Individual lab report #8

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Individual Progress

- Designed an integration mechanism on RGB and Thermal signature detection algorithms.
- Compared the independent algorithms and the integrated one based on OSU Color and Thermal Database.

Integration Mechanisms for RGB and thermal signature detection

1) Assumption

1. Thermal signature detection
    - Low resolution
    - Heated objects which are no humans (a lot of noises)
2. RGB signature detection
    - Higher resolution
    - Fewer noises
    - Higher accuracy
3. The RoIs where both Thermal and RGB algorithms detect as humans are very likely to be humans. So, the basic idea of doing the integration is to find the relationship between RGB and Thermal bounding boxes and decide which bounding box has human in it. As Figure.1 shows, we can see the overlapped region between RGB bounding boxes(white-positive) and the thermal bounding boxes(green-positive). This is the region that might possibly has human.

Figure.1 Find the overlapped region between RGB bounding boxes(white-positive) and the thermal bounding boxes(green-positive)

2) Implementation

Initially,

a. Map the thermal bounding boxes to RGB images
b. Calculate the overlapped area of RGB and thermal bounding boxes with humans
c. If the area of the overlapped region is over a threshold (0.7), then count the bounding box as RoI with human.

However, this method might not be applied to all scenarios. In many cases, I found out that we cannot easily find the common region in both RGB and thermal bounding boxes. Even though in most of these cases, there are human being detected. To be more specific, see Figure 2 which shows that in one frame thermal bounding box (the right picture) has no overlapped region with RGB bounding box (the left picture). In conclusion, simply using the overlapping method cannot take every bounding box into account. We have to do something to measure their ability of detecting humans.

Therefore, I did some improvement on this method.

a. Map the thermal bounding boxes to RGB images
b. Set some weights on each of the positive and negative bounding boxes for both RGB and thermal images.
c. Calculate the overlapped area of RGB and thermal bounding boxes with humans. And add weights on corresponding positive bounding boxes based on the different overlapping situations.
d. Designate a threshold for choosing the bounding boxes whose weight is over than it, then count those bounding boxes as RoIs with human and return them.

Description on all the weights and threshold

Weight Parameter	Description	Value
α1	RGB positive	3
α2	RGB negative	-1
α3	Thermal positive	2
α4	Thermal negative	-2
α5	RGB positive overlaps Thermal positive	5
α6	RGB negative overlaps Thermal positive	-1
α7	RGB positive overlaps Thermal negative	-2

Threshold Parameter	Description	Value
θ1	% of RGB positive overlaps Thermal positive	0.4
θ2	% of RGB negative overlaps Thermal positive	0.4
θ3	% of RGB positive overlaps Thermal negative	0.4
θ_weight	Choose the bounding boxes above this threshold to be human locations	1 - 3

Tests on OSU Color and Thermal Database

1) Introduction of OSU Dataset

This is a publicly available benchmark dataset for testing and evaluating novel and state-of-the-art computer vision algorithms. Several researchers and students have requested a benchmark of non-visible (e.g., infrared) images and videos. The benchmark contains videos and images recorded in and beyond the visible spectrum and is available for free to all researchers in the international computer vision communities. Also, it will allow a large spectrum of IEEE and SPIE vision conference and workshop participants to explore the benefits of the non-visible spectrum in real-world applications, contribute to the OTCBVS workshop series, and boost this research field significantly. This effort was initiated by Dr. Riad I. Hammoud in 2004. It was hosted at Ohio State University and managed by Dr. James W. David until 2013. It is currently managed by Dr. Guoliang Fan at Oklahoma State University.

In our case, we use the thermal and RGB image dataset for integration and comparison. There are 6 sets of images in this dataset. I haven’t done too much numerical experiment this time. Because the parameters might not be optimal and we do not want to tune it with online dataset. The basic idea in this test is to prove the final shows less false positives and higher possibility of detecting humans compared to two independent algorithms

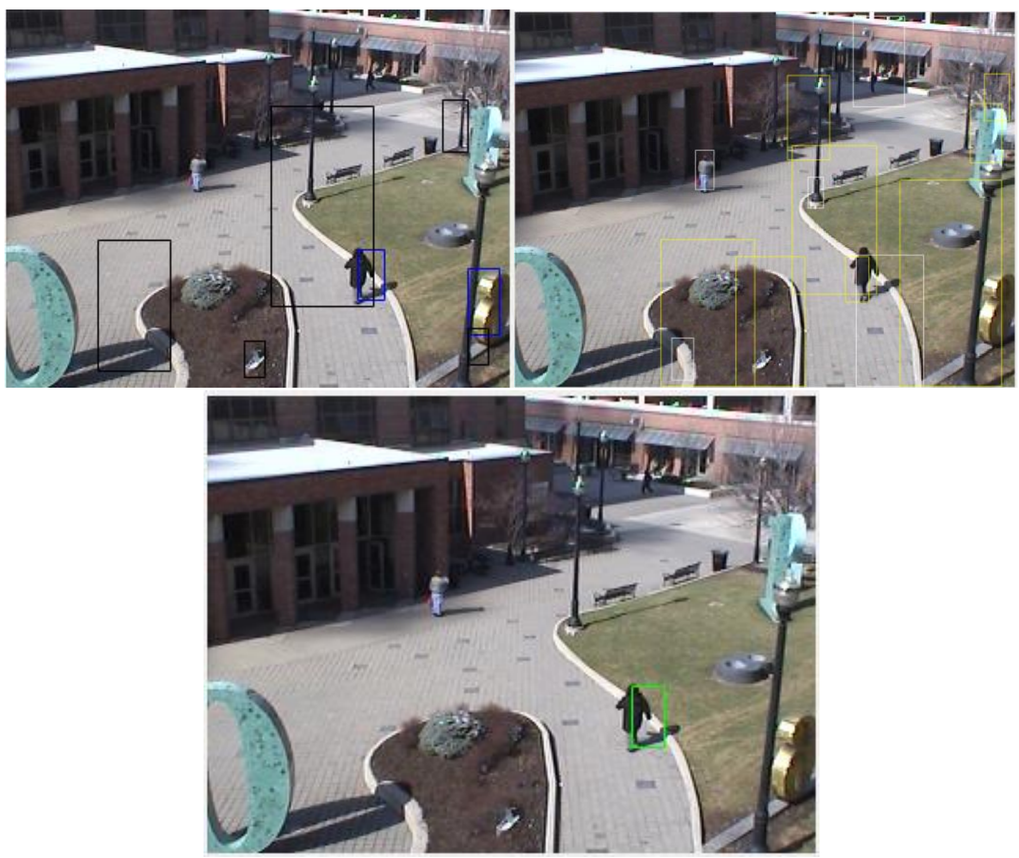

Figure.3 The overall performance of the integration(up-left:RGB, up-right:thermal, down-middle: overall)

p.s. Blue boxes represents for RGB positive bounding boxes, white boxes represent for thermal positive boxes

As we can see in Figure. 3, there are lots of false positives in both RGB and thermal cases. However, after applying the weight updating mechanism to each boxes, we can eliminate those positives in RGB or thermal which overlap the negatives in another algorithm. And this becomes very efficient in eliminating false positives. On the other hand, this mechanism can maintain those positives in RGB or thermal which overlap the positives in another algorithm. This is very useful in determining the true positives.

Also, it might be the case that RGB or thermal outperforms another algorithm in some scenarios. In this case, we can depend only on RGB or thermal by adjusting weight threshold.

p.s. In Figure 4 & 5

Blue boxes represent for thermal positive bounding boxes, yellow boxes represent for thermal negative boxes

Green boxes represent for RGB positive bounding boxes, red boxes represent for thermal negative boxes

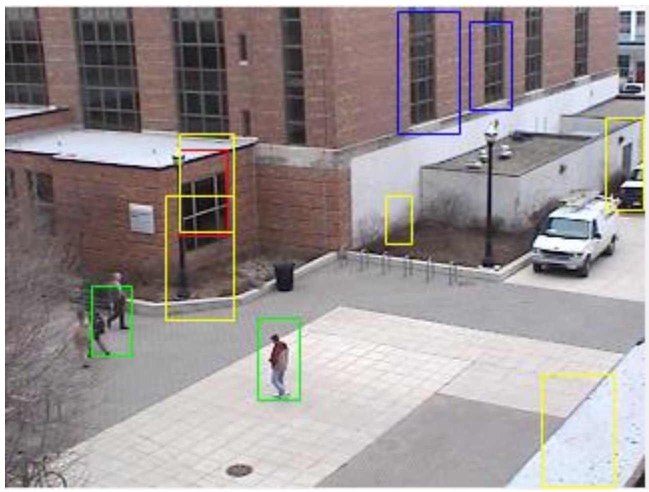

Figure.4 Situation where RGB has a better performance (high weight threshold)

Figure.5 Situation where thermal has a better performance (low weight threshold)

Challenge

1. After first implement the initial integration algorithm I found out that in some cases, we cannot easily find the common region in both RGB and thermal bounding boxes. The reason might be that for thermal detection, the background changes a lot due to illumination and heat issue. So, thermal algorithm cannot detect human sometimes. Similarly, if the background color is too bright or there are a lot of color variations in one scene, it's also very hard for RGB detector to find human in that region. Therefore, after a longtime consideration, I determined to build a weight matrix for all bounding boxes. Hopefully in this way, we can leverage both algorithms better.
2. Tuning all the parameters including weight in the integration process and the threshold in preprocessing process (find all bounding boxes) will be very troublesome if we want to obtain a better result. We cannot depend only on manually setting all the parameters in the end due to the complexity of test situation. So, we can work on automatically tuning parameters using machine learning or feedback control.

Team Work

In this week, Juncheng (Henry) devoted most of his time exploring thermal images feature tracking and segmentation. Karthik worked on improving the performance on sound detection by using the new microphone. Sumit mainly focused on implementing FNN on Tensorflow and find the possibility to extend it into CNN in the future.

Future Work

Before the next progress review, I will try to improve the integration on RGB and thermal algorithm and get training data from our new cameras. Juncheng will also help on this and explore more on mitigating Matlab code to Python. Sumit will develop CNN and improve bright object detection. He also will get GPS location of signature from image. Our whole groups will work on showing end to end working with a video. Migration to python can be ongoing.