University Of Maryland

College Park

ENPM - 673 Perception of Autonomous Robots

Project4

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Video Links:

Video Name	Link
Tracking Usain Bolt 100m run—Lucas Kanade Object Tracking	https://www.youtube.com/watch?v=4Lh4ISospVQ
Dragon versus Baby—Lucas Kanade Object Tracking	https://www.youtube.com/watch?v=i4TaXdF2sTY
Tracking a moving car—Lucas Kanade Object Tracking	https://www.youtube.com/watch?v=o-suy8SslAo
Tracking a moving car—Lucas Kanade Object Tracking	https://youtu.be/Zbeu6yfYEiQ

Github Link:
https://github.com/govindak-umd/ENPM673/tree/master/Project%204

Libraries used :

1	import numpy as np
2	import cv2
3	import glob
4	from scipy.ndimage import affine_transform
5	import matplotlib.pyplot as plt
6	import math

Aim:
The main objective of this project is to implement the Lucas-Kanade (LK) template tracker on the given three data sets that of a car on the road,a baby fighting a dragon, and Usain bolt's race.

1 Answer

Lucas Kanade
The Lucas-Kanade is an optical flow algorithm which can be used to estimate the movement and features of the image in the next frame of the image. There are a few assumptions that are taken into considerations while accounting this algorithm so that the best outcomes are achieved such as

1. The two images are separated by a small time increment Δt, in such a way that objects have not displaced significantly

2. The images depict a natural scene containing textured objects exhibiting shades of gray

The algorithm does not use any colored scenes and also does not scan the second image and check for its pixels.Instead this algorithm tries and predicts the movement in which the image could have moved and tries to account for the change in intensity.
The local change in intensity is represented as

$$I_x(x,y) \cdot u + I_y(x,y) \cdot v = -I_t(x,y) \tag{1}$$

where,
I_x is the increase in brightness per pixel in x direction
I_y is the increase in brightness per pixel in y direction
u is the movement in x direction
v is the movement in y direction

A pixel usually does not contain appropriate structures that can be used to compare with another pixel. So a simplified set pf 9 linear equations is used which is depicted as

$$S \begin{pmatrix} u \\ v \end{pmatrix} = \overrightarrow{t} \tag{2}$$

To find out the movement in both x and y directions we apply the Least Square method. Thus the equation is obtained as,

$$\begin{pmatrix} u \\ v \end{pmatrix} = (S^T S)^{-1} S \overrightarrow{t} \tag{3}$$

The Lucas-Kanade algorithm eliminates regions without structure by looking at the invertibilily of the matrix $S^T S$ in an indirect way, that is, through the eigenvalues of this matrix.

The main advantage of the algorithm is, that for a neighborhood of fixed size,the number of operations needed to compute $(S^T S)^{-1} S^T \overrightarrow{t}$ are constant, and therefore the complexity of the algorithm is linear in the number of pixels examined in the image. Alternative algorithms that match similar regions using a neighborhood, and scanning the second image, have quadratic complexity.

The Lucas-Kanade algorithm is an efficient method for obtaining optical flow information at interesting points in an image. It works for moderate object speeds.

Basic Images:

Bolt

Dragon vs Baby

Car

Templates:

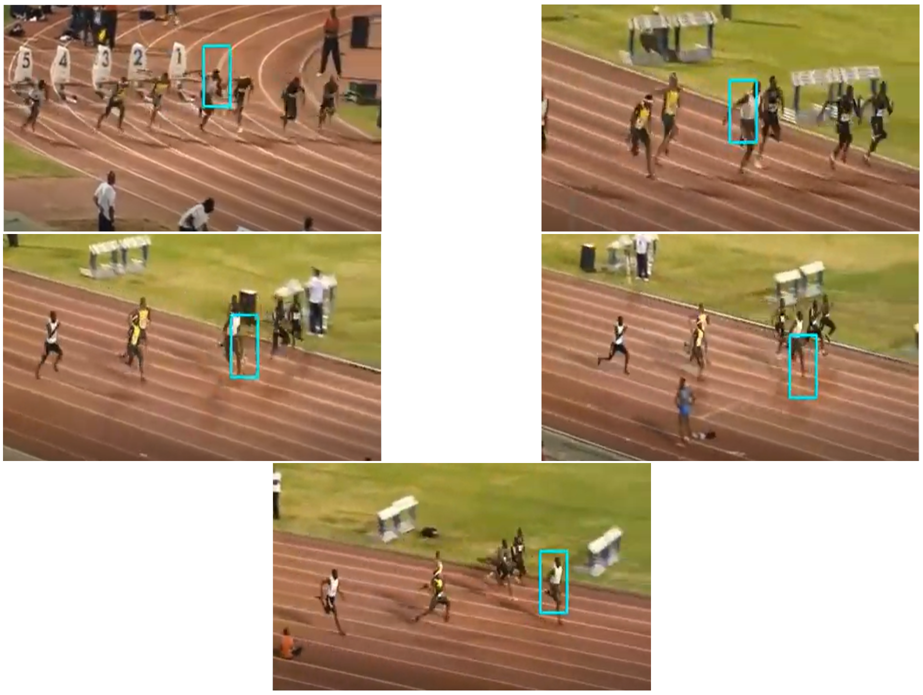
Bolt

Dragon vs Baby

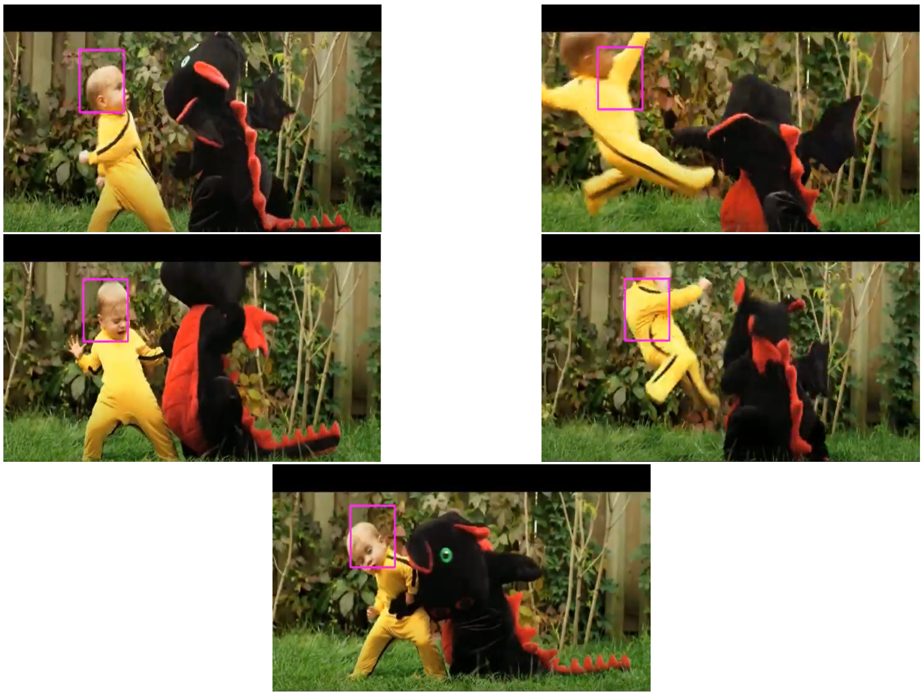
Car

Snapshots:

1.1 Bolt



1.2 Dragon vs Baby



1.3 Car

Challenges:

Some of the challenges that was faced was the tracking of subjects in challenging lighting conditions. Specifically :

1. The car was moving under changing brightness conditions because of the shadow caused by nearby objects and the bridge. The caused the tracker to lose position when it came across the above mentioned obstacles.
2. Bolt image had a fast moving camera. Hence, it was necessity to reduce the image size to reduce the resolution.
3. The baby fighting a dragon also had very fast shots. Hence, the image was considerable reduced in its resolution before doing any Lucas Kanade operations.

2 When does the LK tracker breakdown

There are quite a few cases in which improper functioning of the LK tracker can occur.The main possibilities are

1. There could be error in the eigen values causing aperture problem i.e. the direction of motion is ambiguous because of which various orientations moving at different speeds can cause similar responses. This is solved by ensuring that both the eigen values are almost of same magnitude and large values.
2. As mentioned earlier another major issue is when the motion between two frames is large.In general this should be very small, less than that of a pixel spacing, so that the optical flow algorithm can be applied.When this happens there are possibilities of this tracker not functioning properly. To rectify this the resolution of the image can be lessened and then the tracker can be applied.
3. The problem of occlusion also occurs because of which the tracker might function improperly. Occlusion occurs in tracking when one part blocks another. This is overcome by updating the template with the last image.

3 Robustness to Illumination

The car travels through a change in brightness due to the shadows casted by the tree as well as the bridge. Hence a gamma correction is applied along with image improvement techniques such as CLAHE and histogram equalization. Hence, this improvement can be seen in the video outputs, linked above.