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Image Processing
Lab3-4 Object Tracking

The goal of this lab: is to implement a simple object tracker based on the Particle Filter.

1. Tracking simple objects in videos

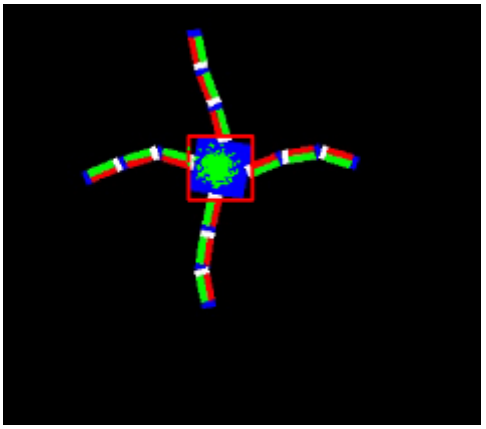
1.1. ParticleFilters

Step 1: Initialize the tracked area by determining the position of the center of the rectangle and its size.

The frames in the video are (640, 480) which means that the center is located at (640/2, 480/2)

Step 2: Calculate the reference histogram h_{ref} associated with the initial tracked area.

We started by defining a make_box function that creates a bounding box over the area we want to track



Plot 1: Rectangle initialization

We then calculate the histograms of the areas inside the bounding boxes. We started by calculating the reference histogram href. this histogram will be used for identifying the next bounding box position using the following distance function:

$$dist(h, h') = (1 - \sum_{i=1}^{N} \sqrt{(h(i)h'(i))})^{\frac{1}{2}}$$

We could not use this function because it is missing a normalization term and all the values are either negative or null.

To fix this error we used the Bhattacharyya distance:

$$dist(h, h') = (1 - \frac{1}{\sqrt{h1 * h2 * N^2}} \sum_{i=1}^{N} \sqrt{h(i)h'(i)})^{\frac{1}{2}}$$

(we used a predefined function for this measurement to increase the speed of execution of the model)

Step 3: Initialize a set of N particles by generating random positions around the center of the tracked area. Initial particle weights are set to $w_0^i = 1/N$, i = 1, ..., N.

We initialized a set of random points, around which we created bounding boxes similar to the reference image, and we compared the histogram distance of each one to the reference histogram h_ref.

Step 4: It includes 3 main steps in the Particle Filter. At every instant k, a set of N particles with associated weights{xi k, wi k}, i=1, ..., N is maintained to track the object. Note that particle weights are normalized so that N i=1wi k=1.

- **Prediction:**

In this step, we predicted the bounding box position at each frame using histogram distances

- **Correction:**

Now that we have predicted the position of the tracked object we used the likelihood function to correct these predictions by updating the weights as follows:

$$w_{k+1}^i \propto g(y_k^i|x_k^i)w_k^i$$

Having:

$$g(y_k^i|x_k^i) \propto \exp(-\lambda dist^2(h_{ref}, h(x_k^i)))$$

h_ref is the reference histogram, h(xk^i) is the histogram associated with the particle xk^i and lambda is a constant

- **Resampling:**

When the majority of the particles have low importance/relevance we use resampling, by "boosting" the more important particles and reducing the influence of the less important ones. To do so we tried three different methods

1. Systematic Resampling

This method calculates the cumulative weights of the particles Wi

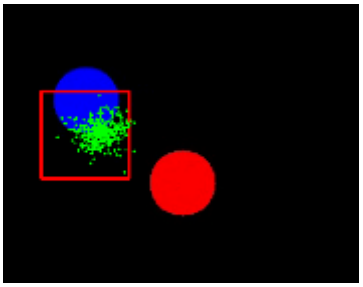
$$Wi = \sum_{j=1}^{i} w_j$$

It then generates a random number in [0;1]

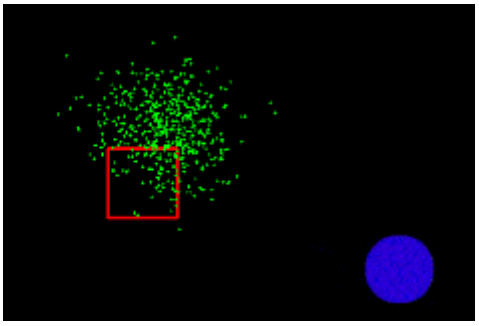
which will be used to select the corresponding cumulative weight of the particles. Based on this we create a new set of particles.

Testing the effect of window size:
When testing on the video sequences provided with the Tp, we were able to track the center object. We tested different window sizes,

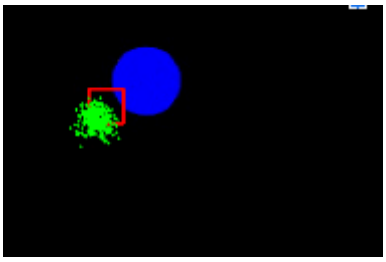
- 1st Test : Window Size = 60



- Second Test: window size = 40



- Third Test: Window size = 20



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