Football field Analysis

VIC Project, Main Code

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Sources :

https://link.springer.com/chapter/10.1007/978-3-540-30125-7_101 pp 818-824. 2004 - Use hue detection to detect grass (ie field) -- The results seems not usable for us

https://static1.squarespace.com/static/5b048119f2e6b103db959419/t/5e99aeb4d85a234bb8752f78/1587130062444/Learning+to+track+and+identify+players+from+broadcast+sports+videos.pdf Canny Edge detector to detect the field lines

https://www.cse.ust.hk/~quan/comp5421/notes/canny1986.pdf Paper on the Canny detector

Python libraries imports

In [1]:
```
import numpy as np
import matplotlib.pyplot as plt
import cv2
import matplotlib.patches as patches
from skimage.morphology import *
np.seterr(invalid='ignore')
```

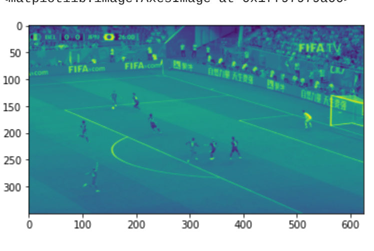
Out[1]:
```
{'divide': 'warn', 'over': 'warn', 'under': 'ignore', 'invalid': 'warn'}
```

Import the image

In [2]:
```
from skimage.transform import resize
img_input = cv2.imread("input_img1.png",cv2.IMREAD_GRAYSCALE)
img = resize(img_input, output_shape=(350, 625))
print(img.shape)
plt.imshow(img)
```

```
(350, 625)
```

Out[2]:
```
<matplotlib.image.AxesImage at 0x1ff97979a00>
```



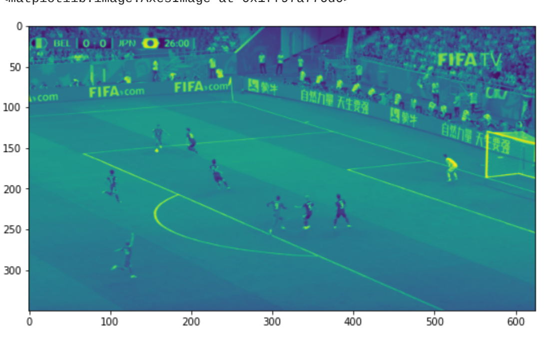
Step 1 : Canny Edge detector

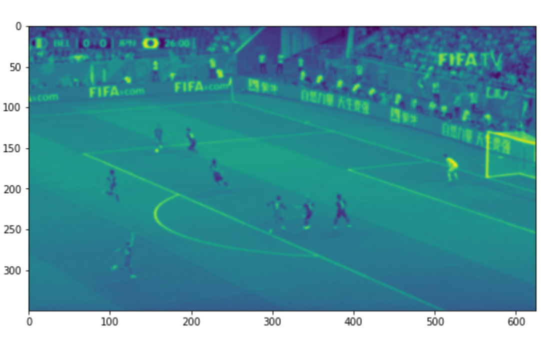
We are first going to try a step by step pipeline for image preparation and the canny edge detector, inspired by the work done in assignment 1 part 2.

A. Smooth the image

In [3]:
```
from scipy.ndimage import gaussian_filter
smoothed = gaussian_filter(img, sigma=1)
fig, axes = plt.subplots(figsize=(20, 12), ncols=2)
axes[0].imshow(img)
axes[1].imshow(smoothed)
```

Out[3]:
```
<matplotlib.image.AxesImage at 0x1ff97a776d0>
```

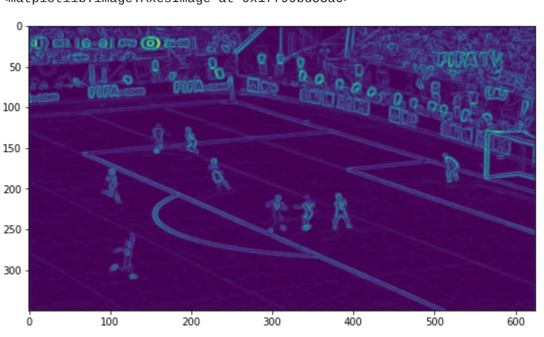


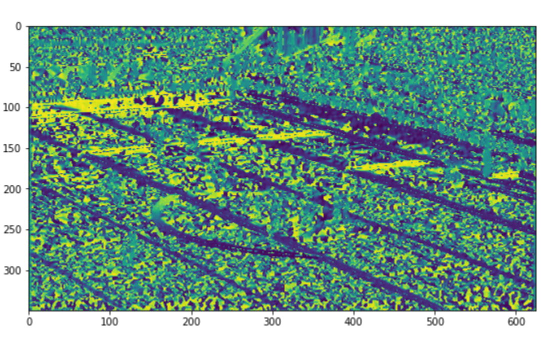


B. Gradients

In [4]:
```
from skimage.filters import sobel
def gradient(img):
    g_x = sobel(img, axis=1)
    g_y = sobel(img, axis=0)
    g_mag = np.sqrt(g_x**2 + g_y**2)
    g_dir = np.arctan(g_y / g_x)
    return g_mag, g_dir
fig, axes = plt.subplots(figsize=(20, 12), ncols=2)
g_magnitude, g_dir = gradient(smoothed)
axes[0].imshow(g_magnitude)
axes[1].imshow(g_dir)
```

Out[4]:
```
<matplotlib.image.AxesImage at 0x1ff99bd53a0>
```

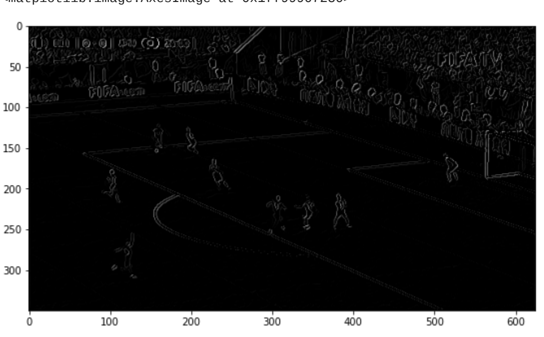


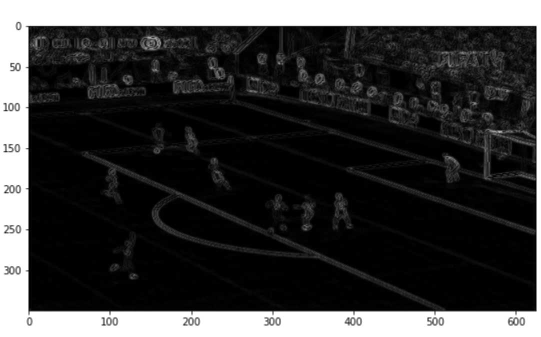


C. Non-maximum suppression

In [5]:
```
def non_maximum_suppression(g_magnitude, g_dir):
    #quantise the gradient directions into 4 values np.array([0, np.pi/4, np.pi/2, 3*np.pi/4])
    h, w = g_magnitude.shape
    values = np.array([0, np.pi, np.pi/4, np.pi/2, 3*np.pi/4])
    g_max = np.zeros_like(g_magnitude)
    for i in range(h-1):
        for j in range(w-1):
            diff = abs(values - g_dir[i,j])
            angle = values[np.argmin(diff)]
            q = 0
            r = 0
            #case angle = 0
            if angle == 0 or angle == 1 :
                q = g_magnitude[i, j+1]
                r = g_magnitude[i, j-1]
            #case angle = pi/4
            elif angle == 2:
                q = g_magnitude[i+1, j-1]
                r = g_magnitude[i-1, j+1]
            #case angle = pi/2
            elif angle == 3:
                q = g_magnitude[i+1, j]
                r = g_magnitude[i-1, j]
            #case angle = 3pi/4
            else:
                q = g_magnitude[i-1, j-1]
                r = g_magnitude[i+1, j+1]

            if g_magnitude[i,j] >= q and g_magnitude[i,j]>=r :
                g_max[i,j] = g_magnitude[i,j]
            else:
                g_max[i,j] = 0

    return g_max

fig, axes = plt.subplots(figsize=(20, 12), ncols=2)

g_max = non_maximum_suppression(g_magnitude, g_dir)

axes[0].imshow(g_max, cmap='gray')
axes[1].imshow(g_magnitude - g_max, cmap='gray')
```

Out[5]:
```
<matplotlib.image.AxesImage at 0x1ff99907280>
```

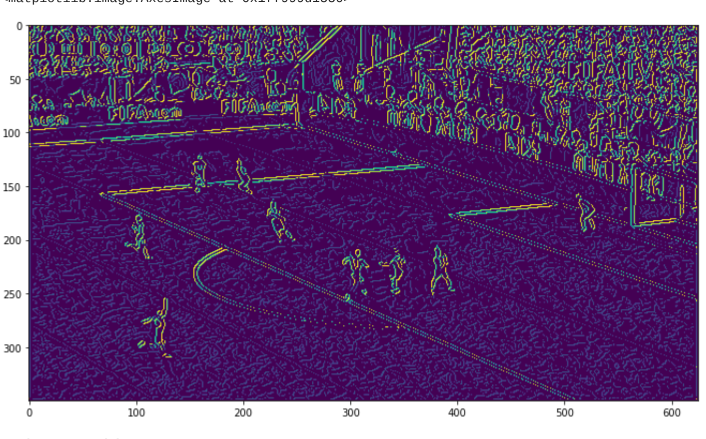




D. Double Thresholding

In [6]:
```
def double_thresholding(g_max, thresh_lo, thresh_hi):
    h, w = g_max.shape
    thresh_img = np.zeros_like(g_max)
    highThreshold = g_max.max() * thresh_hi;
    lowThreshold = highThreshold * thresh_lo;

    for i in range(h):
        for j in range(w):
            if g_max[i,j] > highThreshold :
                 thresh_img[i,j] = 1
            elif g_max[i,j] > lowThreshold:
                thresh_img[i,j] = 0.25

    return thresh_img

thresh_img = double_thresholding(g_max, thresh_lo=0.05, thresh_hi=0.08)

fig, ax = plt.subplots(figsize=(12, 12))
ax.imshow(thresh_img)
```

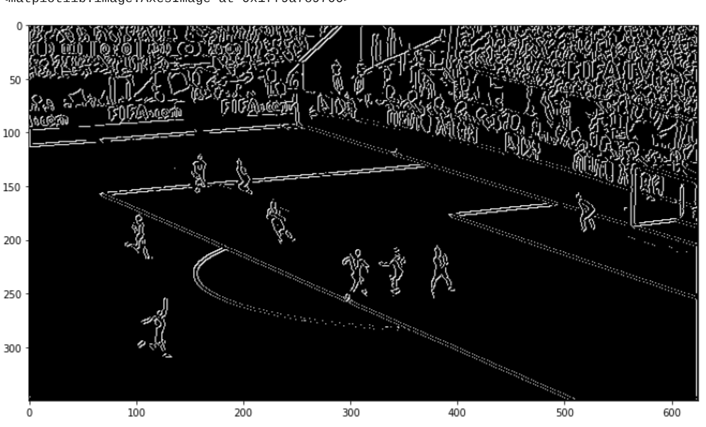
Out[6]:
```
<matplotlib.image.AxesImage at 0x1ff999d1880>
```



E. Edge connectivity

In [7]:
```
def connectivity(thresh_img):
    h, w = thresh_img.shape
    edge_img = thresh_img

    for i in range(h):
        for j in range(w):
            if edge_img[i,j] == 0.25:
                if edge_img[i+1,j] == 1 or edge_img[i+1,j+1] == 1 or edge_img[i,j+1] == 1 or edge_img[i-1,j] == 1 or edge_img[i-1,j-1] == 1 or edge_img[i,j-1] == 1 or edge_img[i+1,j-1] == 1 or edge_img[i-1,j+1] == 1:
                    edge_img[i,j] = 1
                else:
                    edge_img[i,j] = 0

    return edge_img

edge_img = connectivity(thresh_img)

fig, ax = plt.subplots(figsize=(12, 12))
ax.imshow(edge_img, cmap='gray')
```

Out[7]:
```
<matplotlib.image.AxesImage at 0x1ff9a7c9700>
```



Next step: Here, you can see that the players are noising the detections of the fields'line, in the Lu's Paper they decided to detect the bounding boxes of the players to delete them from the edge detection. This is what we are going to try to do next.

Find the players on the field

Main ref paper : http://cs.brown.edu/people/pfelzens/papers/latent.pdf (seen in course)

https://www.cs.toronto.edu/~fidler/slides/2015/CSC420/lecture19.pdf (course on DPM detector -- based on Hog detector)

we used this dataset for training : https://drive.google.com/file/d/1ctJojwDaWtHEAeDmB-AwEcO3apqT-O-9/view?usp=sharing (SoccerPlayerDetection_bmvc17_v1 dataset)

To remove the viewers from the image and keep only the field

If you want to see how we create the player detector model go the Player_detector.ipynb

We apply our model to the image

In [8]:
```
#Player detection
hog = cv2.HOGDescriptor()
hog.load('myHogPlayerDector.bin')
image = cv2.imread("input_img1.png")#Screenshot from World Cup 2018 Belgique VS Japan
rects, scores = hog.detectMultiScale(image, winStride=(4, 4),padding=(8, 8), scale=1.05)
```

6.2. We apply the fast Non Max Suppression

In [9]:
```
#FIXME : Put it in the utils.py
#Non-maximum suppression
def fastNonMaxSuppression(boxes, sc, overlapThresh):
    # if there are no boxes, return an empty list
    if len(boxes) == 0:
        return []
    # if the bounding boxes integers, convert them to floats --
    # this is important since we'll be doing a bunch of divisions
    if boxes.dtype.kind == "i":
        boxes = boxes.astype("float")

    # initialize the list of picked indexes
    pick = []

    # grab the coordinates of the bounding boxes
    x1 = boxes[:, 0]
    y1 = boxes[:, 1]
    x2 = boxes[:, 2]
    y2 = boxes[:, 3]
    scores = sc
    # compute the area of the bounding boxes and sort the bounding
    # boxes by the score of the bounding box
    area = (x2 - x1 + 1) * (y2 - y1 + 1)
    idxs = np.argsort(scores)

    # keep looping while some indexes still remain in the indexes
    # list
    while len(idxs) > 0:
        # grab the last index in the indexes list and add the
        # index value to the list of picked indexes
        last = len(idxs) - 1
        i = idxs[last]
        pick.append(i)

        # find the largest (x, y) coordinates for the start of
        # the bounding box and the smallest (x, y) coordinates
        # for the end of the bounding box
        xx1 = np.maximum(x1[i], x1[idxs[:last]])
        yy1 = np.maximum(y1[i], y1[idxs[:last]])
        xx2 = np.minimum(x2[i], x2[idxs[:last]])
        yy2 = np.minimum(y2[i], y2[idxs[:last]])

        # compute the width and height of the bounding box
        w = np.maximum(0, xx2 - xx1 + 1)
        h = np.maximum(0, yy2 - yy1 + 1)

        # compute the ratio of overlap
        overlap = (w * h) / area[idxs[:last]]

        idxs = np.delete(idxs, np.concatenate(([last],
                                               np.where(overlap > overlapThresh)[0])))

    # return only the bounding boxes that were picked using the
    # integer data type
    return boxes[pick]
```

In [10]:
```
def fastNonMaxSuppression_applied(rects,scores):
    #fastNonMaxSuppression-The first parameter
    for i in range(len(rects)):
        r = rects[i]
        rects[i][2] = r[0] + r[2]
        rects[i][3] = r[1] + r[3]

    #fastNonMaxSuppression-Second parameter
    sc = [score for score in scores]
    sc = np.array(sc)

    pick = []
    print('rects_len',len(rects))
    pick = fastNonMaxSuppression(rects, sc, overlapThresh = 0.3)
    print('pick_len = ',len(pick))
```

In [11]:
```
fastNonMaxSuppression_applied(rects,scores)
```

```
rects_len 53
pick_len =  45
```

In [12]:
```
def create_bbox(rects,scores):#we create the bounding box
    bbox = []
    for i in range(len(scores)):
        if (scores[i] > 0.3):
            bbox.append(rects[i])
    bbox = np.array(bbox)
    return bbox
```

In [13]:
```
bbox=create_bbox(rects,scores)
```

6.3. We apply a color selection on the bounding boxes

In [14]:
```
# Get the Main color in the bounding box and the precision
# image = an image ; colors_on_the_fild = list with all the colors to analyse (ex : ["White","Blue","Red"])
def PrimeColor(image, colors_on_the_field):
    #cv2.imshow('image',image)
    max_ratio = 0
    final_color = ""
    confidence = 0

    # FIXME : Add Cyan
    color_list = ['Blue', 'Red', 'White', 'Black', 'Yellow', 'Green', 'Purple']
    boundaries = [
        ([0, 100, 100], [10, 255, 255]),  # blue
        ([110, 50, 50], [130, 255, 255]),  # red
        ([0, 0, 213], [255, 20, 255]),  # white
        ([0, 0, 0], [10, 10, 10]),  # black
        ([80, 50, 50], [100, 255, 255]),  # yellow
        ([50, 50, 50], [70, 255, 255]),  # green
        ([140, 50, 50], [160, 255, 255]),  # purple (Magenta)
    ]

    try:

        hsv = cv2.cvtColor(image, cv2.COLOR_BGR2HSV)

        for color in colors_on_the_field:
            if color not in color_list:
                raise ValueError("This color : {}, is not yet defined in our code ... Sorry :( ".format(color))
            else:
                index = color_list.index(color)
                lower_range = np.array(boundaries[index][0])
                upper_range = np.array(boundaries[index][1])
                mask = cv2.inRange(hsv, lower_range, upper_range)

                ratio = cv2.countNonZero(mask) / np.size(mask)
                confidence += ratio
                if (ratio > max_ratio):
                    max_ratio = ratio
                    final_color = color

        try:
            conf = max_ratio / confidence
        except:

            final_color = "ERROR"
            conf = 0
    except:
        conf = 0
        final_color = "ERROR"


    return final_color, conf
```

In [15]:
```
def plot_rectangle(bbox,img,colors_on_the_field):
    fig, ax = plt.subplots(figsize=(20, 12))
    new_bbox=[]
    for x1, y1, x2, y2 in bbox:
        dx = x2 - x1
        dy = y2 - y1
        cropped_img = np.array(img[y1:y2, x1:x2])
        final_color,conf=PrimeColor(cropped_img, colors_on_the_field)
        if final_color=="ERROR":
            pass
        if final_color=="Black":
            pass
        else:
            if conf>0.7:
                new_bbox.append([x1,y1,x2,y2])
                rect = patches.Rectangle((x1, y1), dx, dy, edgecolor=final_color, facecolor='none')
                ax.add_patch(rect)

    ax.imshow(img)
    ax.set_title('Prediction for frames {}')
    return new_bbox
```

In [16]:
```
def process_image(image):
    image_resize=cv2.resize(image,(512,256))
    # Converting the image to hsv
    hsv = cv2.cvtColor(image_resize, cv2.COLOR_BGR2HSV)

    # define range of red color in HSV
    lower_green , upper_green = np.array([25, 52, 72]), np.array([50, 255, 255])

    # Threshold the HSV image using inRange function to get only red colors
    mask = cv2.inRange(hsv, lower_green, upper_green)
    #using dilation gives more importance to the bright pixels (Dilation enlarges bright regions and shrinks dark regions)
    img_bg = dilation(np.invert(mask), disk(6))
    img_test = dilation(np.invert(img_bg), disk(13))
    img_input=cv2.resize(image_resize,(image.shape[1],image.shape[0]))
    res = cv2.bitwise_and(img_input,img_input, mask= cv2.resize(img_test,(image.shape[1],image.shape[0])))
    cv2.imwrite('./input_img_processed.png',np.array(res[:,:,::-1]))
    return img_test
```

In [17]:
```
image = cv2.imread("input_img1.png")
colors_on_the_field=['Red', 'Blue',"Black"]
mask=process_image(image)
image = cv2.imread("./input_img_processed.png")
new_bbox=plot_rectangle(bbox,image,colors_on_the_field)
```

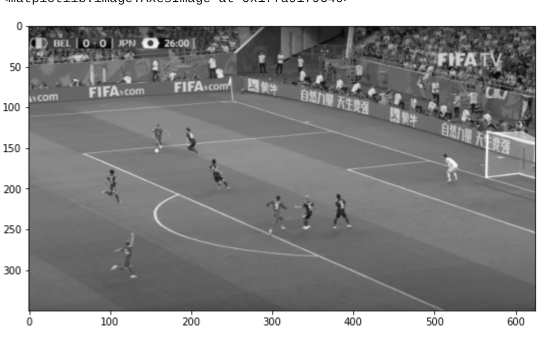
Prediction for frames {}

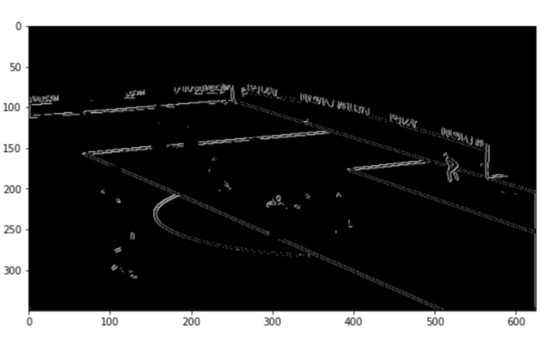
Canny detector Pipeline

Now we will remove the players from the fields

In [18]:
```
def canny_edge_detector(img, bbox,resize_shape,mask, thresh_lo=0.1, thresh_hi=0.2):
    """
    The Canny edge detector.

    Inputs:
        img              The input image
        thresh_lo        The fraction of the maximum gradient magnitude which will
                         be considered the lo threshold.
        thresh_hi        The fraction of the maximum gradient magnitude which will
                         be considered the hi threshold. Ideally should be 2x to 3x
                         thresh_lo.

    Outputs:
        edge_img         A binary image, with pixels lying on edges marked with a 1,
                         and others with a 0.
    """

    # Smooth the image first.
    smoothed             = gaussian_filter(img,1)

    # Find gradient magnitude and direction
    g_magnitude, g_dir   = gradient(smoothed)

    # Non-maximum suppression
    g_max                = non_maximum_suppression(g_magnitude, g_dir)

    # Double thresholding
    thresh_img           = double_thresholding(g_max, thresh_lo, thresh_hi)

    # Final edge connectivity
    edge_img             = connectivity(thresh_img)

    w,h=edge_img.shape
    edge_img=cv2.resize(edge_img,(resize_shape[1],resize_shape[0]))
    for x1, y1, x2, y2 in bbox:
        for x in range(x1,x2+1):
            for y in range(y1,y2+1):
                edge_img[y, x]=0
    # Return the result
    edge_img=cv2.resize(edge_img,(h,w))
    mask=cv2.resize(mask,(h,w))
    edge_img=edge_img*mask
    return edge_img


fig, axes = plt.subplots(figsize=(20, 12), ncols=2)

edges = canny_edge_detector(img,new_bbox,image.shape,mask, thresh_lo=0.05, thresh_hi=0.09)

axes[0].imshow(img, cmap='gray')
axes[1].imshow(edges, cmap='gray')
```

Out[18]:
```
<matplotlib.image.AxesImage at 0x1ffa9179640>
```





We still have imperfections by the fact that the rectangles for the player detection does not include some part of the player (hands, foot, etc) This couldd be improve with further preprocessing and training of the model