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Library Automation using Neural Networking and IoT

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Abstract: ***Efficient automation and accurate object detection have been an important advancement of computer vision systems. With the increase in demand for deep learning techniques, the accuracy for object detection has increased periodically. Our project aims to incorporate the existing technique for object detection to achieve library automation with high accuracy with real-time performance and also interfacing it with the application of IoT. A major challenge in our project is computational hardware, which leads to slow and nonoptimal performance. In this project, we use a completely deep learning-based approach to solve the problem of object detection in an end-to-end fashion and as a result, we can automate the library using the following technique with the help of solid-state relay. The network is trained on 500 images to generate its custom weights using darknet config file. The resulting system is fast and accurate, thus making our system one of the best solutions to modern-day automation.***

Keywords: ***Efficient automation, Deep learning, Library automation, Computational hardware***

I. INTRODUCTION

Today the world centralized principle is to automate each conceivable thing for simplicity of human life, providing security, saving electricity and time. In that library automation is one of the prior things to automatically on and off the appliances in library as due to the careless approach of students towards the electric appliance. Automation are often characterized as a way for doing something without human inclusion. It may incorporate brought together to control of lighting, machines, heating, ventilation, air-conditioning, and security door locking and different systems, to provide improved convenience, comfort, energy efficiency and security. The idea of automating each appliance within the library is done from a few years ago, it started with connecting two electric wires to the battery and shut the circuit by connecting load as a light-weight. Later it are often developed by different organizations, which creates its own automation systems with different devices like sensors, controllers, actuators, buses, and interfaces. In present days most of the automation systems utilize the mixture of hardwired and wireless systems for controlling the appliances. It should have both equipment and programming found out for proficient systems. The popularity of automation has been expanding incredibly due to much higher reasonableness and simplicity through Smartphones and wireless networks. Internet of Things is interlinked through these networks; because of the popularity of automation is improved by the standard of service provided by the devices. There are very few automation that has been done using the new generation Artificial Intelligence or Neural Networking technique. We can reduce the cost of the complete system by replacing all the industrial standard sensors and with a single camera covering the whole region that we need to automate.

There are various Neural Network algorithm such as CNN, ANN, FCN etc. we have used CNN in our project so as to provide faster and precise detection of people entering the library. This CNN deep learning model for processing data that includes a grid pattern, like images, which is inspired by the animal visual and designed to automatically and adaptively learn spatial hierarchies of features, from low to high-level patterns [4]. YOLO, a approach to object detection. Earlier all the work on object detection repurposed classifiers to perform detection. Instead, we frame object detection as a regression problem to spatially separated bounding boxes and associated class probabilities, one neural network predicts bounding boxes and sophistication probabilities directly from full images in one evaluation. Since the entire detection pipeline could be a single network, it may be optimized end-to-end directly on detection performance. Our unified architecture is extremely fast [7].

YOLO model processes images in real-time at a mere 45 frames per second. A smaller version of the network, Fast YOLO, processes an astounding 155 frames per second while still achieving double the Mean Average Precision (mAP) of other real-time detectors. Compared to state-of-the-art detection systems, YOLO makes more localization errors but is much less likely to predict false detections where nothing exists. Finally, YOLO learns very general representations of objects. It outperforms all other detection methods, including DPM and R-CNN, by a good margin when generalizing from natural images to the artwork on dataset given [9].

Our learning rate schedule is as follows: within the first epoch, we slowly increase the training rate from 103 to 102. For instance, if we choose to start at a high learning rate our model often diverges because of unstable gradients. Training our dataset with 102 for 75 epochs, then we decrease it to 103 for 30 epochs, and at the end decreasing it again to 104 for 30 epochs. Dropout and extensive data augmentation are used to avoid overfitting. A dropout layer with rate = 0.5 after the first connected layer prevents co-adaptation between layers. For data augmentation, we introduce random scaling and translations of up to twenty of the first image size. We also randomly adjust the exposure and saturation of the image by up to an element of 1.5 within the HSV colour space [7].

As for GPU available by the Raspberry Pi a 64-bit quad-core processor running at 1.4GHz, dual-band 2.4GHz and 5GHz wireless LAN, Bluetooth 4.2/BLE, faster Ethernet, and PoE capability via a separate PoE HAT. The Raspberry Pi 3 B+ has four built-in USB ports that provide enough connectivity for a mouse, keyboard or the rest that you just feel the RPi needs. But if you would like to feature, even more, you'll be able to still use a USB hub. detain mind, it's recommended that you just use a powered hub so as to not overtax the on-board transformer. Powering the Raspberry Pi 3 B+ is simple just plug and Play with 5V/2.5A USB power supply into the micro USB port. There's no power button, therefore the RPi will begin also as soon as power is applied. to show it off, simply pack up the Pi 3 B+, then remove power. The four built-in USB ports can even output up to 1.2A, enabling you to attach more power-hungry USB devices [12].

II. MATERIAL AND METHODS

A. Record Maintenance

Under University there are many Institutes. All institutes have to maintain the record of every single activity conducted in colleges such as timely submission, usage of the library, number of assets, etc. Every year the data is been checked by different committees such as NBA, ISO. Here comes a problem of students not updating their entry into the library logbook provided by the library management, this causes the problem in maintaining the records. Our project is about updating the record regardless students not marking their entries. Using Convolution Neural Network (CNN), the objects (students) can be detected using an optical camera and accordingly, there will be an increment in the counts of the students entering the library, this incremented count will be stored and this data which is necessary at the time of committee accreditation will be kept safe. As mentioned in Fig 1.

The detection here is done by using the centroid tracking mechanism where a different id is assigned to an object having different centroid value. This will make sure that the there is no redundancy of same object been recorded multiple times. Here we take the distance from previous centroid calculated by the bounding boxes till the centroid distance from upcoming frame. Once the Id is assigned then the count gets incremented.

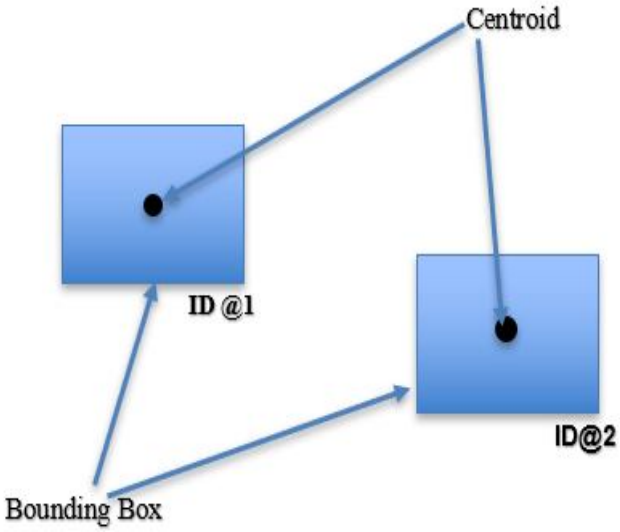

Fig. 1 Centroid Tracking

x = co-ordinate{1}(1:end-1,1) is the equation that we use in order to get the X co-ordinate of the bounding box, y = co-ordinate {1}(1:end-1,2) is the equation that we use in order to get the Y co-ordinate of the bounding boxes, xc =∑ x/|x| and yc = ∑ (y)/length(y) is the x and y intercept. rp = sqrt((x - xc)^2.+ (y - yc)^2

using this equation we get the centroid value of the object and a unique ID is assign to it.

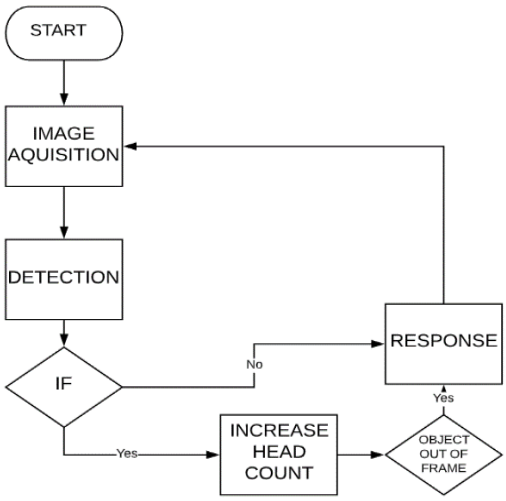

Fig.2 Flow Chart of Record maintenance

B. Electrical Appliance Automation

There is also a need for saving electricity as people are careless about switching Off the electrical appliances, this issue is also resolved by Using same CNN technique installing the Pi-cams in various angles, through which the presence of a person in a particular area in the library is observed and with the help of that switching OFF/ONN of the appliances will be done with the help of a Relay. As mentioned in Fig2.

To make this possible the detection is done using the famous YOLO algorithm where the model is trained using darknet community based on 90% training and 10% validation set. Once the training is done, we use the weights generated through the training and use it in our transfer learning method to detect the object. In order to detect the presence of the people in the room. We split a single frame into 8 different images and apply detection algorithm on all 8 split images separately. Once the detection is done on the basis of the result the following relay will turn ON/OFF through the following excited GPIO pins.

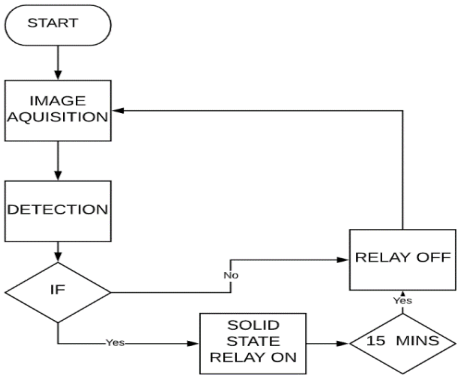

Fig. 3 Flow chart of Light and fan automation

III.DISCUSSION

In our project, the main two focus is to maintain the records of the total number of students entering the library and to automate the lights and fans using Neural Networks and IoT. In the traditional methods, we normally use an IR sensor for counting and also to detect the presence of people in a certain area. But this system is not cost-effective and at the same time does not give a better accuracy as to detect the presence of a person in a room we would need multiple IR sensors placed in different locations, at the same time the reflected wave of an IR sensor may be affected due to various noises present in the atmosphere. Another problem is the redundancy of data as the person entering and leaving the library there will not be any unique identity given and the same person's data will be recorded multiple times. To avoid these problems, we can make use of Convolution Neural Network technique to detect the presence of an object (people) in any room and after the detection, we can also identify the location of objects to turn ON/OFF the electric appliances of that area accordingly. Using the same technique of CNN and centroid tracking method we can give a unique identity of several students getting inside the library. So, this will also solve the redundancy issue.

Once the person is detected the relay of that location will turn On and our electric appliance will start to work. The entire processing of data is done by using a micro-processor Raspberry Pi.

The output can be observed can also be monitored using the remote server access that is the VNC viewer feature that Raspberry Pi has a built in feature. Using this application we can connect the raspberry pi on a network using the WiFi or else ethernet cable. This will make our remote PC to access the raspberry pi screen by using the IP address of the network on which it is connected.

IV. EXPERIMENTAL RESULTS

A total of 500 images were used for training to develop custom weights. The images had to be pre-processed just like the train set by which noise and uniform illumination was obtained. The prepared model showed the mAP of 57.8. After the detection the GPIO pins turns to HIGH/LOW state to trigger the relay module in order to turn the LIGHTS and FANS ONN/OFF.

TABLE I
PERFORMANCE REPORT

Performance	Algorithm		
	YOLO	SSD	R-FCN
MaP	57.8	48.8	52
Time	51ms	61ms	81ms

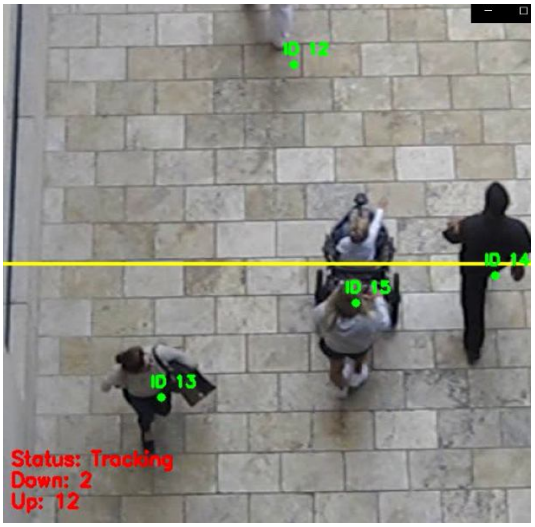

Fig.4 Result of Record maintenance using centroid

Fig. 5 Result of detection of students inside library using YOLO algorithm

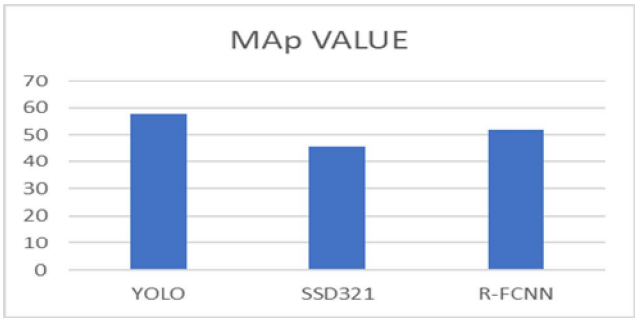

Fig. 6 Graphical analysis of MAp value of different Algorithms

Fig. 7 Graphical analysis of Time of different algorithm

V. CONCLUSIONS

In the era of Machine Learning and Artificial Intelligence our project is a benchmark that breaks the stereotype of automating the system using multiple sensors which are costly to manufacture and cannot be affordable to every institution. Our system is only using a single camera and automating the complete surrounding, which would be captured over our camera module and processed on Raspberry Pi. As the efficiency of our CNN model is very decent it is having an upper hand over other models mentioned. Although we can see through the graphical analysis that R-FCNN is having more mean average precision over YOLO algorithm but for real time application the response time of R-FCNN is more than YOLO which makes it slow to process. As we are using Raspberry Pi the GPU is having less capacity to process this kind of heavier models. Hence using YOLO algorithm, we successfully managed to give a decent accuracy over detection with less computational power and less response time.

Hence the record of all the students entering the library is automatically maintained without any human efforts. At the same time due to this system the electricity consumption is also reduced as the unwanted use of lights and fans are avoided and hence this system will also give the institution an upper hand on utilizing energy resources in an efficient way.

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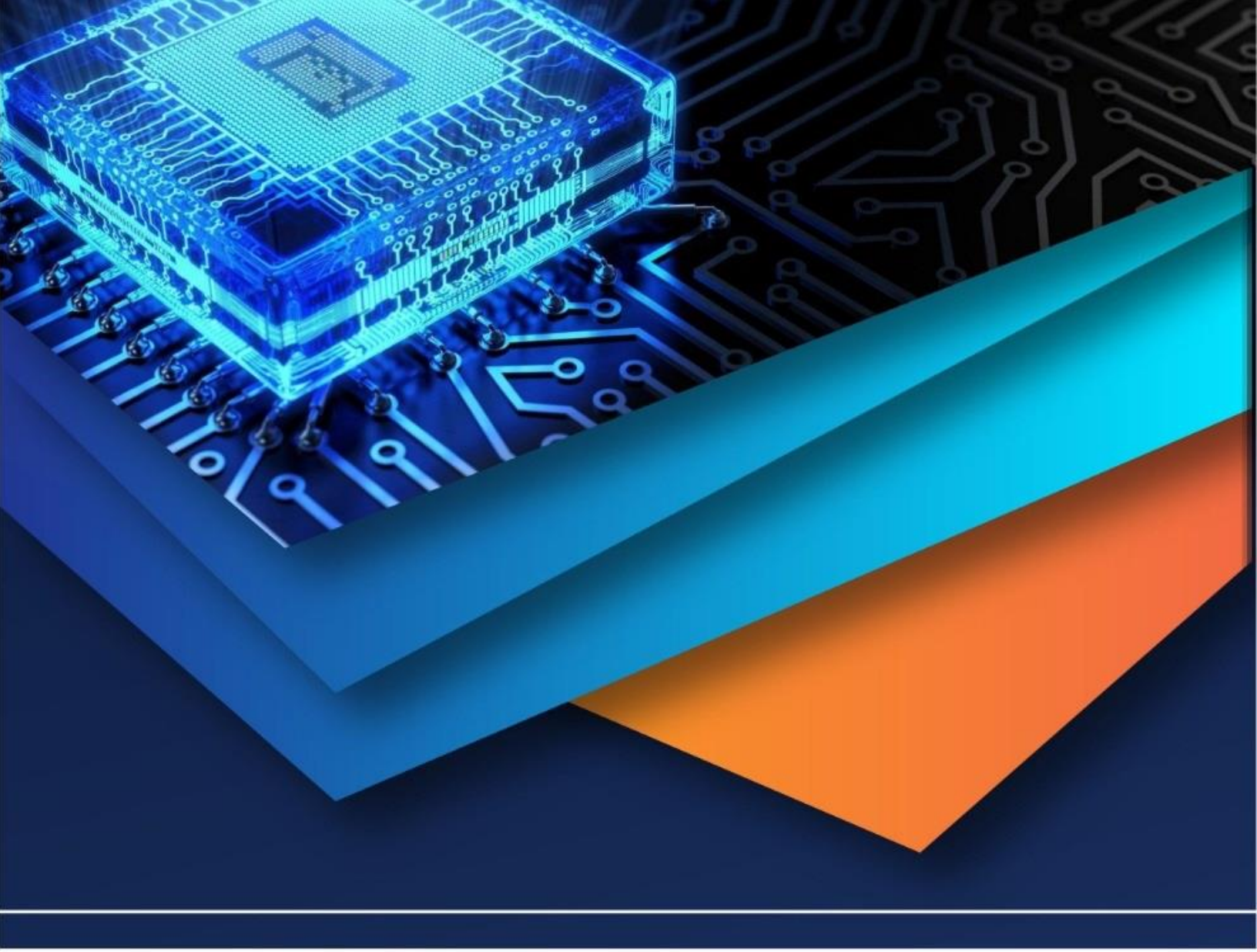

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