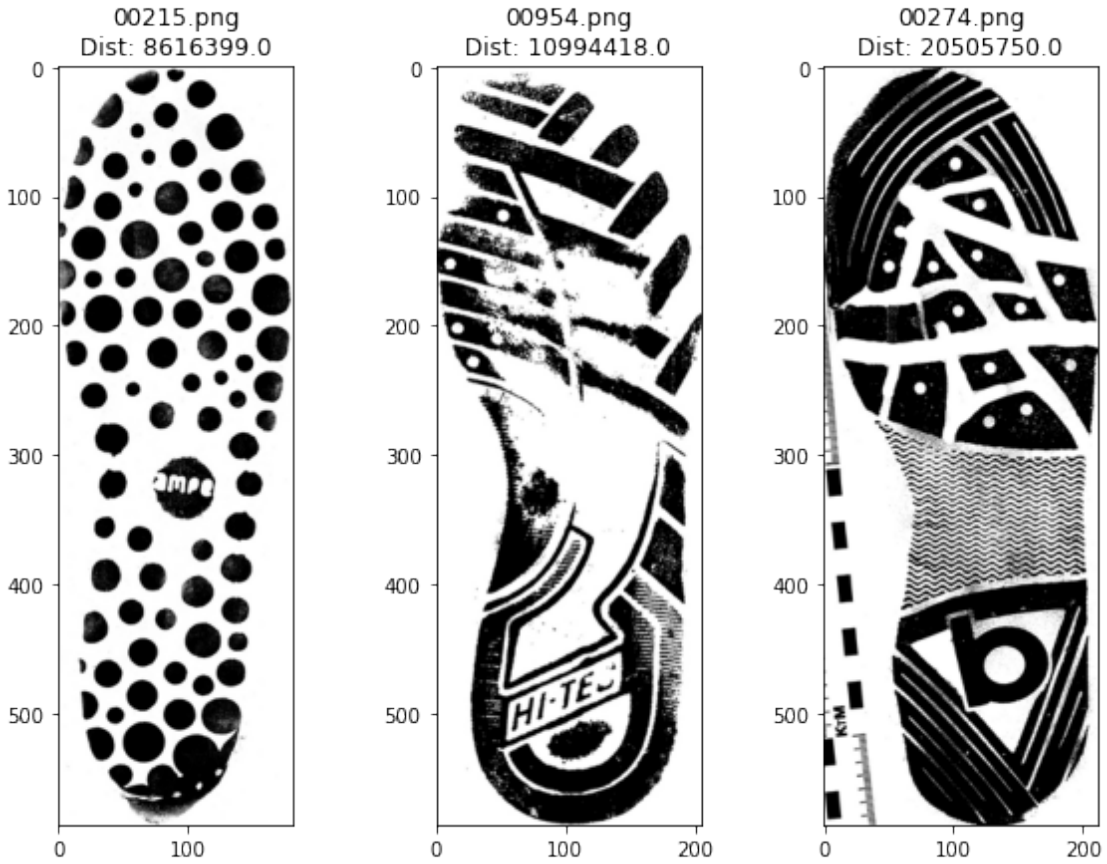
[70]:
```
#Test test0006 (huella entera)
test0006 = load_img('./fid300/tracks_cropped/{}'.format("00006.jpg"),
                    target_size = (img_height, img_width),␣
 ↪color_mode='grayscale')

plt.imshow(test0006)
plt.show()
getTop3Similars(test0006)
```



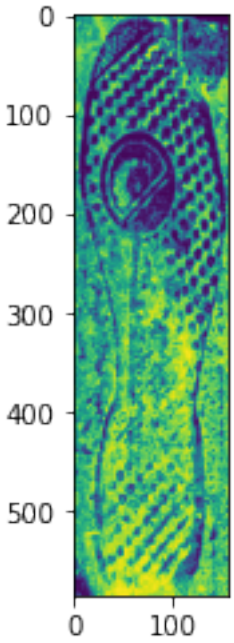

```
1/1 [==============================] - 0s 68ms/step
Most similar images
```



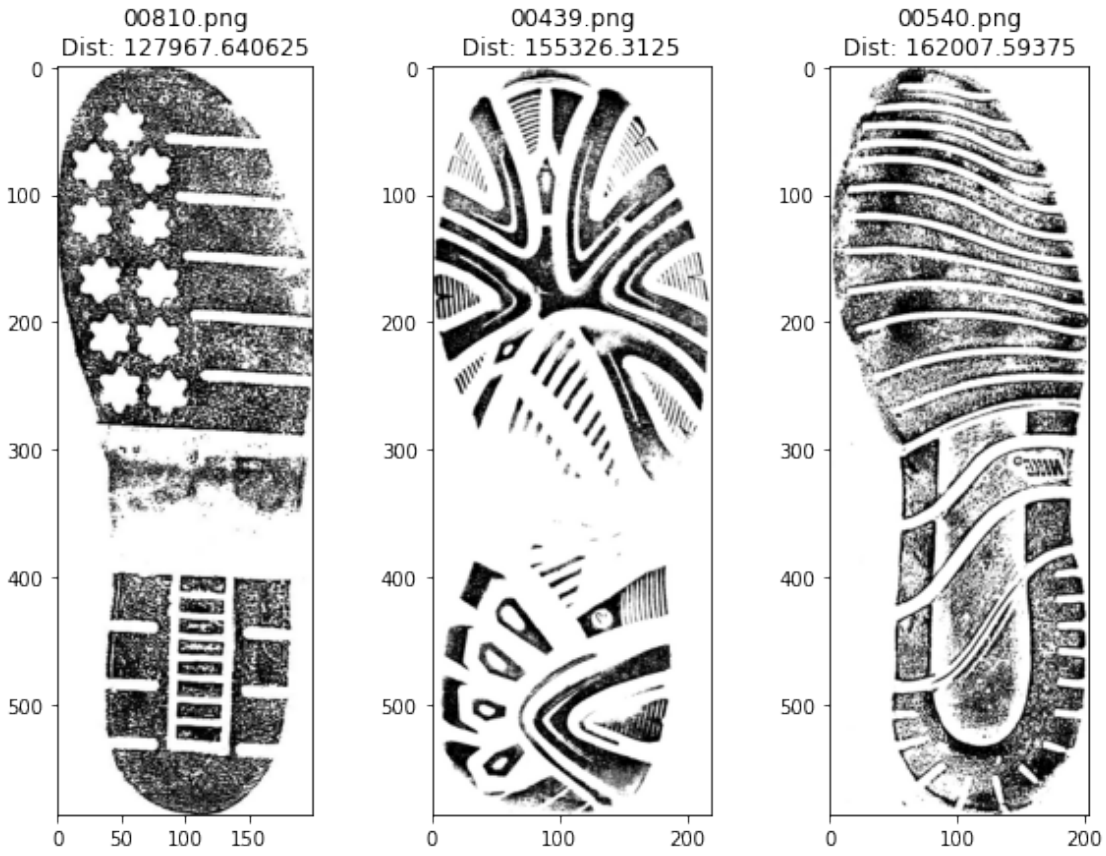
Less similar images



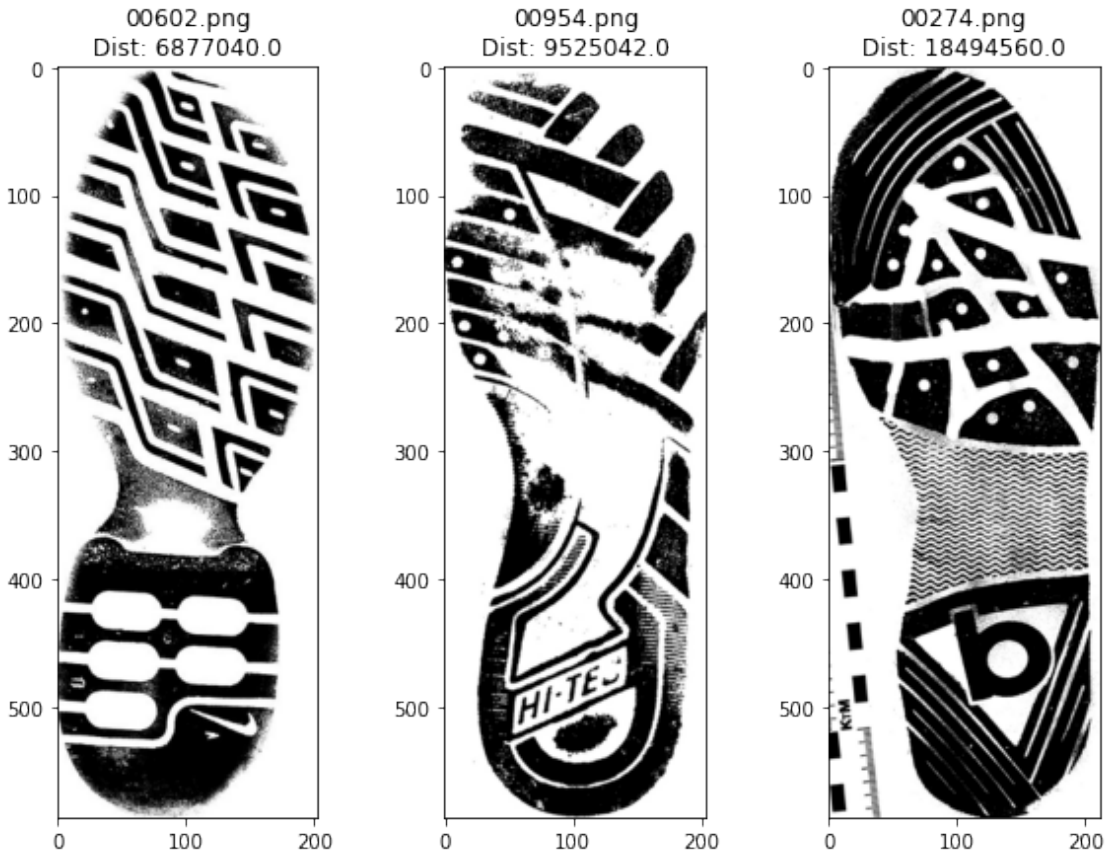
[71]:
```
#Test test0012 (huella entera)
test0012 = load_img('./fid300/tracks_cropped/{}'.format("00012.jpg"),
                    target_size = (img_height, img_width),␣
 ↪color_mode='grayscale')

plt.imshow(test0012)
plt.show()
getTop3Similars(test0012)
```



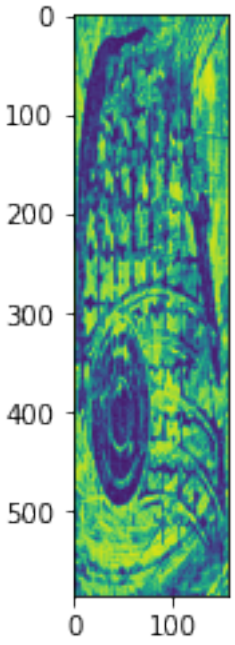

```
1/1 [==============================] - 0s 68ms/step
Most similar images
```



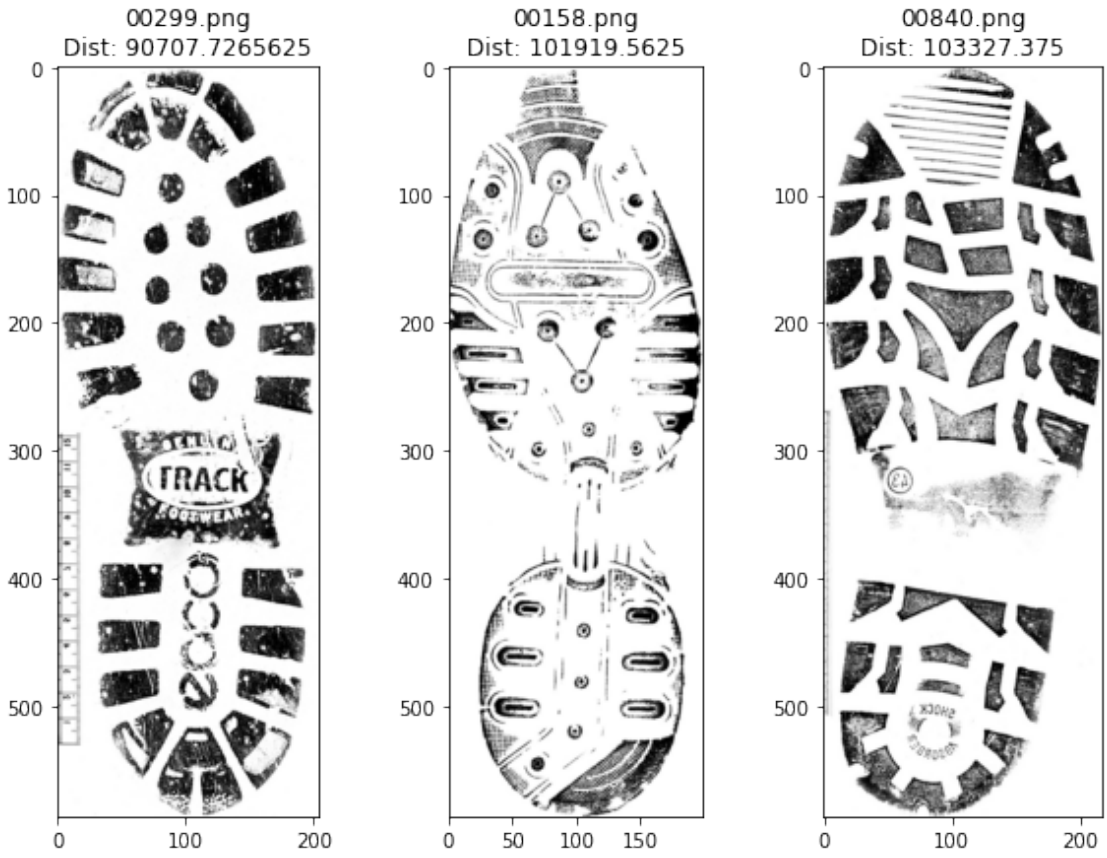
Less similar images



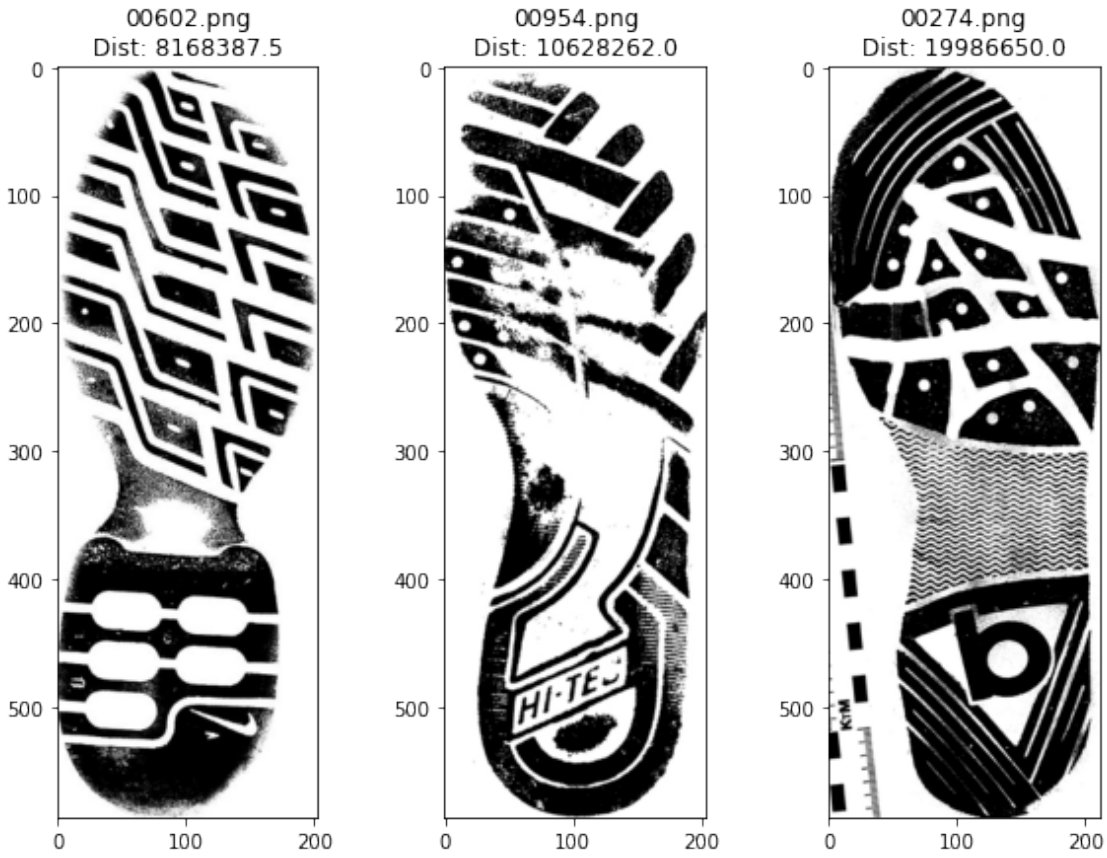
[72]:
```
#Test test0019 (huella mitad)
test0019 = load_img('./fid300/tracks_cropped/{}'.format("00019.jpg"),
                    target_size = (img_height, img_width),␣
 ↪color_mode='grayscale')

plt.imshow(test0019)
plt.show()
getTop3Similars(test0019)
```



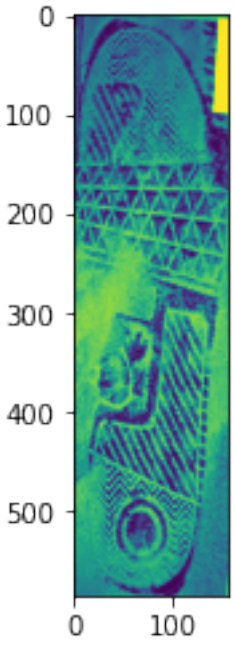

```
1/1 [==============================] - 0s 86ms/step
Most similar images
```



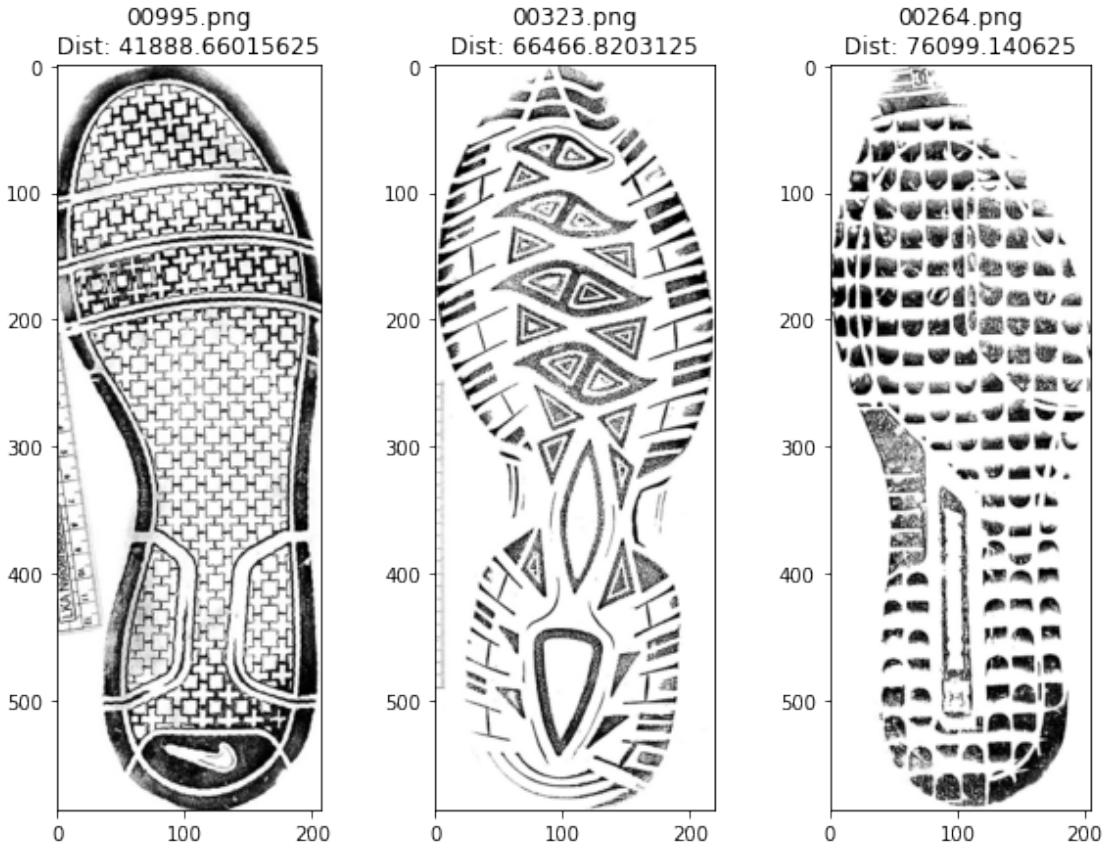
Less similar images



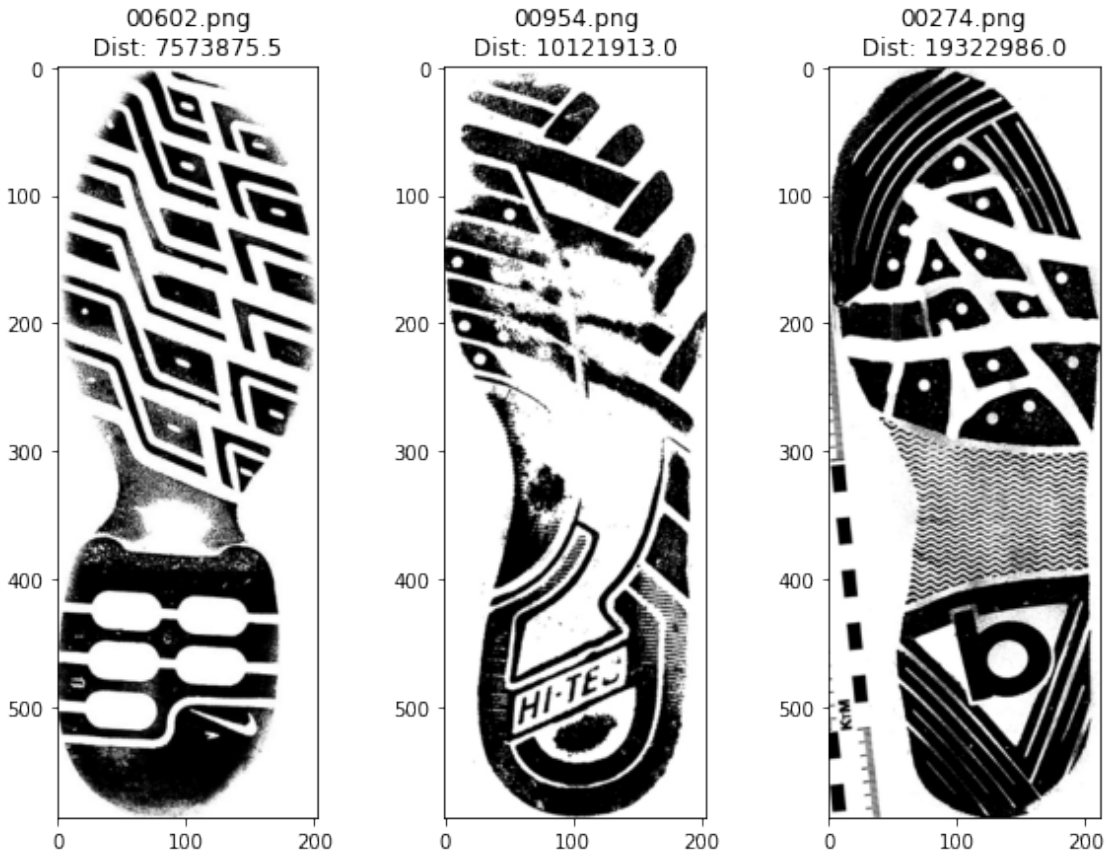
[74]:
```
#Test test0053 (huella más nítida)
test0053 = load_img('./fid300/tracks_cropped/{}'.format("00053.jpg"),
                    target_size = (img_height, img_width),␣
 ↪color_mode='grayscale')

plt.imshow(test0053)
plt.show()
getTop3Similars(test0053)
```



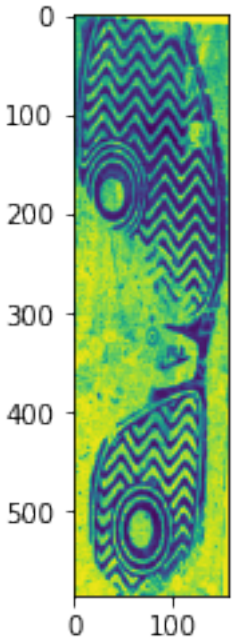

```
1/1 [==============================] - 0s 73ms/step
Most similar images
```



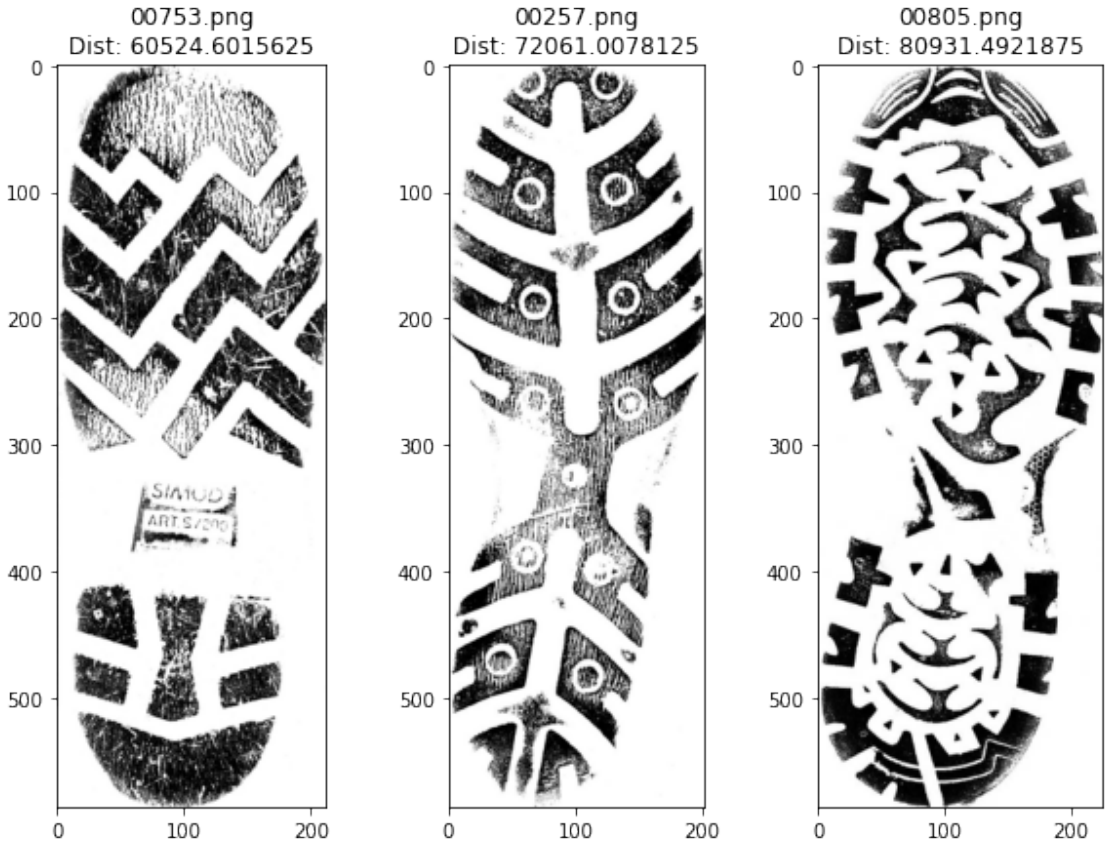
Less similar images



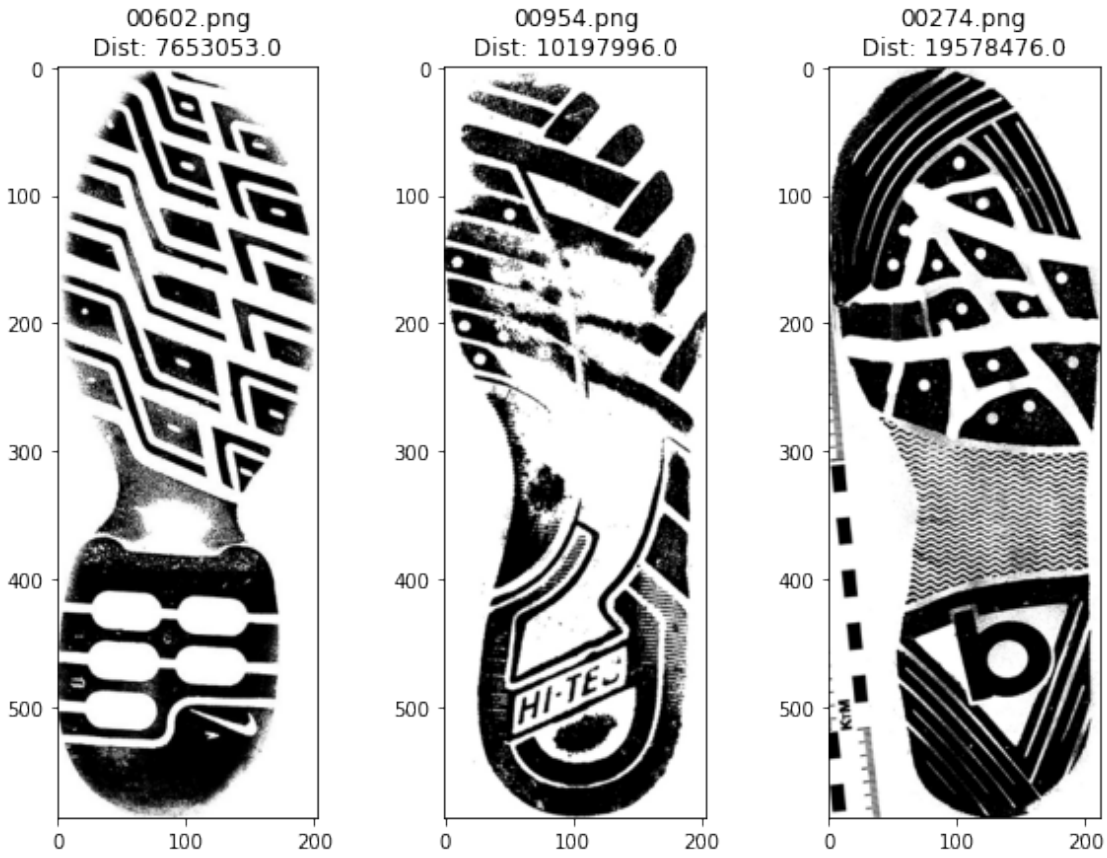
[76]:
```
#Test test0077 (huella nítida)
test0077 = load_img('./fid300/tracks_cropped/{}'.format("00077.jpg"),
                    target_size = (img_height, img_width),␣
 ↪color_mode='grayscale')

plt.imshow(test0077)
plt.show()
getTop3Similars(test0077)
```



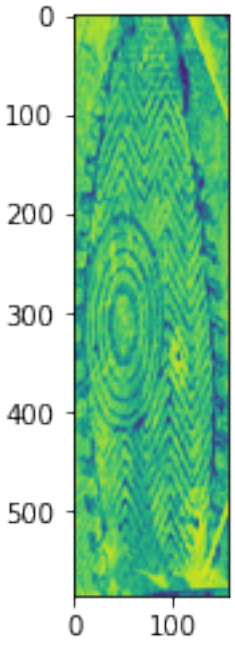

```
1/1 [==============================] - 0s 70ms/step
Most similar images
```



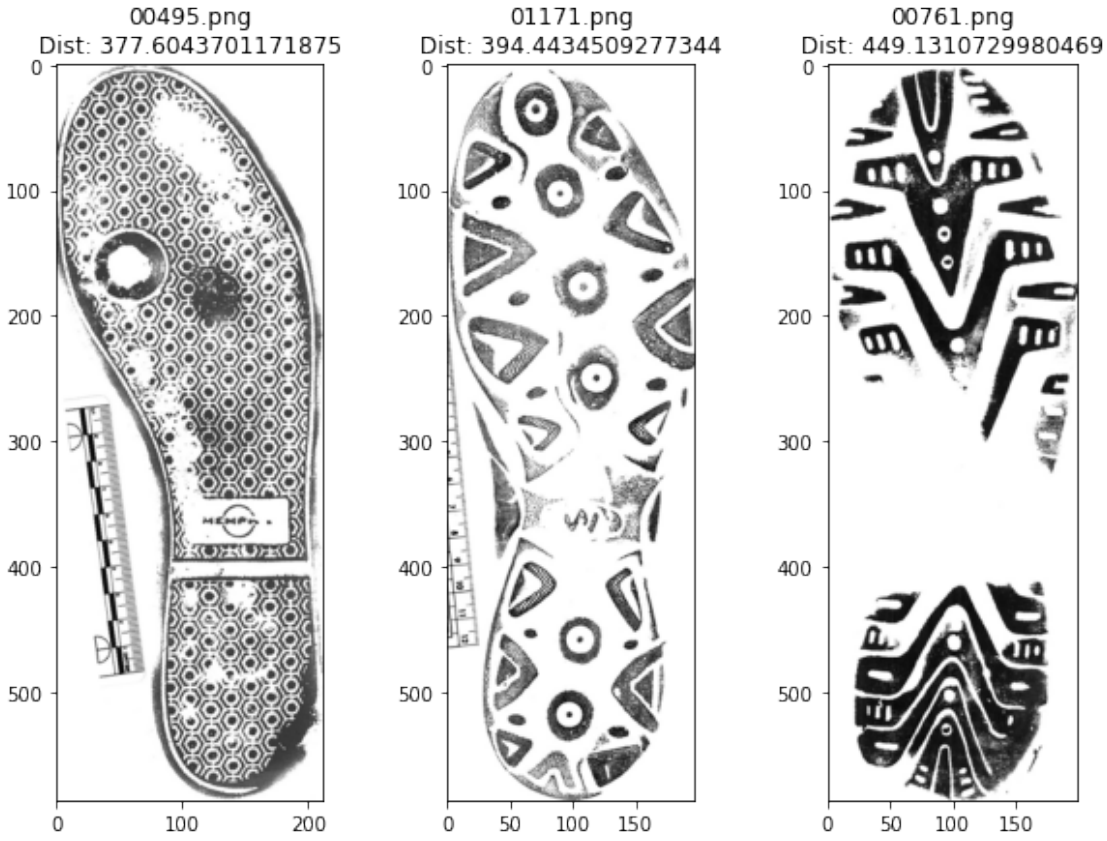
Less similar images



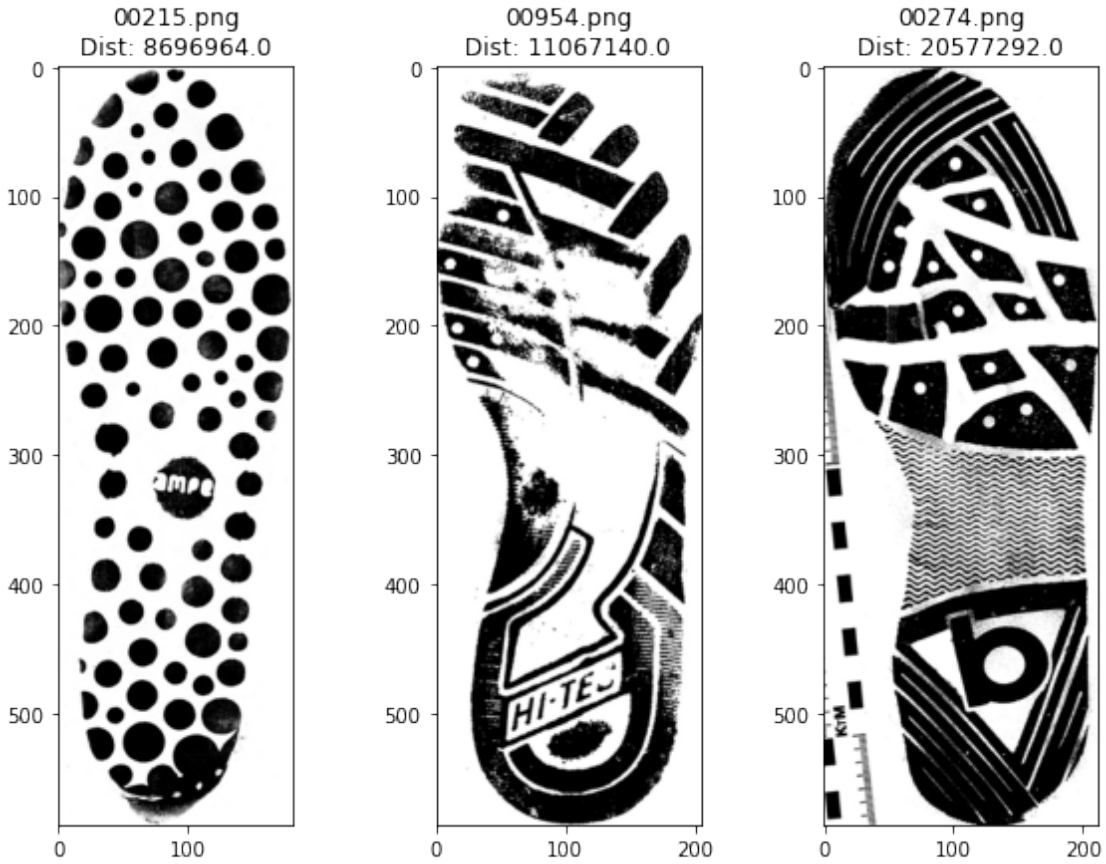
[80]:
```
#Test test0223 (huella media con un circulo)
test0223 = load_img('./fid300/tracks_cropped/{}'.format("00223.jpg"),
                    target_size = (img_height, img_width),␣
 ↪color_mode='grayscale')

plt.imshow(test0223)
plt.show()
getTop3Similars(test0223)
```




```
1/1 [==============================] - 0s 79ms/step
Most similar images
```



Less similar images



2 Analisis de resultados

En los experimentos con imágenes de referencia, se puede ver cómo en muchos de ellos las 3 imágenes más similares comparten alguna similitud. En cambio, en el caso de las menos similares, suelen aparecer las mismas en la mayoría de los casos (aunque mediante observación y bajo una representación subjetiva, no sean las menos parecidas).

Por último, en los experimentos con imágenes de huellas reales, en el caso de huellas enteras se puede observar alguna similitud como en *test0077*, pero en el caso de huellas parciales no, ya que en el caso del *test0223* se podría considerar aceptable ya que la huella más parecida contiene también un circulo a la izquierda, pero en otros casos, como en *test0001* o *test0019*, no obtiene un resultado satisfactorio.

Este cuaderno y modelo se ha creado como un ejercicio para aprender a crear y comprender una red siamesa, pero necesitaría más trabajo para que la búsqueda no fuera de la imágen entera, sino de fragmentos para mejorar la experiencia con huellas parciales ya que el modelo actual trata el fragmento como una huella entera.

[ ]: