1.

In [1]:
```
import matplotlib
import matplotlib.pyplot as plt
import matplotlib.image as mpimg
import pandas as pd
import numpy as np
import scipy as sp
import cv2
import os
import sys
#suppress warnings for cleanliness
import warnings
warnings.filterwarnings('ignore')
```

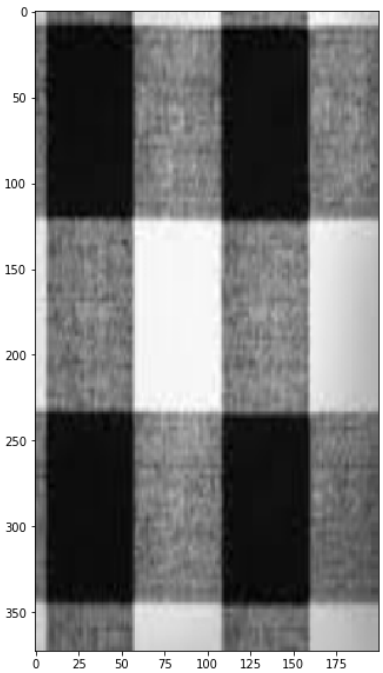
executed in 709ms, finished 18:22:09 2019-04-20

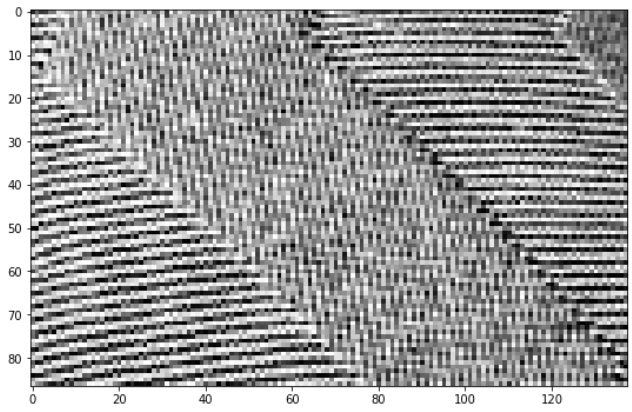
In [67]:
```
flower = "texture2.jpg"
leaf   = "texture1.jpg"

imgtex1 = cv2.imread(flower)
imgtex2 = cv2.imread(leaf)
imgtex1 = cv2.cvtColor(imgtex1, cv2.COLOR_BGR2GRAY)
imgtex2 = cv2.cvtColor(imgtex2, cv2.COLOR_BGR2GRAY)
imgtex1 = cv2.resize(imgtex1, (200,373))
plt.figure(figsize=(20,10))
plt.subplot(121)
plt.imshow(imgtex1, cmap="gray")
plt.subplot(122)
plt.imshow(imgtex2, cmap="gray")
```

executed in 317ms, finished 19:07:25 2019-04-20

Out[67]:
```
<matplotlib.image.AxesImage at 0x127024550>
```





In [68]:
```
#blur
blurred1 = cv2.GaussianBlur(imgtex1, (5,5), 1.5)
blurred2 = cv2.GaussianBlur(imgtex2, (5,5), 1.5)
```

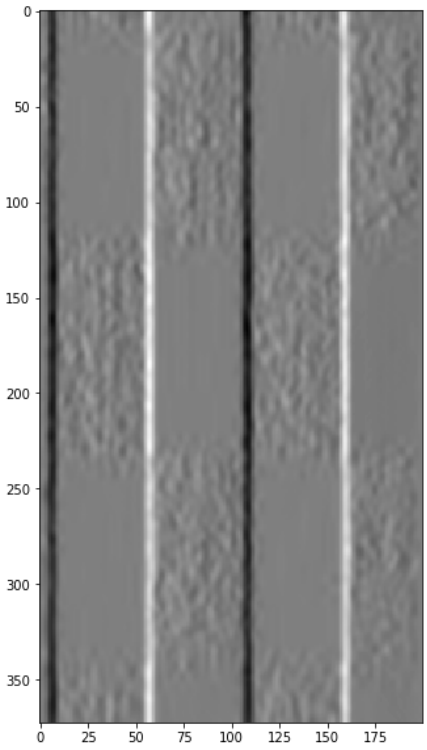
executed in 3ms, finished 19:07:27 2019-04-20

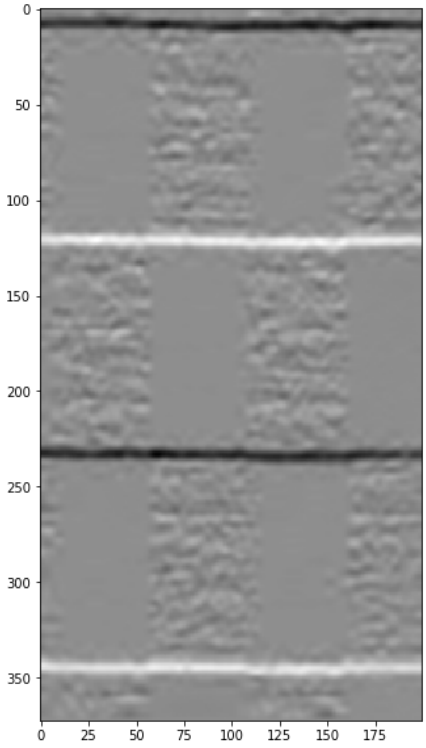
In [69]:
```
sobelx = cv2.Sobel(blurred1,cv2.CV_64F,1,0,ksize=5)
sobely = cv2.Sobel(blurred1,cv2.CV_64F,0,1,ksize=5)

plt.figure(figsize=(20,10))
plt.subplot(121)
plt.imshow(sobelx, cmap="gray")
plt.subplot(122)
plt.imshow(sobely, cmap="gray")
```

executed in 336ms, finished 19:07:30 2019-04-20

Out[69]:
```
<matplotlib.image.AxesImage at 0x1270aeac8>
```





In [70]:
```
shape = sobelx.shape + (2,)
A_1 = np.zeros(shape)

for i in range(shape[0]):
    for j in range(shape[1]):
        A_1[i][j][0]=sobelx[i][j]
        A_1[i][j][1]=sobely[i][j]
```

executed in 97ms, finished 19:07:33 2019-04-20

In [71]:
```
shape = sobelx.shape + (2,2)
B_1 = np.zeros(shape)
for i in range(shape[0]):
    for j in range(shape[1]):
        B_1[i][j] = np.matmul(A_1[i][j], A_1[i][j].T)

def avg(matrix, i, j):
    C = np.zeros((2,2))
    counter = 0
    for i in range(max(i-2, 0), min(i+2, matrix.shape[0]-1)):
        for j in range(max(j-2, 0), min(j+2, matrix.shape[1]-1)):
#             print(i, j)
            C = C + matrix[i][j]
            counter = counter + 1
    C = C/counter
    return C

N = np.zeros(shape)
for i in range(N.shape[0]):
    for j in range(N.shape[1]):
        N[i][j] = avg(B_1, i, j)

D = []
for i in range(N.shape[0]):
    for j in range(N.shape[1]):
        D.append(N[i][j])
```

executed in 1.46s, finished 19:07:35 2019-04-20

In [ ]:

In [81]:
```
#defining loss functions
from scipy import linalg
def forb_loss(mat1, mat2):
    diff = mat1 - mat2
    A = np.square(diff)
    return np.sqrt(np.sum(A))

def max_col_sums(mat1, mat2):
    diff = mat1-mat2
    diff = np.absolute(diff)
    maxcol = 0
    for i in range(diff.shape[1]):
        colsum = diff.sum(axis=0)
        if np.sum(colsum) > maxcol:
            maxcol = np.sum(colsum)
    return maxcol

def stein_loss(mat1, mat2):
    d = 10000
    try:
        choleskyA = np.linalg.cholesky(np.absolute(mat1) + np.identity(2))
        choleskyB = np.linalg.cholesky(np.absolute(mat2) + np.identity(2))
        choleskyAB = np.linalg.cholesky(np.absolute((mat1 + mat2)/2) + np.i
        d = 2* np.log(np.linalg.det(choleskyAB)) - np.log(np.linalg.det(cho
        return d
    except:
        return d
```

executed in 8ms, finished 19:16:43 2019-04-20

In [ ]:

In [51]:
```
#My own k means

import random

metrics = [forb_loss, max_col_sums, stein_loss]
clusters_imgs = [np.zeros(imgtex1.shape), np.zeros(imgtex1.shape), np.zeros
clusters = 2
iterations = 5

def color(cluster_count, k):
    return 250 * k/cluster_count

def recompute(cluster_centers, cluster_members):

    cont = 0
    for group in cluster_members:
        craw = np.zeros((2,2))
        counter = 0
        for item in group:
            craw = item + craw
            counter = counter + 1
        craw = craw/counter
        cluster_centers[cont] = craw
        cont = cont + 1
    return cluster_centers

clus_count = 0
for metric in metrics:
    #init
    cluster_centers = []
    cluster_centers_size = np.ones(clusters)
    cluster_members = np.empty((clusters, 0)).tolist()

    for k in range(clusters):
        i_rand = random.randint(0, imgtex1.shape[0])
        j_rand = random.randint(0, imgtex1.shape[1])
        cluster_centers.append(N[i_rand][j_rand])
        cluster_members[k].append(N[i_rand][j_rand])
    for it in range(iterations):
        for i in range(N.shape[0]):
            #starting iteration
            for j in range(N.shape[1]):
                shortest = 0
                short_dist = 1073741823
                for k in range(len(cluster_centers)):
                    d = metric(N[i][j], cluster_centers[k])
                    if d <= short_dist:
                        shortest = k
                        short_dist = d
                clusters_imgs[clus_count][i][j] = color(clusters, shortest)
                cluster_members[shortest].append(N[i][j])
            #recompute means after iteration
            cluster_centers = recompute(cluster_centers, cluster_members)
            cluster_members = np.empty((clusters, 0)).tolist()
    clus_count = clus_count + 1
```

```
print("Clustering for forbloss finished")
```

executed in 1m 4.02s, finished 18:59:43 2019-04-20

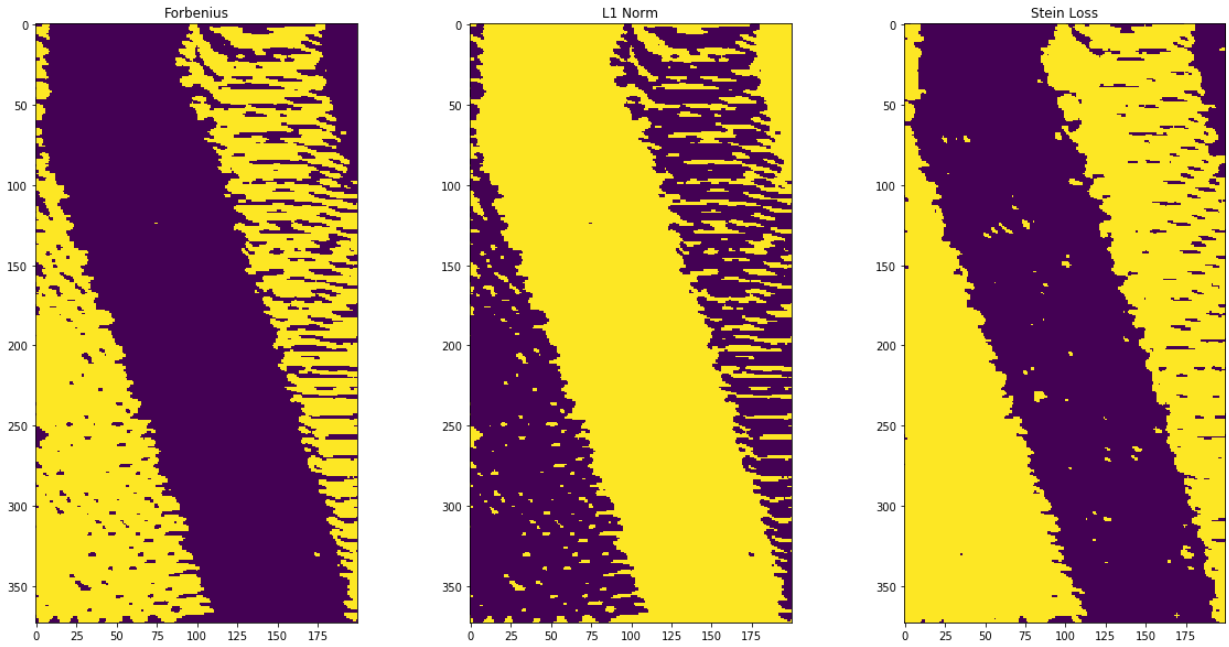
```
17 55
253 21
Cluster center shape (2, 2, 2)
40 127
190 130
Cluster center shape (2, 2, 2)
237 165
258 45
Cluster center shape (2, 2, 2)
Clustering for forbloss finished
```

In [53]:
```
print("Iterations = ", iterations)
print("Clusters = ", clusters)
plt.figure(figsize=(20,10))
plt.subplot(131)
plt.imshow(clusters_imgs[0])
plt.title("Forbenius")
plt.subplot(132)
plt.imshow(clusters_imgs[1])
plt.title("L1 Norm")
plt.subplot(133)
plt.imshow(clusters_imgs[2])
plt.title("Stein Loss")
```

executed in 410ms, finished 19:00:13 2019-04-20

```
Iterations =  5
Clusters =  2
```

Out[53]:
```
Text(0.5, 1.0, 'Stein Loss')
```



In [65]:
```
metrics = [forb_loss, max_col_sums, stein_loss]
clusters_imgs = [np.zeros(imgtex1.shape), np.zeros(imgtex1.shape), np.zeros
clusters = 3
iterations = 5
clus_count = 0
for metric in metrics:
    #init
    cluster_centers = []
    cluster_centers_size = np.ones(clusters)
    cluster_members = np.empty((clusters, 0)).tolist()

    for k in range(clusters):
        i_rand = random.randint(0, imgtex1.shape[0])
        j_rand = random.randint(0, imgtex1.shape[1])
        cluster_centers.append(N[i_rand][j_rand])
        cluster_members[k].append(N[i_rand][j_rand])
    for it in range(iterations):
        for i in range(N.shape[0]):
            #starting iteration
            for j in range(N.shape[1]):
                shortest = 0
                short_dist = 1073741823
                for k in range(len(cluster_centers)):
                    d = metric(N[i][j], cluster_centers[k])
                    if d <= short_dist:
                        shortest = k
                        short_dist = d
                clusters_imgs[clus_count][i][j] = color(clusters, shortest)
                cluster_members[shortest].append(N[i][j])
            #recompute means after iteration
            cluster_centers = recompute(cluster_centers, cluster_members)
            cluster_members = np.empty((clusters, 0)).tolist()
    clus_count = clus_count + 1

print("Clustering for forbloss finished")
```

executed in 1m 36.9s, finished 19:05:09 2019-04-20

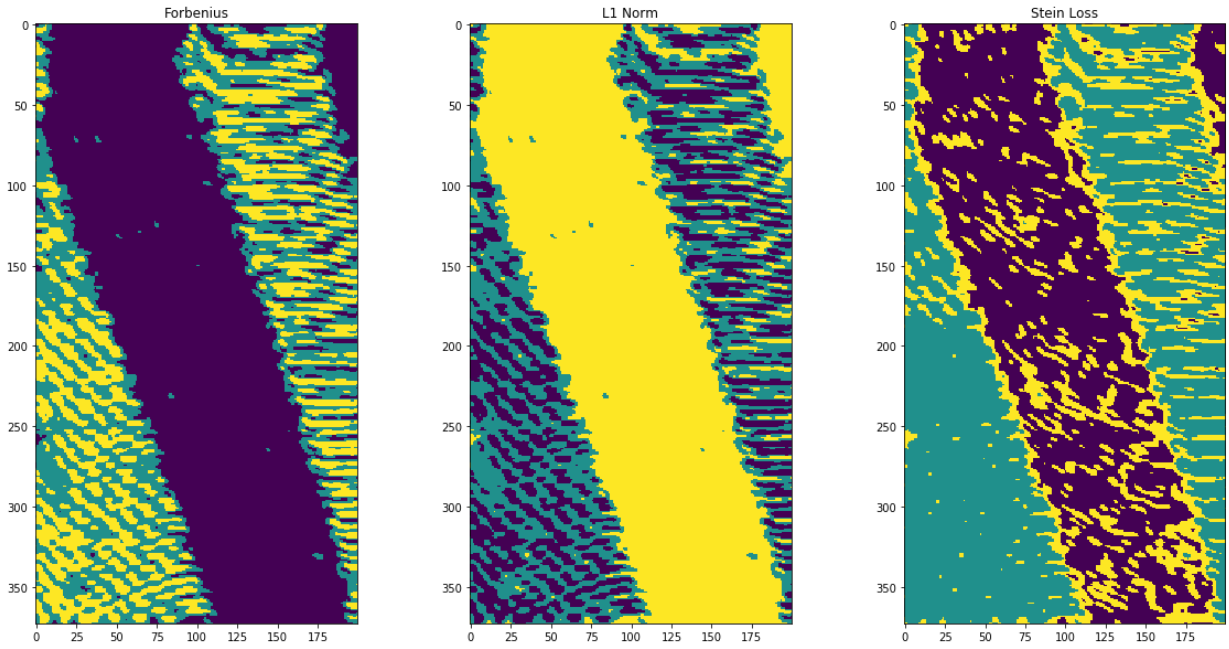
```
Clustering for forbloss finished
```

In [66]:
```
print("Iterations = ", iterations)
print("Clusters = ", clusters)
plt.figure(figsize=(20,10))
plt.subplot(131)
plt.imshow(clusters_imgs[0])
plt.title("Forbenius")
plt.subplot(132)
plt.imshow(clusters_imgs[1])
plt.title("L1 Norm")
plt.subplot(133)
plt.imshow(clusters_imgs[2])
plt.title("Stein Loss")
```

executed in 565ms, finished 19:05:09 2019-04-20

```
Iterations =  5
Clusters =  3
```

Out[66]: Text(0.5, 1.0, 'Stein Loss')



In [82]:
```
metrics = [forb_loss, max_col_sums, stein_loss]
clusters_imgs = [np.zeros(imgtex1.shape), np.zeros(imgtex1.shape), np.zeros
clusters = 2
iterations = 5
clus_count = 0
for metric in metrics:
    #init
    cluster_centers = []
    cluster_centers_size = np.ones(clusters)
    cluster_members = np.empty((clusters, 0)).tolist()

    for k in range(clusters):
        i_rand = random.randint(0, imgtex1.shape[0])
        j_rand = random.randint(0, imgtex1.shape[1])
        cluster_centers.append(N[i_rand][j_rand])
        cluster_members[k].append(N[i_rand][j_rand])
    for it in range(iterations):
        for i in range(N.shape[0]):
            #starting iteration
            for j in range(N.shape[1]):
                shortest = 0
                short_dist = 1073741823
                for k in range(len(cluster_centers)):
                    d = metric(N[i][j], cluster_centers[k])
                    if d <= short_dist:
                        shortest = k
                        short_dist = d
                clusters_imgs[clus_count][i][j] = color(clusters, shortest)
                cluster_members[shortest].append(N[i][j])
            #recompute means after iteration
            cluster_centers = recompute(cluster_centers, cluster_members)
            cluster_members = np.empty((clusters, 0)).tolist()
    clus_count = clus_count + 1

print("Clustering for forbloss finished")
```

executed in 52.5s, finished 19:17:38 2019-04-20

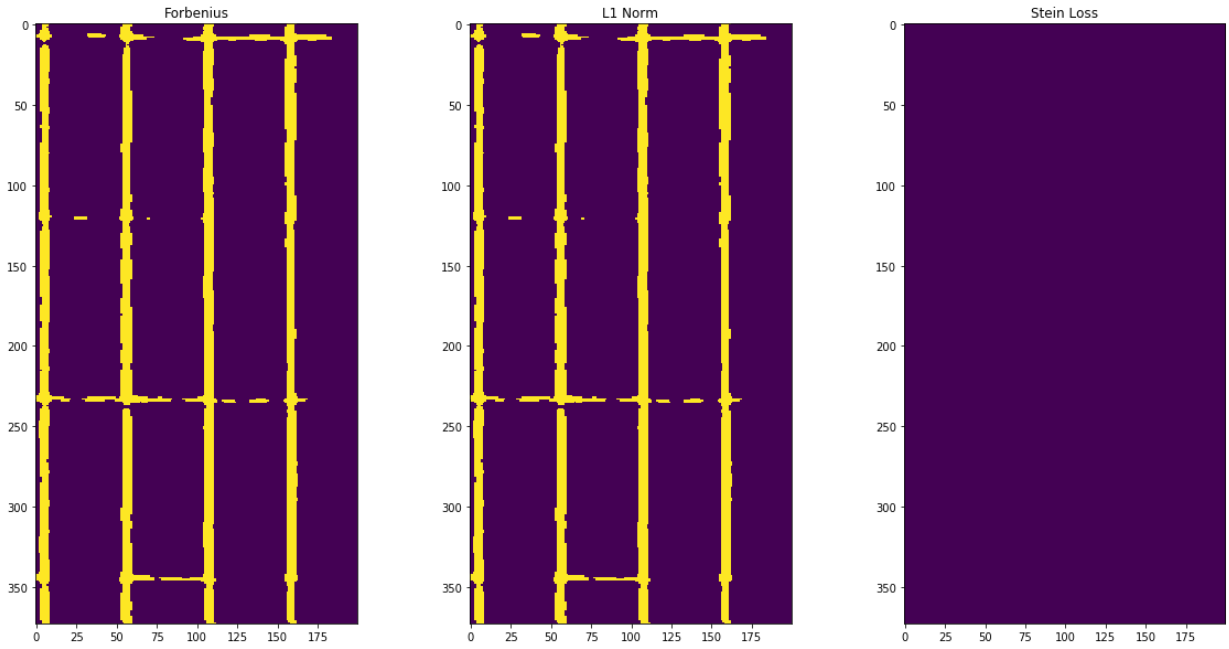
```
Clustering for forbloss finished
```

In [83]:
```
print("Iterations = ", iterations)
print("Clusters = ", clusters)
plt.figure(figsize=(20,10))
plt.subplot(131)
plt.imshow(clusters_imgs[0])
plt.title("Forbenius")
plt.subplot(132)
plt.imshow(clusters_imgs[1])
plt.title("L1 Norm")
plt.subplot(133)
plt.imshow(clusters_imgs[2])
plt.title("Stein Loss")
```

executed in 446ms, finished 19:17:38 2019-04-20

```
Iterations =  5
Clusters =  2
```

Out[83]: Text(0.5, 1.0, 'Stein Loss')



In [84]:
```
metrics = [forb_loss, max_col_sums, stein_loss]
clusters_imgs = [np.zeros(imgtex1.shape), np.zeros(imgtex1.shape), np.zeros
clusters = 3
iterations = 5
clus_count = 0
for metric in metrics:
    #init
    cluster_centers = []
    cluster_centers_size = np.ones(clusters)
    cluster_members = np.empty((clusters, 0)).tolist()

    for k in range(clusters):
        i_rand = random.randint(0, imgtex1.shape[0])
        j_rand = random.randint(0, imgtex1.shape[1])
        cluster_centers.append(N[i_rand][j_rand])
        cluster_members[k].append(N[i_rand][j_rand])
    for it in range(iterations):
        for i in range(N.shape[0]):
            #starting iteration
            for j in range(N.shape[1]):
                shortest = 0
                short_dist = 1073741823
                for k in range(len(cluster_centers)):
                    d = metric(N[i][j], cluster_centers[k])
                    if d <= short_dist:
                        shortest = k
                        short_dist = d
                clusters_imgs[clus_count][i][j] = color(clusters, shortest)
                cluster_members[shortest].append(N[i][j])
            #recompute means after iteration
            cluster_centers = recompute(cluster_centers, cluster_members)
            cluster_members = np.empty((clusters, 0)).tolist()
    clus_count = clus_count + 1

print("Clustering for forbloss finished")
```

executed in 1m 8.77s, finished 19:18:47 2019-04-20

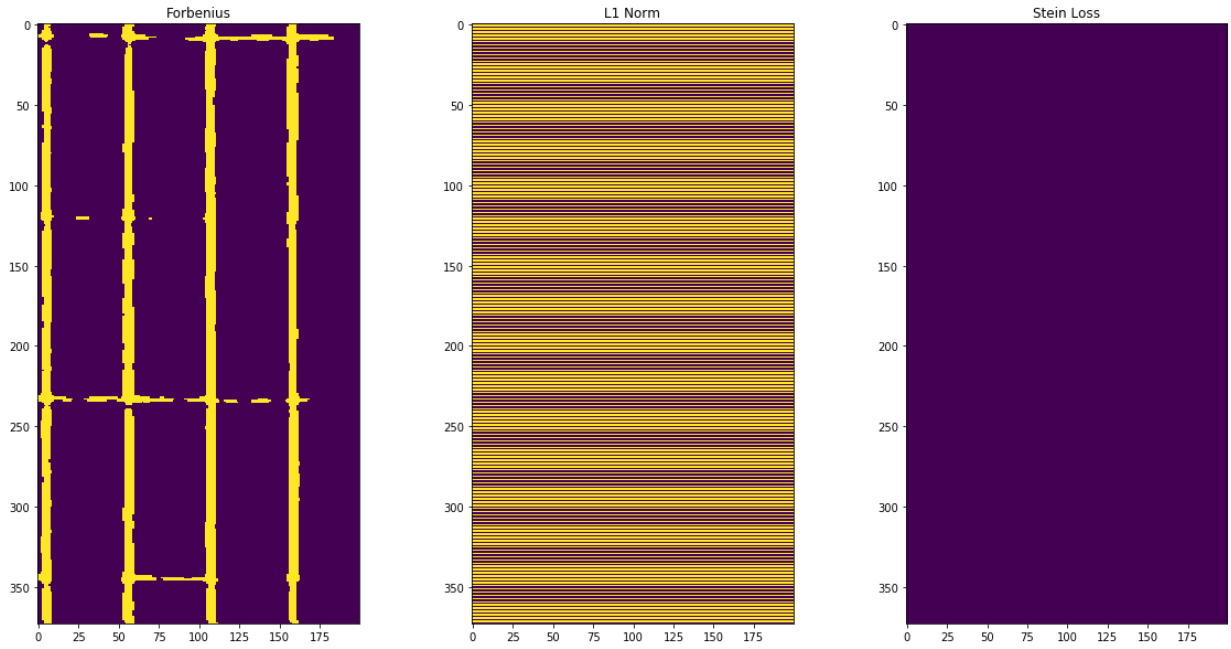
```
Clustering for forbloss finished
```

In [85]:
```
print("Iterations = ", iterations)
print("Clusters = ", clusters)
plt.figure(figsize=(20,10))
plt.subplot(131)
plt.imshow(clusters_imgs[0])
plt.title("Forbenius")
plt.subplot(132)
plt.imshow(clusters_imgs[1])
plt.title("L1 Norm")
plt.subplot(133)
plt.imshow(clusters_imgs[2])
plt.title("Stein Loss")
```

executed in 442ms, finished 19:18:47 2019-04-20

```
Iterations =  5
Clusters =  3
```

Out[85]: Text(0.5, 1.0, 'Stein Loss')



2.

In [ ]:

executed in 9m 33s, finished 19:28:54 2019-04-20

In [87]:

executed in 10m 7s, finished 19:28:54 2019-04-20

```
(400, 112, 92)
[[ 41.  43.  63. ... 125. 119. 125.]
 [ 47.  50.  53. ... 119. 120. 124.]
 [ 47.  41.  35. ... 124. 120. 124.]
 ...
 [ 35. 158.  41. ...  36.  89.  36.]
 [ 37. 153.  10. ...  39.  94.  35.]
 [ 38. 169.  24. ...  40.  85.  34.]]

---------------------------------------------------------------------------
--
KeyboardInterrupt                         Traceback (most recent call las
t)
<ipython-input-87-cf3d6e9df9e2> in <module>
     16     u.append(colmean)
     17 #eignvalues
---> 18 w, v= np.linalg.eig(np.matmul(A, A.T))
     19 print(w, v)
     20 summed = []

~/miniconda3/lib/python3.7/site-packages/numpy/linalg/linalg.py in eig(a)
   1309         _raise_linalgerror_eigenvalues_nonconvergence)
   1310     signature = 'D->DD' if isComplexType(t) else 'd->DD'
-> 1311     w, vt = _umath_linalg.eig(a, signature=signature, extobj=exto
bj)
   1312
   1313     if not isComplexType(t) and all(w.imag == 0.0):

KeyboardInterrupt:
```

In [ ]:

In [ ]: