Projectile Tracking and Launch Point Prediction

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ABSTRACT

The project aims at creating a path projection for a projectile launched from a source so as to determine the source of the said projectile.This can be applied in military field where it can be utilized to track an artillery barrage.By determining the position of the gun, it will make it easier for the army to strategize. We intend to accomplish this via image processing to track an object in 3d space and reverse project its course.

Keywords -**Computer Vision, Object Detection, Object Tracking, Trajectory Mapping**

1. Introduction

Computer Vision is a field of computing that involves processing and analyzing visual data in order to interpret and understand the information. This information can then be processed to produce accurate high-quality result that cannot be deciphered by naked vision.

Computer vision technology can be used to interpret the input for various purposes. For our project we need multiple cameras so that we can view a projectile from multiple angles which enables us to get a perception of depth and place it in a 3D space.

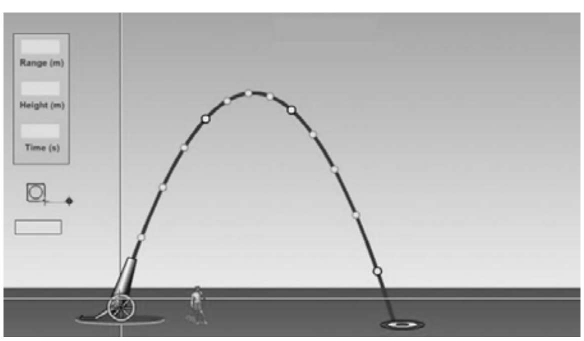

Fig. 1: Actual path

Fig. 2: Path detected and captured

After successfully detecting a projectile midway its path, we need to track its trajectory in flight. The trajectory we track can then be reverse projected to find the source. The object that is launched from the ground will take a parabolic route to the target. We can use this to calculate exactly where the said projectile was launched.

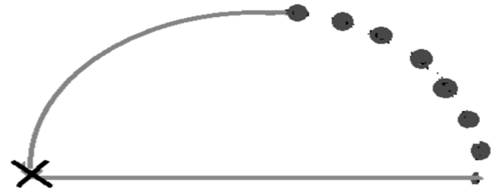

Fig. 3: Predicting the source

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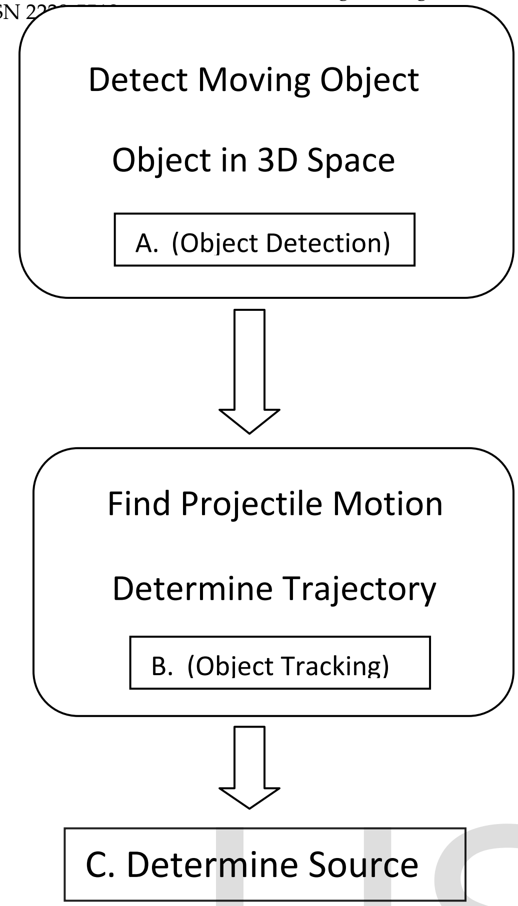

Fig 4: Workflow

Such an application can be useful for the military since it can be used to detect the source let the soldiers know where the enemies are firing artillery from.

The position of the opposition forces are vital for armies to form their strategy. This information can be very useful. Such information can not only allow the forces to assault effectively but it can also save lives of several soldiers.

To accomplish this we can use image processing using computer vision.

Videos are represented as some hierarchical structure units like scene, shot and frame. In video retrieval, generally, video application must partition a given video sequences into video shots. A video shot can be defined as the video frame sequence that presents continuous action. The frames in video shots are captured from a single operation of one camera. The complete video sequence is formed by joining two or more frames which are considered as input to the object tracking.

2. Modules

The aim here is accomplished by dividing it in two steps. As we can see in Fig. 4, first we need to detect the object using two cameras. Since capture the object from two different angles, we can use the difference to position it in 3D space, i.e., determine the distance of the object from the camera.

After we have that, we can determine the trajectory of the object in 3D space by tracking it in successive frames of a video, and then successfully determine the source by reverse projecting the path.

We have the following modules that we divided the project in:

2.1. Object Detection

Object detection is the process of finding instances of real-world objects such as faces, bicycles, and buildings in images or videos.Object detection algorithms typically use extracted features and learning algorithms to recognize instances of an object category.It is commonly used in applications such as image retrieval, security, surveillance, and automated vehicle parking systems

Every tracking method requires an object detection mechanism either in every frame or when the object first appears in the video.Detection methods can make use of the temporal information computed from a sequence of frames to reduce the number of false detections.This temporal information is usually in the form of frame differencing, which highlights changing regions in consecutive frames.

Common methods for detection are:

- Point detectors
- Background Modeling
- Supervised Learning

2.2. Object Tracking

Real time object tracking is defined as the process of estimating trajectory or path of an object in

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consecutive frames. The main goal of object tracking is the process of segmenting the interest of an object or multiple objects from the video scene and keeping track of its motion, occlusion and orientation. It is challenging and interesting task to track the object of interest using image processing techniques for various applications.

Object tracking is an important task within the field of computer vision. The proliferation of high-powered computers, the availability of high quality and inexpensive video cameras, and the increasing need for automated video analysis has generated a great deal of interest in object tracking algorithms. There are three key steps in video analysis: detection of interesting moving objects, tracking of such objects from frame to frame, and analysis of object tracks to recognize their behavior (Yilmaz, 2006).

The aim of an object tracker is to generate the trajectory of an object over time by locating its position in every frame of the video. The tasks of detecting the object and establishing correspondence between the object instances across frames can either be performed separately or jointly.Common methods for Tracking are:

- Point Tracking
- Kernel Tracking (Yilmaz, 2006)
- Silhouette Tracking (Yilmaz, 2006)

2.2.1. Comparative Study and Analysis

Point tracking is required for our project since it is best suited for our project keeping with our constraints. Here, we do a comparative study on three common algorithms used for this purpose.

GOA (Veenman et al., 2001) Uses Greedy Approach based on proximity and rigidity constraints Common motion constraint for correspondence.
MFT (Shafique and Shah, 2003) Multi-frame approach to preserve temporal coherency. Multiple frame correspondence relates to finding the best unique path $P_i = \{x_0,\ldots,x_k\}$ for each point.
MHT (Cox and Hingorani, 1996) Motion correspondence is established using only two frames. Maintains several correspondence hypothesis for each object at each time frame.

TABLE. 1

Algo.	No. of Objects	Entry	Exit	Occlusion
GOA	Multiple	×	×	√
MFT	Multiple	√	√	√
MHT	Multiple	√	√	√

TABLE. 2

3. Object Positioning in 3D Space

We create a setup where we use two cameras set at a specific horizontal distance(**b**) from each other. The cameras used are identical and we already know the angle of its field of view. We can use this knowledge to ascertain the distance of object with respect to the position of cameras. In fig. 5, we have a perpendicular reference(D) from the object to the baseline (i.e. the horizontal displacement between two cameras.) The distance to the object can only be appropriately determined if it happens to lie in the field of view of both the cameras.

We can see that the perpendicular projection of the object to the baseline of the cameras divides it into two parts named b_1 and b_2 and it also creates two angles named θ_1 and θ_2 respectively.

$$tan\theta_1 = \frac{b_1}{P}$$

$$P.tan\theta_1 = b_1 \ (1)$$

$$tan\theta_2 = \frac{b_2}{P}$$

$$P.tan\theta_2 = b_2 \ (2)$$

We know the value of b, since it is our initial setup. However, we still need to figure out the angles θ_1 and θ_2. Figure 6 is a representation of one half of each of the cameras. We can use the ratio between the distances of the object from the field of view with

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respect to that of the object from the perpendicular to the camera.

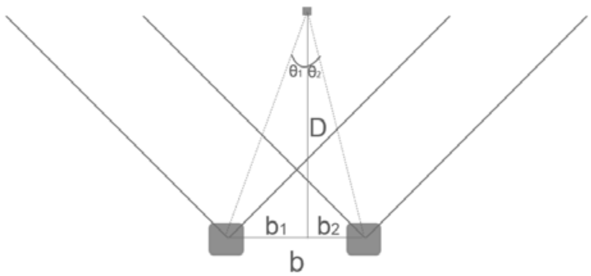

Fig. 5

Adding (1) and (2)

$$P.tan\theta_1 + P.tan\theta_2 = \mathrm{b}_1 + b_2$$

$$P.(tan\theta_1 + tan\theta_2) = \mathrm{b}$$

$$P = \frac{\mathrm{b}}{tan\theta_1 + tan\theta_2} \;(3)$$

Where,

$$tan\theta_i = \frac{\mathrm{m}}{\mathrm{P}}$$

$$\rightarrow P.tan\theta_i = \mathrm{m}\;(4)$$

$$tan\alpha = \frac{\mathrm{m+n}}{\mathrm{P}}$$

$$\rightarrow P.tan\alpha = \mathrm{m+n}\;(5)$$

Subtracting Equation 4 from Equation 5, we get:

$$n = \mathrm{P}.(\tan\alpha - tan\theta_i)\;(6)$$

Dividing Equation 4 by Equation 6, we get:

$$\frac{\mathrm{m}}{\mathrm{n}} = \frac{P.tan\theta_i}{\mathrm{P}.(\tan\alpha - tan\theta_i)}$$

Substituting $\frac{\mathrm{m}}{\mathrm{n}}$ with r

$$\mathrm{r} = \frac{tan\theta_i}{\tan\alpha - tan\theta_i}$$

$$\mathrm{r}.(\tan\alpha - tan\theta_i) = \tan\theta_i$$

$$\tan\theta_i = \mathrm{r}.\tan\alpha - r.tan\theta_i$$

$$\tan\theta_i + r.tan\theta_i = \mathrm{r}.\tan\alpha$$

$$\tan\theta_i.(\mathrm{r}+1) = \mathrm{r}.\tan\alpha$$

$$\tan\theta_i = \frac{\mathrm{r}.\tan\alpha}{(\mathrm{r}+1)}$$

$$\theta_i = \tan^{-1}\frac{\mathrm{r}.\tan\alpha}{(\mathrm{r}+1)}$$

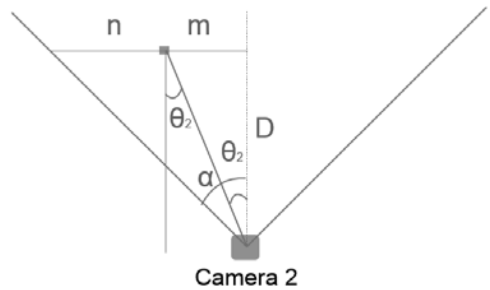

Fig. 6

4. Gaps

Currently the most widely used system similar to the project is the popular hawk eye technology used to determine the path of the ball in games like cricket and tennis. However, it requires six cameras placed at specific positions around the stadium and the stadium data to be input beforehand for it to work properly. (Duggal, Manish. "Hawk Eye Technology.")

Such a luxury is not available for such an application in real world.

5.Conclusion

Using this system we can create a path projection for a projectile launched from a source so as to determine the source of the said projectile.

Object detection in 3D space is the first step in order to accomplish our objective. This simple setup is enough for us to make calculations fairly accurately.

Future work on this will include tracking the object in 3D space and derive an equation for its path. That equation could be later used to determine the source of the projectile.

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