CMPEN 454

Project 3

Motion Detection

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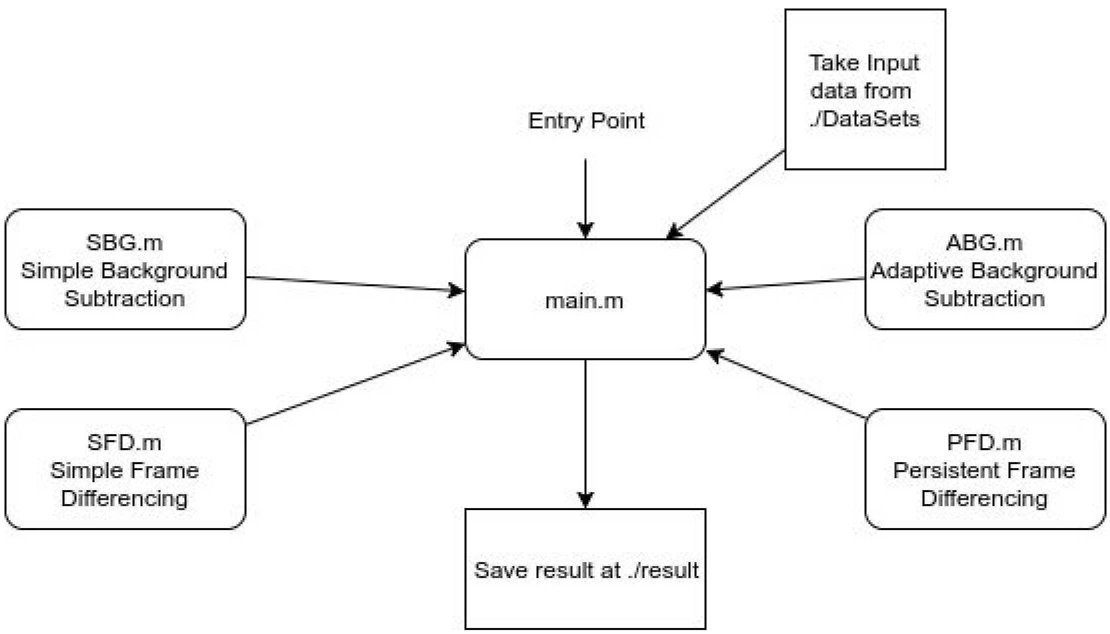
Introduction

This project is about to implement four simple motion detection algorithms and compare their differences. Through the comparing, we can find these algorithms' advantages and disadvantages. Under different conditions, we can choose which algorithm is better to use for motion detection. To test these four algorithms, a given video sequence will be read in each image in a loop and convert it to grayscale. The four images displayed by four algorithms will be put in a single matrix for easy comparison.

Implementation



As we can see from the diagram above, we separate the four motion detection algorithms completely independent from each other, for it will be easier to implement and debug. And we can assign different algorithm to different members of our group. The main function will take the input data from folder ./DataSets and use four different algorithm to do the motion detection. Then we combine four results together so that it will be easier to compare the performance. The result images are also used to generate a short video.

Simple Background Subtraction

```
function output = SBG(im, threshold)
    getRowSize = size(im,1);
    getColSize = size(im,2);
    T = size(im,3);
    output = zeros(getRowSize,getColSize,T-1);
    for t=2:T
        diff = abs(im(:,:,1)-im(:,:,t));
        output(:,:,t-1) = diff > threshold;
    end
end
```

Simple background subtraction is the basic algorithms and just an easy comparison between the first image and other images. If the difference between the first image and other images is greater than threshold, the value will be set to one, otherwise set to zero. The new size of the output matrix is one image less than the original matrix.

Simple Frame Differencing

```
function output = SFD(img, lamda)
    [a, b, c] = size(img);
    output = zeros(a,b,c-1);
    for i = 2: c
        diff = abs(img(:,:,i-1) - img(:,:,i));
        output(:,:,i-1) = diff > lamda;
    end
end
```

Simple Frame Differencing is the algorithm that subtracts the present frame and the previous one, and then take the absolute value, compare to the lambda, which is the threshold we set. If we determine this is not motion, which means small absolute value, we set the pixel value to 0, black. And if we determine this is motion, which means large absolute value, we set the pixel value to 1, white.

Adaptive Background Subtraction

```
function output = ABG(im, threshold, alpha)
    getRowSize = size(im,1);
    getColSize = size(im,2);
    T = size(im,3);
    B = zeros(getRowSize,getColSize,T);
    B(:,:,1)=im(:,:,1);
    output = zeros(getRowSize,getColSize,T-1);
    for t=2:T
        diff = abs(B(:,:,t-1)-im(:,:,t));
        output(:,:,t-1) = diff > threshold;
        B(:,:,t) = alpha*im(:,:,t) + (1-alpha)*B(:,:,t-1);
    end


end
```

Adaptive Background Subtraction has an extra parameter alpha. When alpha equals 0, the algorithm yields simple background subtraction. When alpha equals 1, the algorithm yields frame differencing. The algorithm compares the previous image and current image. In each iteration, the next previous image is changed depend on the parameter alpha. The value of the output matrix is the determined by the comparison between threshold and difference between the previous image and current image. If the difference is greater than threshold, the value will be set to one, otherwise set to zero. The new size of the output matrix is one image less than the original matrix.

Persistent Frame Differencing

```
function output = PFD(img,lamda,gamma)
    [a, b, c] = size(img);
    output = zeros(a,b,c);
    M = zeros(a,b,c);
    for i = 2: c
        diff = abs(img(:,:,i-1) - img(:,:,i));
        M(:,:,i) = diff > lamda;
        tmp = max(output(:,:,i-1)-gamma,0);
        output(:,:,i) = max(255*M(:,:,i),tmp);
    end
    output = output(:,:,2:end)/ 255;
end
```

Persistent Frame Differencing is also known as motion history images. It has a linear decay term. The motion detected previously will decay with time, having smaller value. The most bright one will be the motion that is newly detected. This is good for determining the motion vector of the object because we know which direction the object is moving. By knowing the previous location information of the object, we are able to have more detail on the objects.

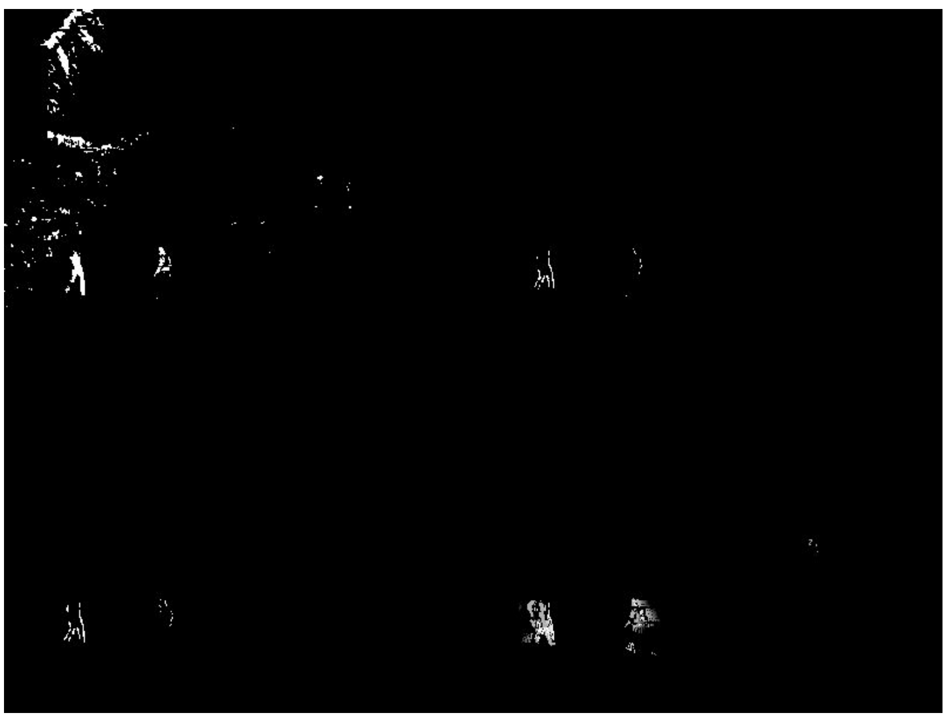
Result

Different Thresholds

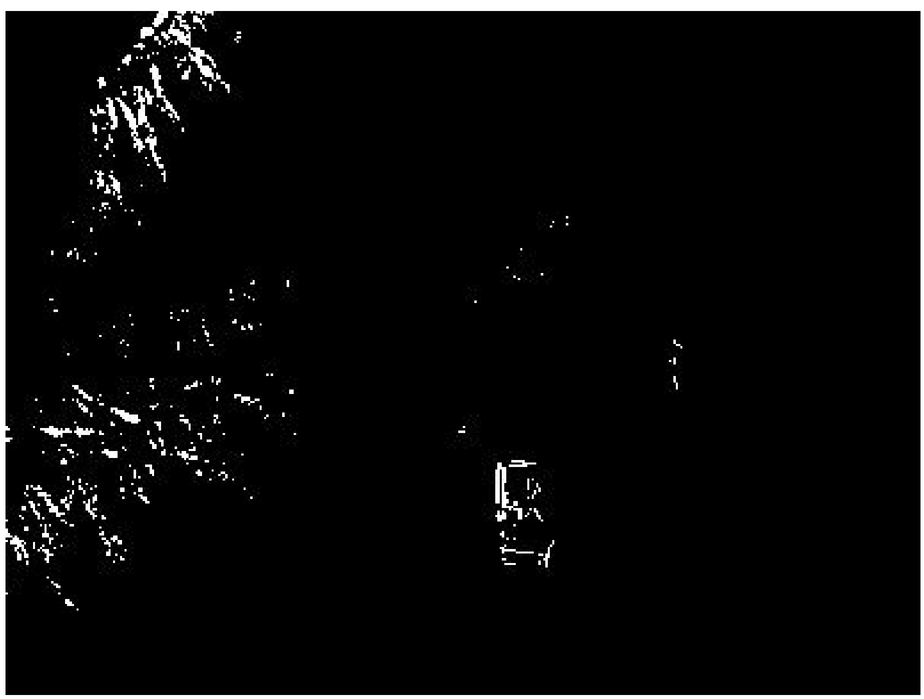
We try couple difference thresholds and generate different results, as shown below. And we choose the one that gives us the most reasonable result, which is 30.

As shown below, we can see that when the threshold is too low, the result has many noise at the background where there is no motion. And when the threshold is too high, the result has less detail on the moving object as well as the background.

threshold = 5	

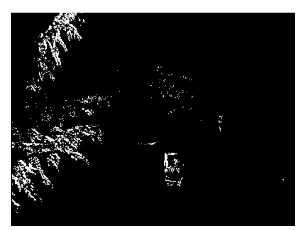
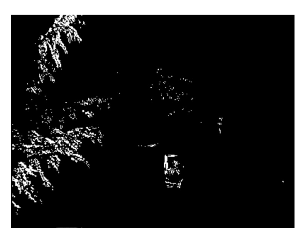
threshold = 30	
threshold = 100	

Adaptive Background Subtraction with Different Alpha

Alpha value	Image
0.1	
0.5	

0.9	

When we keep the threshold and only change alpha value, if we set alpha value near 0, the output image is close to that produced by simple background subtraction. When we set alpha value near to 1, the output image is close to that produced by simple frame differencing.

Alpha value	ABG	SBG	SFD
0			
1			

From the images above, we can find when we keep the threshold and set alpha value to 0, Adaptive Background Subtraction produces same image as Simple Background Subtraction does. When we set alpha value to 1, Adaptive Background Subtraction produces same image as Simple Frame differencing does.

Persistent Frame Differencing with different Decay Parameter

The parameter Gamma plays an important role in the persistent frame differencing algorithm. When the parameter is large, the previous motion has less impact on the motion detection. In other words, the motion detection contains less information of the previous motions. That is because when it is large, the previous frame's pixel value minus the parameter and it will rapidly drop below 0 and the information would be buried in the max test. But when the parameter is small, the more "shadow" will be in the motion detection because more previous information is contained.

Decay	
100	

26	
5	

Experimental Comparisons

We can see from the top left image, the result of simple background subtraction, the result shows that the leaves are moving, but the leaves in the input are not moving. The simple frame differencing can only capture the two moving people, but it only show the edge of the moving object.
The adaptive background subtraction have a thicker edge than the result of simple frame differencing, which make it easier to recognize the object.
The result of the persistent frame differencing left the trace of the moving object.

When the background is moving dramatically the simple background subtraction produces a terrible results, as shown below. The reason is that The simple background subtraction will not adapt the new background.

In conclusion, we prefer to use the persistent frame differencing. It has couple advantages over other algorithm. It will not robust enough to adapt the background when some object stop moving. It also gives us information about the direction and speed of the moving object.