1. The Human Eye

In [ ]:
```python
from math import pi, tan
```

In [ ]:
```python
TV_RESOLUTION = int(input("Please enter the TV resolution in pixels: "))
if TV_RESOLUTION <= 2:
    print("Please enter a good resolution!")
    exit()
TV_WIDTH = int(input("Please enter the TV width in inches: "))
if TV_WIDTH <= 0:
    print("Please enter a positive width!")
    exit()
ROOM_LENGTH = int(input("Please enter the room length in feet: "))
if ROOM_LENGTH <= 0:
    print("Please enter a positive length!")
    exit()
```

How it works

```
|-30cycles-|
                 |-- 60px --|
_________________________________TV__
 |   \           |           /
 |    \          |          /
 |     \         |         /
 |      \        |        /
 |       \       |       /
(d)       \      |      /
 |         \     | ½°  /
 |          \    |____/
 |           \   |   /
 |            \  |  /
 |             \ | /
 |              \|/
___             (eye)
```

In [ ]:
```python
d = (60*(TV_WIDTH/TV_RESOLUTION)/tan(pi/360))/12
```

In [ ]:
```python
print(
    "The distance between the TV and the couch should be ", min(ROOM_LENGTH,
)
```

```
The distance between the TV and the couch should be  8.20621843373962 feet
```

2. Gray Scale Images

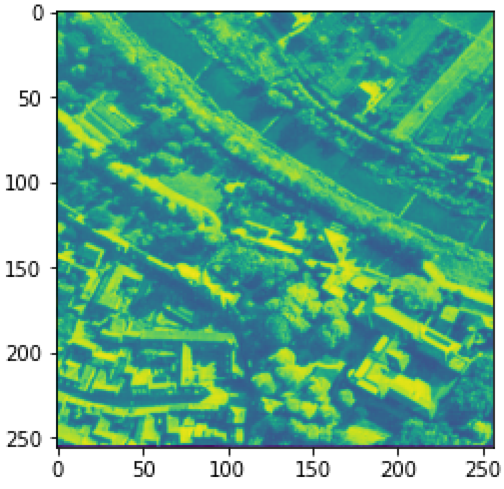
In [ ]:
```python
from matplotlib import pyplot as plt, image as mpimg
from math import log2, ceil
import os

aerial = mpimg.imread("aerial.tiff")
airplane = mpimg.imread("airplane.tiff")
APC = mpimg.imread("APC.tiff")
```

2.1 Display the images

In [ ]:

```
plt.imshow(aerial)
```

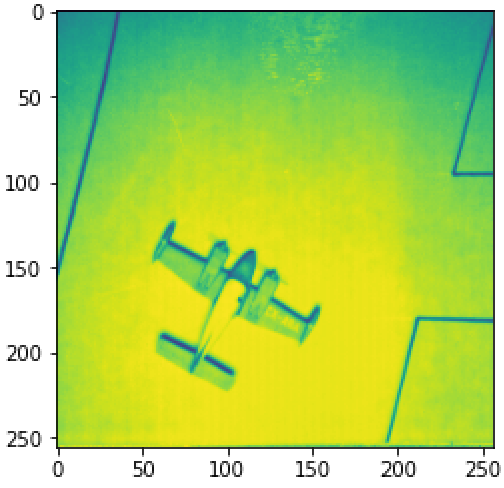
Out[ ]: <matplotlib.image.AxesImage at 0x7f0be58a2490>



In [ ]:

```
plt.imshow(airplane)
```

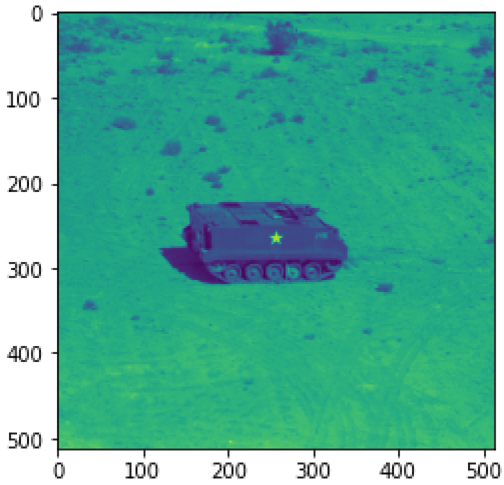
Out[ ]: <matplotlib.image.AxesImage at 0x7f0be2f18130>



In [ ]:

```
plt.imshow(APC)
```

Out[ ]: <matplotlib.image.AxesImage at 0x7f0be279cac0>



2.2 Max and min pixel values

In [ ]:

```
maxVal = aerial[0][0]
minVal = aerial[0][0]
for i in range(len(aerial)):
    for j in range(len(aerial[i])):
        if maxVal < aerial[i][j]:
            maxVal = aerial[i][j]
        if minVal > aerial[i][j]:
            minVal = aerial[i][j]
bitsNeeded = ceil(log2(maxVal - minVal))
IMAGE_WIDTH = len(aerial[0])
IMAGE_HEIGHT = len(aerial)
aerialImageSize = IMAGE_WIDTH * IMAGE_HEIGHT * bitsNeeded
print("aerial.tiff")
print("Resolution: " + str(IMAGE_WIDTH) + "x" + str(IMAGE_HEIGHT))
print("Max value: " + str(maxVal))
print("Min value: " + str(minVal))
print("Bits needed: " + str(bitsNeeded))
```

```
aerial.tiff
Resolution: 256x256
Max value: 248
Min value: 1
Bits needed: 8
```

In [ ]:

```
maxVal = airplane[0][0]
minVal = airplane[0][0]
for i in range(len(airplane)):
    for j in range(len(airplane[i])):
        if maxVal < airplane[i][j]:
            maxVal = airplane[i][j]
        if minVal > airplane[i][j]:
            minVal = airplane[i][j]
bitsNeeded = ceil(log2(maxVal - minVal))
IMAGE_WIDTH = len(airplane[0])
IMAGE_HEIGHT = len(airplane)
airplaneImageSize = IMAGE_WIDTH * IMAGE_HEIGHT * bitsNeeded
print("airplane.tiff")
print("Resolution: " + str(IMAGE_WIDTH) + "x" + str(IMAGE_HEIGHT))
print("Max value: " + str(maxVal))
print("Min value: " + str(minVal))
print("Bits needed: " + str(bitsNeeded))
```

```
airplane.tiff
```

```
Resolution: 256x256
Max value: 232
Min value: 0
Bits needed: 8
```

In [ ]:

```
maxVal = APC[0][0]
minVal = APC[0][0]
for i in range(len(APC)):
    for j in range(len(APC[i])):
        if maxVal < APC[i][j]:
            maxVal = APC[i][j]
        if minVal > APC[i][j]:
            minVal = APC[i][j]
bitsNeeded = ceil(log2(maxVal - minVal))
IMAGE_WIDTH = len(APC[0])
IMAGE_HEIGHT = len(APC)
APCImageSize = IMAGE_WIDTH * IMAGE_HEIGHT * bitsNeeded
print("APC.tiff")
print("Resolution: " + str(IMAGE_WIDTH) + "x" + str(IMAGE_HEIGHT))
print("Max value: " + str(maxVal))
print("Min value: " + str(minVal))
print("Bits needed: " + str(bitsNeeded))
```

```
APC.tiff
Resolution: 512x512
Max value: 215
Min value: 12
Bits needed: 8
```

2.3 Compression

In [ ]:

```
aerialFilesize = os.path.getsize("./aerial.tiff") * 8  # times 8 for size in
airplaneFilesize = os.path.getsize("./airplane.tiff") * 8
APCFilesize = os.path.getsize("./APC.tiff") * 8
print(
    "aerial.tiff compression: "
    + str((aerialFilesize / aerialImageSize) * 100)[0:8]
    + "%"
)
print(
    "airplane.tiff compression: "
    + str((airplaneFilesize / airplaneImageSize) * 100)[0:8]
    + "%"
)
print("APC.tiff compression: " + str((APCFilesize / APCImageSize) * 100)[0:8]
```

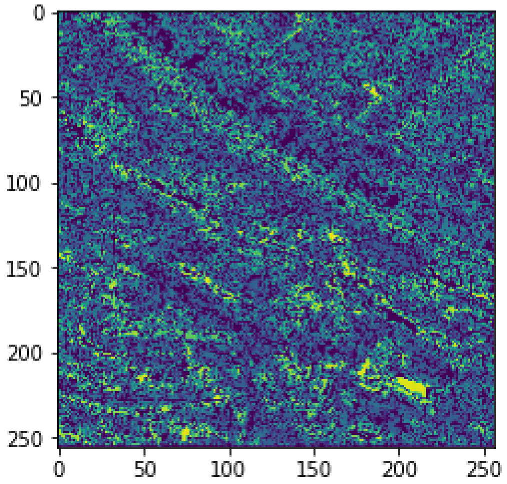
```
aerial.tiff compression: 100.2044%
airplane.tiff compression: 100.2044%
APC.tiff compression: 100.0511%
```

2.4 Bitplane

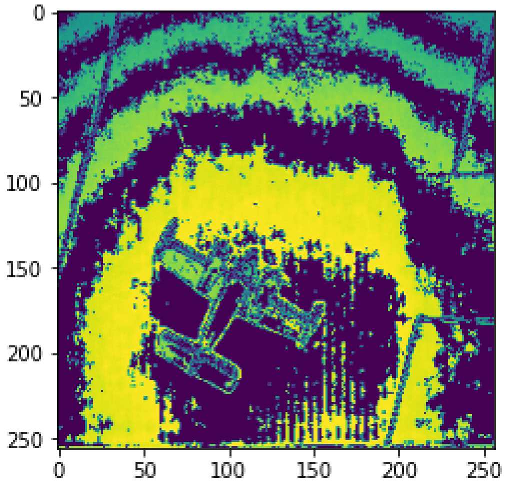
In [ ]:

```
def bitPlane(img, bitplane):
    for i in range(len(img)):
        for j in range(len(img[i])):
            if (img[i][j] >> bitplane) & 1 == 1:
                img[i][j] = img[i][j]
            else:
                img[i][j] = 0
    plt.imshow(img)
```

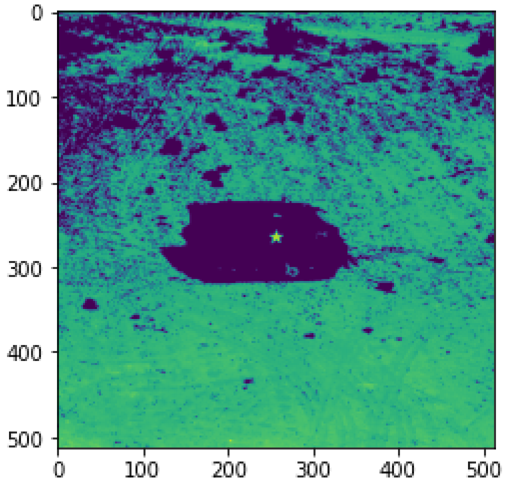
```
bitPlane(aerial, 3)
```



In [ ]:
```
bitPlane(airplane, 4)
```



In [ ]:
```
bitPlane(APC, 7)
```



3. Binary Image Processing

In [ ]:
```
from matplotlib import pyplot as plt, image as mpimg
```

```
airplane = mpimg.imread("airplane.tiff")
truck = mpimg.imread("truck.tiff")
airport = mpimg.imread("airport.tiff")
APC = mpimg.imread("APC.tiff")
```

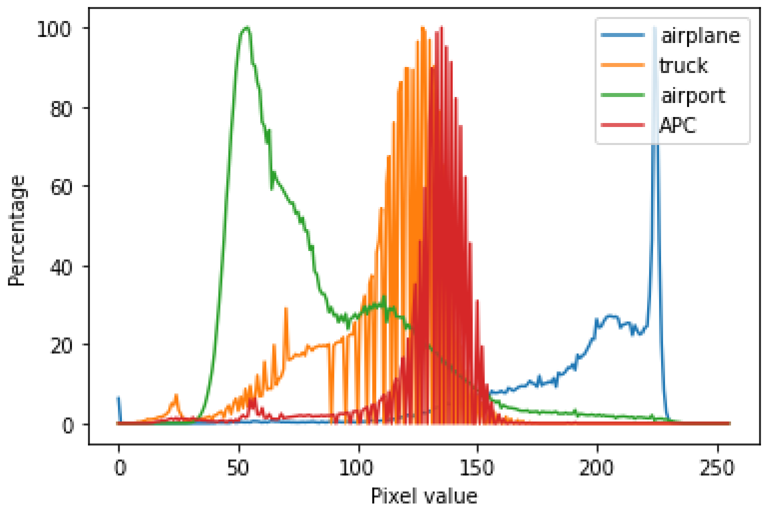
In [ ]:

```
def normalize(colors, max_value):
    for (i, color) in enumerate(colors):
        colors[i] = color / max_value * 100
    return colors


def histogram(img):
    colors = [0] * 256
    max_value = 0
    for (i, row) in enumerate(img):
        for (j, pixel) in enumerate(row):
            colors[pixel] += 1
            max_value = max(max_value, colors[pixel])
    plt.plot(normalize(colors, max_value))
```

3.1 Histogram and modality

In [ ]:

```
histogram(airplane)
histogram(truck)
histogram(airport)
histogram(APC)
plt.legend(["airplane", "truck", "airport", "APC"])
plt.ylabel("Percentage")
plt.xlabel("Pixel value")
plt.show()
```



- All images are unimodal

3.2 Binarize the images

In [ ]:

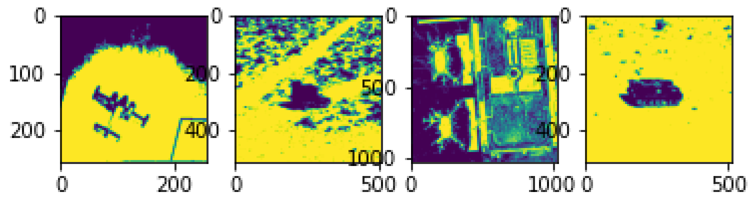
```
def binarize(img, threshold):
    for (i, row) in enumerate(img):
        for (j, pixel) in enumerate(row):
            if pixel < threshold:
                img[i][j] = 0
```

```
            else:
                img[i][j] = 255
    return img


binarizedAirplane = binarize(airplane, 190)
binarizedTruck = binarize(truck, 90)
binarizedAirport = binarize(airport, 80)
binarizedAPC = binarize(APC, 80)
```

In [ ]:

```
f, arr = plt.subplots(1, 4)

arr[0].imshow(binarizedAirplane)
arr[1].imshow(binarizedTruck)
arr[2].imshow(binarizedAirport)
arr[3].imshow(binarizedAPC)
```

Out[ ]: <matplotlib.image.AxesImage at 0x7f0be5362850>



3.3 Otsu's algorithm

In [ ]:

```
# Incomplete
```

3.4 Connected Components

In [ ]:

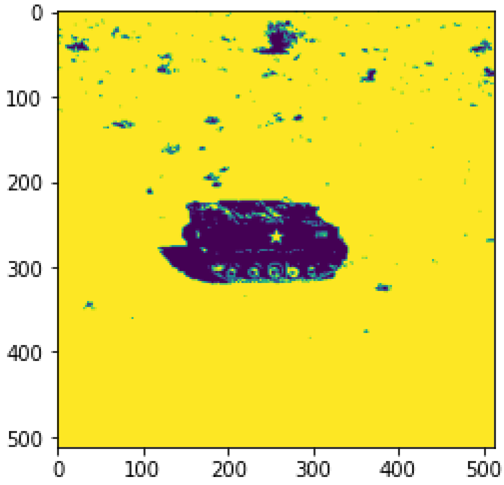
```
def connected_components(img) :
    components = []
    visited = [[False for _ in row] for row in img]
    for (i, row) in enumerate(img):
        for (j, pixel) in enumerate(row):
            if pixel == 255 and not visited[i][j]:
                component = []
                queue = [(i, j)]
                while len(queue) > 0:
                    (i, j) = queue.pop()
                    visited[i][j] = True
                    component.append((i, j))
                    if i > 0 and img[i - 1][j] == 255 and not visited[i - 1][
                        queue.append((i - 1, j))
                    if i < len(img) - 1 and img[i + 1][j] == 255 and not visi
                        queue.append((i + 1, j))
                    if j > 0 and img[i][j - 1] == 255 and not visited[i][j -
                        queue.append((i, j - 1))
                    if j < len(img[0]) - 1 and img[i][j + 1] == 255 and not v
                        queue.append((i, j + 1))
                components.append(component)
    return components
```

In [ ]:

```
temp = binarizedAPC.copy()
components = connected_components(binarizedAPC)
```

```
for (j, (x, y)) in enumerate(components[0]):
    temp[x][y] = 255
for (j, (x, y)) in enumerate(components[1]):
    temp[x][y] = 0

plt.imshow(temp)
```

Out[ ]: `<matplotlib.image.AxesImage at 0x7f0be25d5970>`

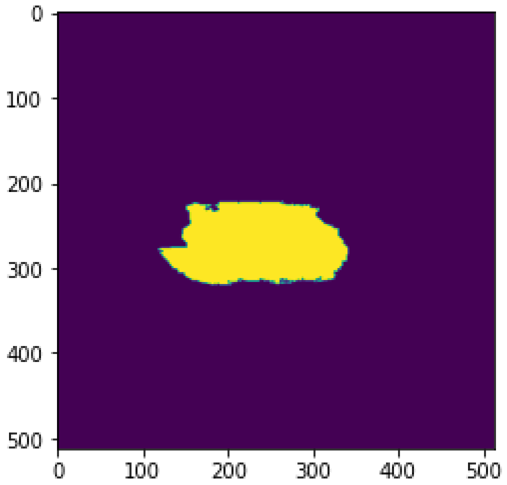


3.5 Minor blob removal

In [ ]:

```
def max_blob(img):
    max_size = 0
    max_component = None
    components = connected_components(img)
    for component in components:
        size = len(component)
        if size > max_size:
            max_size = size
            max_component = component
    return max_component

def minor_blob_removal(img):
    r = img.copy()
    for (i, row) in enumerate(img):
        for (j, pixel) in enumerate(row):
            r[i][j] = 0
    max_component = max_blob(img)
    for (i, j) in max_component:
        r[i][j] = 255
    return r

def complement_image(img):
    r = img.copy()
    for (i, row) in enumerate(img):
        for (j, pixel) in enumerate(row):
            r[i][j] = 255 - pixel
    return r

plt.imshow(minor_blob_removal(complement_image(minor_blob_removal(binarizedAF
```

Out[ ]: `<matplotlib.image.AxesImage at 0x7f0be220ea90>`


0
100
200
300
400
500
0
100
200
300
400
500