Real-Time Projectile Detection and Trajectory Prediction

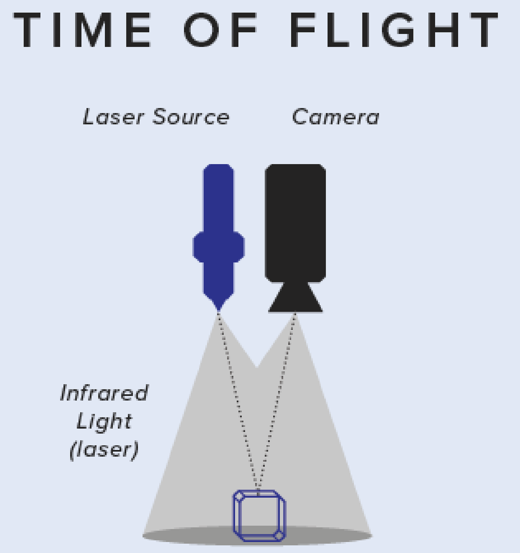
Liam Day, BEng (Honours) Software & Electronic Engineering

Summary

The recent availability of low cost RGB-D ("D" is for "Depth") cameras such as the Microsoft Kinect has led to a wave of development in computer vision applications. This project is an investigation into the real-time capabilities of computer vision by using an RGB-D camera to detect an aerial projectile, map its position in 3-dimensional space and predict its remaining trajectory relative to a target area. With the aid of OpenCV, an open-source Python library for computer vision development, the system provides real-time impact coordinates to enable any form of mechanical or digital interaction with or interception of the projectile.

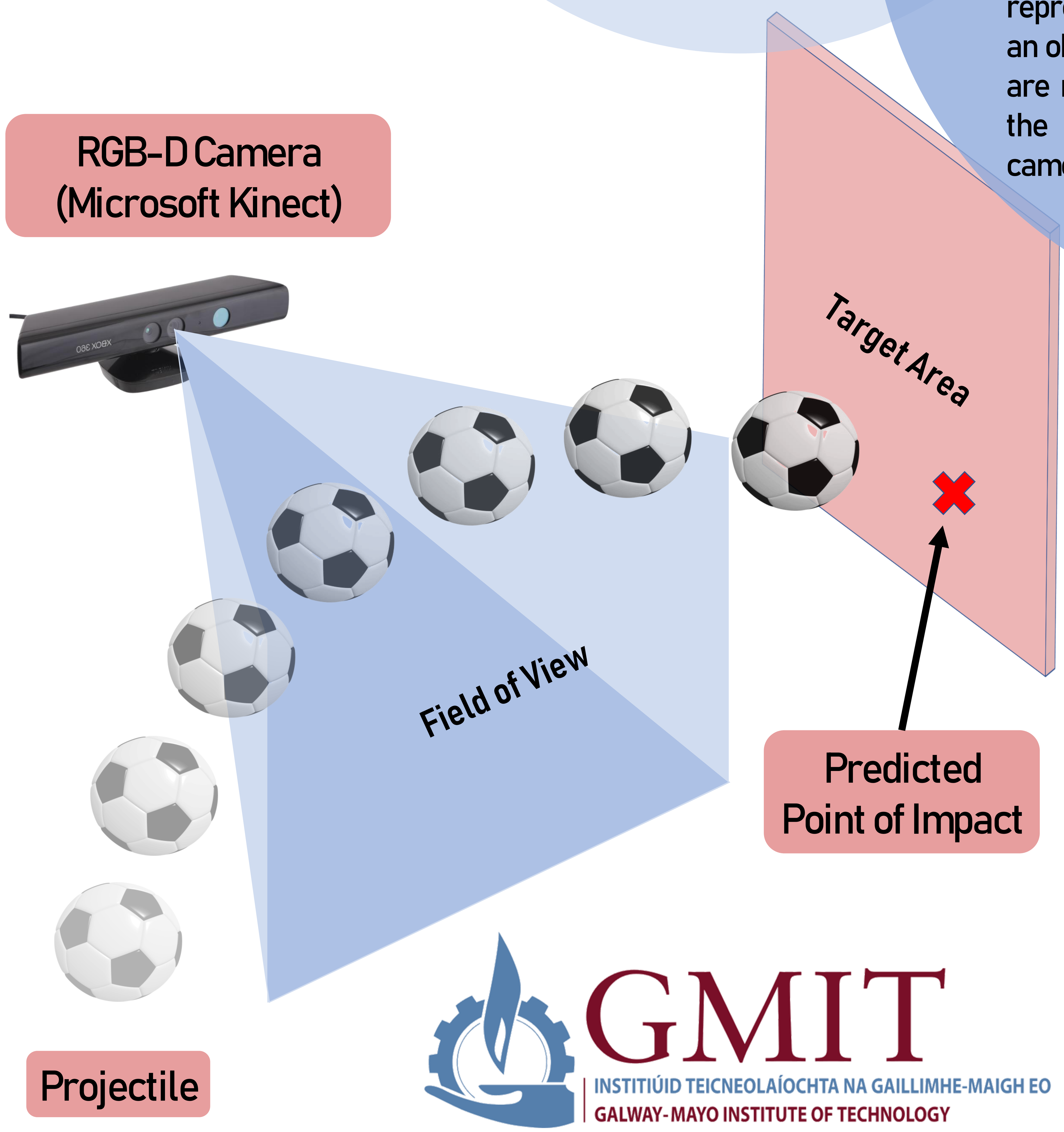
RGB-D (Depth) Cameras

RGB-D cameras use an infrared Time-of-Flight sensor to understand the depth information of a scene. The depth of an object is determined by measuring the time it takes for an infrared light wave emitted from a laser to travel to the object, reflect off it and return to the infrared receiver.



Projectile Tracking

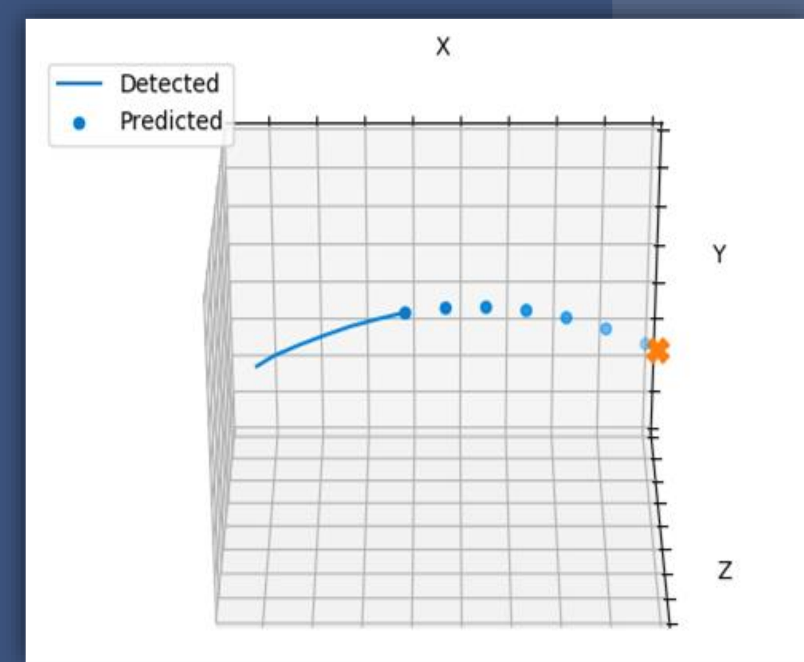
Using a method known as Background Subtraction, the projectile can be detected by the system as it moves across the view of the camera. Background Subtraction is the process of cross-referencing the current frame with the "background image", which is captured when the system is initialised. If there is any difference detected in the frames, it can be concluded that the difference represents a moving object in the scene. Once an object is detected, its X, Y and Z coordinates are recorded in each subsequent frame until the object is no longer in the view of the camera.



Applications

The projectile detection system is designed to be generic and versatile, meaning possible applications are numerous and varied. For instance, it may be applied in a weaponized defence systems, where the projectile is an incoming missile. Other possible applications include sports training and statistics collection (e.g. tennis, hurling, golf) systems and industrial automation.

Trajectory Prediction



The system utilises the fact that, when ignoring air resistance, a trajectory curve is always symmetrical around the highest point, (i.e. when the vertical velocity = 0) thus making it a 2nd degree polynomial, or quadratic, function. Using the 3D points of the projectile that are detected in each frame that it is in view of the camera, polynomial interpolation can be used to find the coefficients that best describe the trajectory curve as a quadratic function. From this function we can accurately calculate the exact point of impact with the target area.

GMIT
INSTITIÚID TEICNEOLAÍOCHTA NA GAILLIMHE-MAIGH EO
GALWAY-MAYO INSTITUTE OF TECHNOLOGY