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OBJECT DETECTION, TRACKING AND PATTERN RECOGNITION MODEL USING EDGE COMPUTING AND MACHINE LEARNING ALGORITHM

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Abstract : The Internet of Things(IOT) devices like video cameras and sensors have small memories and less computational power. Traditional approaches for detecting, tracking and recognition of moving objects used only in the cloud computing. This approach suffered from high latency and more network bandwidth to transfer data into the cloud. We address this computing, IOT devices can't handle high computation cost workload so we try to reduce computation cost of detection method which need to use CNN in video and simultaneously perform object detection/tracking. Multiple object detection, tracking and time series prediction are fundamental challenges in modern computer vision. Although deep learning has made significant strides in solving sum of the sub-problems, there are still many problems lacking satisfactory solutions, especially in real world application. Object detection and tracking are usually treated as two separate process. Which perform detection on every frame, so here I use tracking-by-detection pipeline by successfully detection on first frame and tracking associate by detection result. We will use well-known reference model of detection and tweaked the parameters extensively try to reduce load from cloud to edge which improve response time which indirectly reduce latency with better bandwidth availability, skipping detection from every frame and remove idle frame from computation which reduce computation cost with time budget. This output can be used for any further analytics like counting, direction finding, speed estimation etc. One of the fundamental application which is automotive use Edge-Computing as a single standalone processing power.

Index Terms **- Edge Computing, Object Detection, tracking, YOLO**

I. INTRODUCTION

Object detection is the technology of computer vision field for locating instance of object in images or videos.it consist wide application area in: autonomous vehicle vision, smart home, smart industries, visual surveillance and robot vision for human-computer interactions. Object detection algorithms uses machine learning or deep learning which can produce meaningful results of images or video, and for interest of object to recognize and locate that object within an image or video. For video there is a matter of moments of the object. The goal of object detection is to detect all instances of objects into image or video frame from known class or labels such as car, person etc. as intelligence using a computer [1].
There are few Object detection methods which are based on deep learning.
Deep learning based method uses convolution neural networks(CNNs) for example R-CNN and YOLO algorithm of detecting object. This method automatically learns to detect objects in images or frame of video [1].

Figure 1: Object Detection [1]

Deep learning based approaches:
In First Approach Create and train a custom object detector: In this method design a network architecture, this architecture learns the feature of object and train the model from scratch and CNN is trained by huge set of labeled
data. In this method layers of network are set manually and weights set manually. For doing this take a lot of time of this all settings and training.

In second Approach use a pre-trained object detector: with the concept of transfer learning we can perform detection with pre trained CNN and we also can fine tune it in our application. By this approach we can get faster result because the network has already trained on many like thousands or millions of images. this approach save time of training the CNN and we can use it by downloading weights and config files of CNN[1].

II. Bringing Intelligence to Edge Computing Through Machine Learning

Edge computing use machine learning concept as one of the top use case. Models of machine learning support augmented and virtual reality. Machine learning will find similarity or some patterns in data and from that perform actions.ML is using in industrial Internet of things, performing intelligence in smart devices, for smart healthcare and cities, and Connected vehicles with combining with edge computing.ML is giving smartness and edge is giving how to access or via through access this smartness like human. Low-Powered devices are not alone capable to make communication with public cloud platform so they connect with edge computing layer using gateway. with help of this layer and GPU the models of ML can train on cloud and result send back to edge for any actions.

Machine Learning model run on Edge which enable intelligence to device with help of IOT. This consider Edge computing as server less computing, ML will function as a service or ML will be used as integration platform as a service, we can say that ML model can drive the Edge computing. edge computing also enable the interoperation of deep learning model with ONNX open neural network exchange [7].

For cloud application data processing or storage is at cloud at far but in edge computing it is the type of framework where the storage or processing is done near to the IOT device or at the local edge server. because of this near operations this framework is providing benefits like improvement in response time and low latency but this benefits are depends on available bandwidth of network.

Today IOT devices are increasing and data of this device increments simultaneously. As 5G arrive the data of the connected mobiles or devices grow more and more day by day. our todays life is becoming digital day by day with the mobile devices. In past cloud was giving a solution for AI to automate and speed un the innovation by insights from data. data is increasing same time the complexity of accessing those data is also increasing. this all together increase burden on network and infrastructure capacity. there are some latency issues of cloud service. And congestion in network arise bandwidth issues.so for this edge computing give better solution which analyze and process the data near the creation place of data and data do not have to traverse to distanced location through network due to that latency is reduced. Faster and Comprehensive data analysis can be possible with help of the 5G and mobile Edge computing. large chunk of data will be possible to access near and give user a good experience of using intelligence via application.

III. Comparison of Edge Computing with Cloud Computing

Edge computing:-

- Edge computing used for application with latency concern. the company which have medium scale with limited budget use this computing.
- Different platforms used for programming, all having different runtimes.
- When there is sensitivity of time this computing used.
- Robust security plan required which include advanced authentication methods and it proactively tackling attacks.

Cloud Computing:-

- When these is plenty of data to process and store need cloud computing. it means it's for massive storage.
- Actual programming for clouds and one target platform with use of one programming language.
- Not time-sensitivity based computing.
- less robust security plan requires.

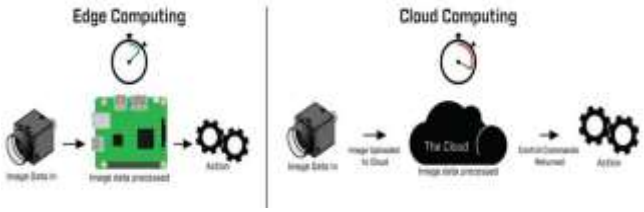

Figure 2: Computing on the Edge vs cloud [9].

IV. Overview of YOLO-Object Detection Model

If YOLO :you only look once. Yolo has classification and recognition strategy to perform.

Effective recognition model or algorithm, joseph RedMon first described this model in the seminal 2015 paper the concept of object detection . open sources of implementation of YOLO algorithm is: Darknet.

Classification of image is one of the application of CNN. In computer vision object detection is one of the fascinating problem and one of the most interesting to consider. object detection is associated with self-driving cars, LIDAR technology, automated IOT devices blended with computer vision technology, which generates multidimensional representation of data. Object detection used surveillance camera, counting the objects or cars on the road, employees entering or leaving the office, help to prevent attacks by terrorists, monitor the cloud, taking attendance in workspace by custom detection etc.

YOLO object detection model has two approach one is pre-trained and second is custom Object detection. Pretrained model uses weights and listed class to detect object. and in custom mode it train the model with labeled images of the object which created manually. Object detection begin with concept of image classification in which it give object a category like car, kite, bike. classification is not that simple it has to pass through some layer to label the class or predict the class.

Object localization is the process of locating an object in the image.it means it give the position on the image.as given in fig 3 one or more than one object can be localizing in image. for example, if we consider a automated car, it will locate traffic lights or

person if cross the road, sign or animal and it will take appropriate action on bases of that information. thus by Object detection classification and localization can perform by this algorithm.by this it can search and draw rectangular box call bounding box around the object.

Fig 3 shows Instant Segmentation which is the process of find exact boundaries of our objects in the process. but right now we are not considering this concept.

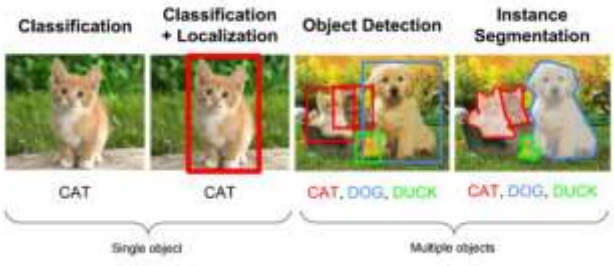

Figure 3 classification, localization, detection [12]

V. IMPLEMENTATION ENVIRONMENT

Python:

Python is an integrated high-level general purpose programming language. This programming language lets you work quickly and integrate system more effectively. Python's design emphasizes on code readability with its notable use of significant indentation. Object-oriented approach of python helps programmers to write clear, logical code for small as well as large scale projects. Python is dynamically-typed and garbage-collected language. It provide structured, object-oriented, functional and support multiple programming paradigms.it has its comprehensive standard library which describe it as a" batteries included "Guido van Rossum began working on python in the late 1980s, as a successor to the ABC programming language, and first related it in 1991 as python 2.0 was released in 2000 and introduced new features, such as list comprehensions and garbage collection system using reference counting and was discontinued with version 2.7219 in 2020. Python 3.0 was released in 2008 and was a major revision of the language that is not completely backward compatible and much Python 2 code does not run in modifies on Python 3.Python consistently ranks as one of the most popular programming language [21].

OpenCV:

In the practical stage of this thesis we will use OpenCV which is an open-source library and it has large number of //function libraries. It includes several hundreds of computer vision algorithm, used in image processing and machine vision. The document described the so-called OpenCV 2.x API, which is essentially a c++ API, as opposed to the C-based OpenCV 1.x API.it can run on Linux, windows and mac os.

Microsoft visual studio:

An integrated development environment(IDE) created and maintained by Microsoft. It is providing a platform to develop websites, interfaces, mobile applications, web services computer programs, windows applications etc. with this platform it is possible to use Microsoft Silverlight for giving the designing look, windows form app as application for any company to store and access resources in easy manner. Windows Presentation Foundation and Windows Store can be possible to evaluate on system, native code and managed code can be produce by this.

It is Editor to create code which support intelliSense means sense of complete code like name of the functions or library.it has debugger which works as both a source-level debugger and a machine-level debugger. It contains Solution Explorer which include all necessary library, datasets, files, folders relevant to project and configuration settings files.

VI. METHODOLOGY

Input: video with frames F={f1, f2, …, fN}
Output: Bounding Box B= {b1, b2 ,…, bN} where bi= {recti, labeli} label is class of an object and count value
1: B ←{ }
2: Detect f1 with yolo object detection and get detected object list
3: for i ← N do
Apply Background Subtraction method on ni frame
If contour size not valid then
Skip frame from tracking or detection process
Else
Call Detection module
Add bounding box in B
Assign detected bounding box to initiate tracker and track boxes from ft to fi
Call counter module and increment counter if passes from reference line
end if
end for

In this Proposed System video is taken as input. Any video which streamed at edge server can be taken or any social media video with static background. This System consist Detection, Tracking and Counter module.

Detection Module: YOLOv3 Object Detection model with pertained neural network is used to classify objects which pertained on COCO dataset used.

The model is confident about object is define by confidence score. which tells the box has object or not. for further process the score is compared with threshold value set by programmer for further processing.

Thus IOU between ground truth and prediction is give score of confidence. each cell also calculates probability of object presence and per grid cell one probability will find.

During testing time we multiply the conditional class probabilities with single box confidence predictions,

IOU * Pr(Classi|Object) * Pr(object) = IOU * Pr(Classi) (1)

Which gives us class-specific confidence score for each box, these scores encode both the probability of that class appearing in the box and how well the predicted box fits the object.

Below table shows speed at different threshold in detection module.

Table 1 Speed at different threshold level

Detection threshold	Average FPS
0.1	8.89
0.3	6.78
0.5	10.73
0.7	12.39
0.9	13.38

Tracking Module: Detected objects with labelled classes and bounding boxes are used to initiate KCF tracker. Tracker track the object in subsequent frames until object leave the frame or tracker fails. When object leave the frame need to update tracker with new detected object by detection module.

Counting Module: This module use background subtraction method which serve two purpose. First it will count the object when it cross predesigned reference line on frame and second when there is no object on frame which is idle frame means no need to detect or track.by this method of background subtraction we can remove processing the idle frames. When this module found any object it will call Detection module to detect object.

By this way this method is capable to associate an object appearing different frames with labelled tag, such that the trajectories of frame resist on frames. By this way we can formulate problem as a sequential decision problem.

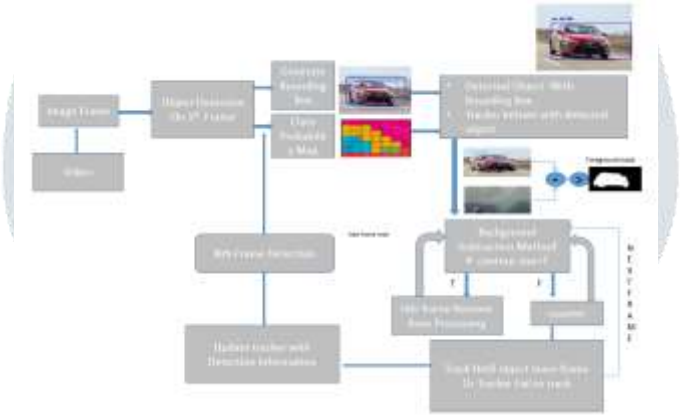

Figure 4 Proposed System

VII. RESULT ANALYSIS

Below table shows result analysis of proposed method. method implemented in python and opencv. we tested method on a system Intel core i5 1135G7 2.40 Ghz 8G memory and windows 10 64-bit os.

Performance evaluation of counter: Static background video

Table 2 Counting analysis on test video

Direction	Direction	Direction	Direction	Direction	Direction
Downward	Video1	1000	60	47	78.33%
Downward	Video2	700	18	11	61.11%
Upward	Video3	800	40	25	62.50%
Up/down	Video4	1500	60	56	93.33%
Up/down	Video5	1000	29	23	79.32%

VIII. CONCLUSION

Aim was to detect and track moving object in video frame sequence in edge computing as a standalone architecture.by combining detection method with tracking and counting we can get higher FPS compared with base paper used method of tracking. In proposed system background subtraction method used to reduce computation when there is no object on video and call detection method. Thus by combining detect to track methodology we can get higher FPS and get speedy result, as the speed increase the accuracy of system decrease compared to base paper. Proposed system have been tested on few videos and give higher FPS compared to base paper combined method.

For counting module counting base line is prefixed.so according to that line pixel value counter consider object trajectory values. that's why in counting module need to change few parameters while testing on different video.

Taken video has static background and object are moving, no consideration of moving background in video. Work only on static background camera like surveillance camera or web cam or any taken video which have static camera position.

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