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YOLOV7 BASED INDOOR AND OUTDOOR NAVIGATION ASSISTANCE FOR VISUALLY IMPAIRED PEOPLE

Mr.DR.R.RAGUPATHY[1],SOWMYA.L.R[2], SAMYUKTHA.E[3], VISHNUPRIYA.P[4], VASUKI.G[5]
1 ASSISTANT PROFESSOR, 2,3,4,5 UG STUDENTS
ELECTRONICS AND COMMUNICATION ENGINEERING
V.S.B ENGINEERING COLLEGE, TAMILNADU, INDIA

ABSTRACT

Visually challenged people can lose independence and quality of life due to navigational difficulties. Navigation aids like white canes and guiding dogs have limits and require training. With deep learning and computer vision technology improving, navigation assistance systems can be improved. The ultrasonic-sensored YOLOv7 indoor and outdoor navigation assistance system helps vision impaired people navigate securely and independently. You Only Look Once version 7 (YOLOv7) and an ultrasonic sensor are used to detect and locate items in real time. The technology alerts the user to the existence, location, and relative position of items using auditory and haptic input. The real-time YOLOv7 algorithm detects things in the user's path. A wearable gadget gives the user acoustic and tactile feedback once the ultrasonic sensor identifies the object's distance and position. Real-time navigation aid in indoor and outdoor locations can improve visually impaired people's freedom and quality of life. YOLOv7 object detection and ultrasonic sensors allow the system to correctly detect and locate items, giving the user a better awareness of their environment.

Keywords: YOLOv7, Accessibility, Navigation, Ultrasonic sensor, Assistive Tools, Assistive Technology

I. INTRODUCTION

Everyone requires guidance. Work, school, shopping, and other tasks need navigation. Vision aids navigation. Visualizing our house or business without sight is easy. Navigating unfamiliar areas is difficult. WHO estimates 2.2 billion people suffer visual impairment. Blind persons may travel alone. No- or low-vision folks may travel everyday. Safe and efficient navigation is a key obstacle to independence for visually impaired persons [1].

Travel skills and non-visual environmental information that eyesight-dependent people seldom evaluate may assist assure safe and successful navigation. Visually impaired persons have navigation challenges [2]. Security is complicated [3]. Seeing pits, hanging barriers, stairs, traffic junctions, street signs, moist flooring inside, greasy or slippery outdoor routes, etc. Blind persons have utilised white canes2, guide dogs3,4, and trained guides or volunteers [4,5]. Early-blind people travel through echolocation [6–8]. Landmarks guide navigation. Some travel by scent or hearing. Tactile pavement helps blind individuals traverse cities. They enhance public transit station pedestrian safety [9].

O&M helps visually impaired persons navigate new environments. Orientation and mobility help visually impaired people navigate. Knowing where you're going is orientation. It incorporates user preferences like room changes and mall visits. Mobility is safe, efficient travel. Walking securely to a station, crossing streets, and utilising public transit [10–12]. People began adopting assistive devices that used ordinary item technology. These help impaired people live. Assistive Technologies later. Assistive technology includes equipment, devices, apparatus, services, systems, processes, and environmental modifications that help them overcome physical, social, infrastructural, and accessibility barriers to independence and live active, productive, and independent lives as equal members of society [13]. Assistive technology is helping impaired people navigate [14]. Wayfindr8, Envision [15], etc. Due to mobile industry technical advances, navigation system development is possible on mobile devices with high processor and sensor capacities. Csapó et al. [16] that the most popular mobile platforms are becoming assistive technology standards. Blind navigation assistance research is extensive. It may be because its breadth covers physiological variables associated to visual loss, human aspects impacting mobility, direction, and information access, and technological characteristics in developing tools and processes for navigation, wayfinding, information access, engagement, etc. According to [13], defining this area in one photograph is tough. According to [17], just a few blind and visually impaired navigation systems can offer dynamic interactions and reactivity to changes, and none works perfectly inside and outdoors.

Even if there is a system that works in all circumstances, it tends to be complicated and ignores blind people's needs for simplicity of use, simple interface, and decreased complexity. Blind and visually impaired navigation devices and procedures have been reviewed. In [18] investigated outdoor navigation devices for vision impaired people.[19] examined vision-assisted indoor navigation. [20] lists several blind-friendly Electronic Travel Aids (ETA) using machine vision. Hojjat blind and vision impaired indoor navigation technology [21]. Technology-classified indoor-outdoor navigation systems are seldom studied. This review organises visually impaired navigation material. This study includes navigation systems that function inside, outdoors, and with varied technologies (vision, non-vision, mobile based, etc). This research organises evaluated works by technology. Recommendations finish the extensive study. This study reviews domain developments and suggests visually impaired navigation solutions.

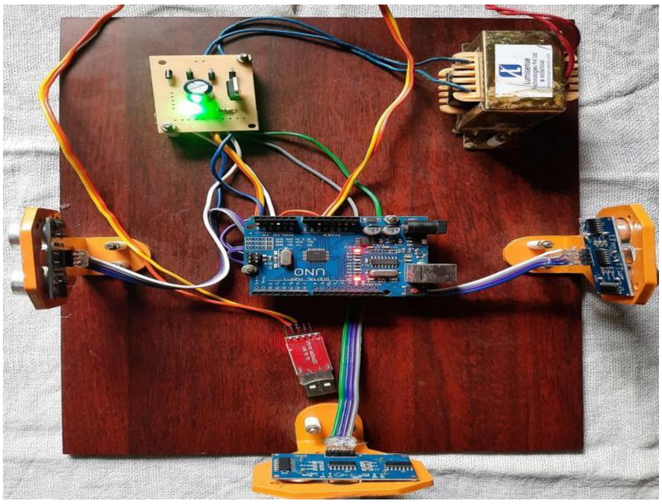
Paper organization: Section 2 discusses assistive transportation equipment and navigation system design technology. Section 3 discusses the navigation systems and review method. This section also categorizes navigation systems by technology. Section 4 debates and proposes. Section 5 concludes the argument.

II. RELATED WORK

Traditional object recognition methods employ hand-crafted features and descriptors to identify visual objects. Histogram of Oriented Gradients (HOG) and Local Binary Patterns (LBP) features have been used to identify pedestrians in visible light pictures [10], with the Integral Channel Feature (ICF) detector [12] being the most effective [13]. Convolutional neural networks (CNNs) can automatically extract features, which improve detector performance [13]. Two-stage and single-stage CNN-based object detectors exist. Two-stage detectors are usually R-CNNs. In Faster R-CNN [14], the region proposal network (RPN) predicts the bounding box and score at each place concurrently, reducing prediction time. Deep learning algorithms based on variations of the R-CNN architecture are commonly used to identify pedestrians in visible light pictures [15,16], while the Faster R-CNN architecture was effectively adapted for fusion of visual and thermal data in pedestrian recognition [8,17,18]. Two-stage detector neural networks cannot process pictures at a camera's full resolution and frame rate, despite their computational efficiency improvements. Real-time operations demand single-stage detectors. YOLO single-stage CNN architectures are the most popular. YOLO [6] handles object detection as regression. Regression-based detectors are quicker but less accurate than regionproposal-based ones [19]. YOLO's creators enhanced it [20,21], and Bochkovskiy et alcurrent .'s version [7] speeds up the algorithm and improves detection accuracy. YOLO design surpasses two-stage detectors in computational performance, resulting in a greater frame rate in image processing when identifying objects. The Darknet backbone network in YOLO requires too much RAM for embedded devices, which slows processing performance in certain applications. Thus, "YOLO-Tiny" variations have been suggested [22]. YOLO-Tiny variants have performed well in automotive object detection [23,24]. YOLO family networks were used for pedestrian identification using visible light pictures [25], and lately, YOLO-based network designs were proposed for multispectral fusion. MAF-YOLO [26] modified YOLOv3. Our investigation used the latest YOLOv7, which [27] uses. The Single Shot Detector (SSD) and Central and Scale Prediction Network (CSPNet) were also examined for multispectral pedestrian identification.

III. SYSTEM DESIGN

1. Hardware



1.1 Components

(a)Ultrasonic Sensors

An ultrasonic sensor is an electronic device that detects the object and measures the distance of a target object by emitting ultrasonic sound waves, and converts the reflected sound into an electrical signal. Ultrasonic sensors have two main components: The transmitter (which emits the sound using piezoelectric crystals). The receiver (which encounters the sound after it has travelled to and from the target).To calculate the distance between the sensor and the object, the sensor measures the time it takes between the emission of the sound by the transmitter to its contact with the receiver. The formula for this calculation is $D = ½ T x C$ (where D is the distance, T is the time, and C is the speed of sound ~ 343 meters/second).

(b) Arduino UNO

The Arduino UNO is an open source microcontroller board based on the microchip ATmega328 microcontroller. Some of the features are, ATmega328 microcontroller operating at 5V. 2Kb of RAM, 32 Kb of flash memory. The clock speed is 16 MHz. The board has 14 digital I/O pins and 6 analog input pins.

(c) Step Down Transformer

A step-down transformer is an electrical device that reduces the voltage of an alternating current (AC) power supply. It consists of a primary winding, a secondary winding, and an iron core. When an AC voltage is applied to the primary winding, it creates a fluctuating magnetic field in the iron core. Step-down transformers are used to decrease the voltage incoming to the site by increasing the electrical current.

(d) Capacitor

A capacitor is a device that stores electrical energy in an electric field by virtue of accumulating electric charges on two close surfaces insulated from each other. It is a passive electronic component with two terminals. The effect of a capacitor is known as capacitance.

(e) Rectifier

A rectifier is a special type of diode that converts alternating current (AC) into direct current (DC). This is an important process, as alternating current is able to reverse direction periodically, while direct current consistently flows in a single direction, making it simple to control.

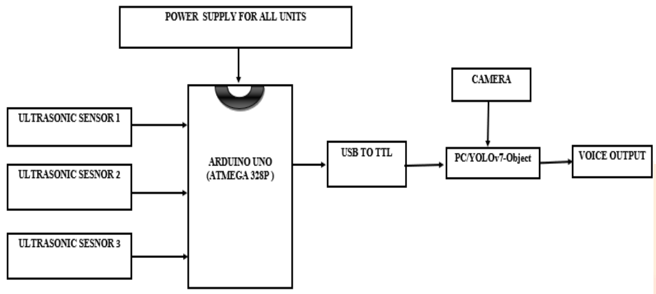
(f) Voltage Regulator 7805

Voltage regulator 7805 IC is one of the most widely used voltage regulator IC in different electrical and electronic circuits. It takes an unregulated voltage of 7 V to 35 V and produces a fixed regulated output voltage of 5 V DC.

1.2 Hardware Workflow

The three ultrasonic sensors will detect the objects on the three sides: left, right and center. Once when the object is detected by the ultrasonic sensor it will send the signal to the arduino uno. This signal is then send to the USB to TTL converter in order to receive the serial data. This hardware setup is connected to the PC in which the YOLOv7 algorithm is implemented. When the signal is received by the PC the camera gets on and recognise the objects. After the implementation of this algorithm the object's name and position will be analysed and it will be voiced out.

Block diagram



2. Getting Started with YOLOv7

The one-stage you only look once version 7 (YOLOv7) object detection network has a backbone, neck, and head.VGG16 or CSPDarkNet53 can be the backbone. The YOLOv7 backbone computes feature maps from input photos.The neck links the head and backbone. It has an SPP module and a path aggregation network (PAN). The neck feeds the head backbone network feature maps.The head predicts bounding boxes, objectness scores, and classification scores from aggregated features. YOLOv7 uses one-stage object detectors like YOLO v3 as detecting heads.

YOLOv7 extracts features from input photos using CSPDarkNet-53. Five residual block modules in the backbone fuse feature map outputs at the YOLOv7 network neck.

The neck SPP module concatenates the max-pooling outputs of the low-resolution feature map to obtain the most representative features. SPP max-pooling kernels are 1-by-1, 5-by-5, 9-by-9, and 13-by-13. Stride is 1. Concatenating feature maps boosts backbone feature receptivity and network accuracy for small objects. PANs combine the SPP module's concatenated feature maps with the high-resolution feature maps. The PAN sets bottom-up and top-down routes for merging low-level and high-level features via up and down sampling.

PAN generates aggregated feature maps for predictions. YOLOv7 features three detector heads. Each detecting head's YOLO v3 network makes predictions. The YOLOv7 network predicts bounding boxes, classification scores, and objectness scores using 19-by-19, 38-by-38, and 76-by-76 feature maps. The lightweight Tiny YOLOv7 network has fewer network layers. The compact YOLOv7 network has two v3 detection heads and a feature pyramid neck. Prediction maps are 13-by-13 and 26-by-26.

3. Predict Objects Using YOLOv7

Anchor boxes help YOLOv7 classify images. Anchor Boxes for Object Detection explains anchor boxes. YOLOv7 predicts these three anchor box features like v3:

Intersection over union (IoU)—Predicts anchor box objectness.

Anchor box offsets—Refines anchor box position.

Class probability—Predicts anchor box class labels.

The graphic shows dotted anchor boxes at each feature map position and the refined location after adding offsets. Class-matched anchor boxes are colored.

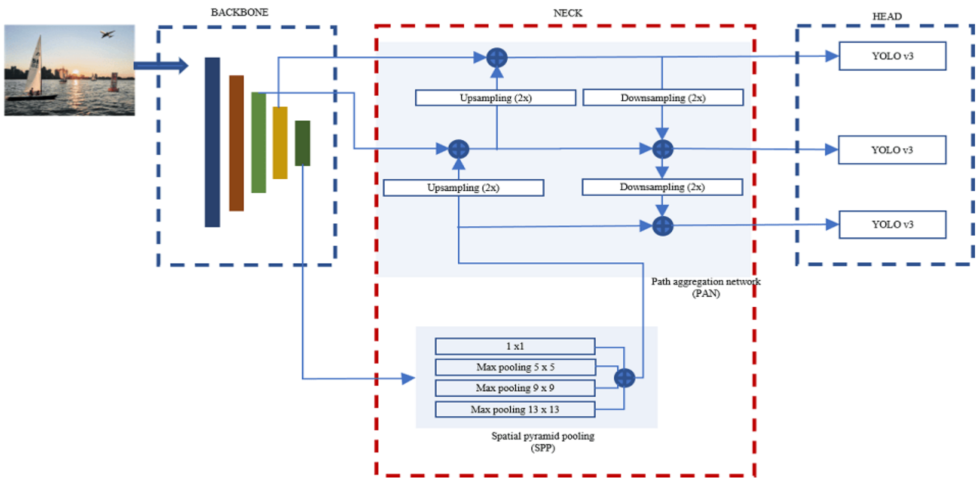


Fig.1 : Real-time object detection method based on improved YOLOv7

3.1 Create YOLOv7 Object Detection Network

The yolov7ObjectDetector object creates YOLOv7 deep learning networks programmatically. Using pretrained YOLOv7 deep learning networks, you may develop a yolov7ObjectDetector object to recognise objects in images. csp-darknet53-coco and tiny-yolov7-coco. These networks are COCO-trained. csp-darknet53-coco is a three-detection-head YOLOv7 network, whereas tiny-yolov7-coco has two. Install the Computer Vision ToolboxTM Model for YOLOv7 Object Detection support package to obtain these pretrained networks.

3.2 Train and Detect Objects Using YOLOv7 Network

The trainYOLOv7ObjectDetector function trains a labelled dataset YOLOv7 object detection network. The data set used to train the network must have class names and preset anchor boxes.

Training yields a yolov7ObjectDetector object. The trained YOLOv7 object detector can then recognise unknown things in a test image. To develop and train YOLOv7 object detectors.

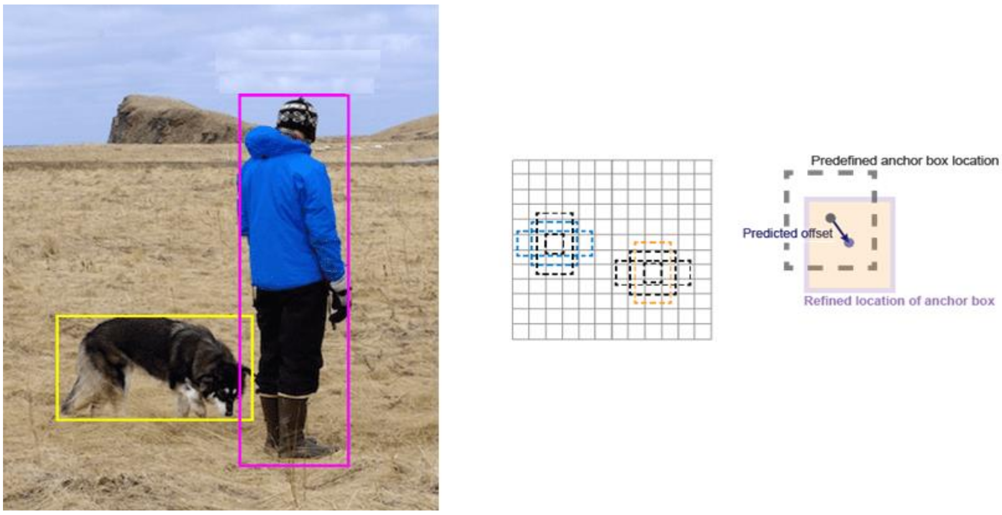


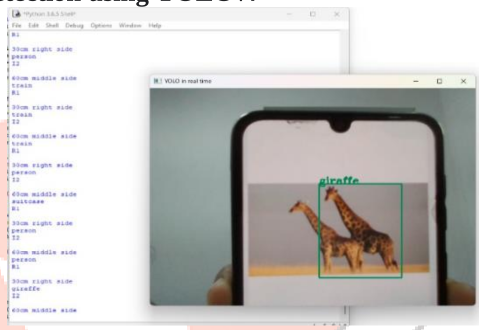
Fig. 2: Hardware acceleration for object detection using YOLOv7

IV. RESULTS AND DISCUSSION

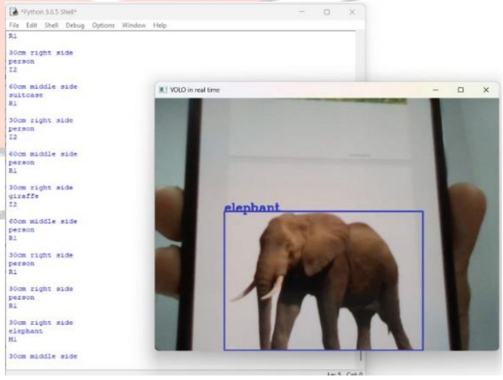
YOLOv7, a visually impaired navigation aid incorporating an ultrasonic sensor, was tested in various indoor and outdoor settings to determine its capacity to detect and locate objects in the user's path and offer accurate feedback. Crowded streets, parks, and malls tested the technology. The algorithm spotted people, cars, trees, and benches. YOLOv7 is cutting-edge for real-time object detection. Deep neural networks classify photos and videos.

YOLOv7 predicts bounding boxes and item classes for each cell in an image grid. One network assessment predicts observed object class probability and bounding boxes. Unlike two-stage object detection techniques, this approach is faster and more efficient. YOLOv7 extracts picture features using a multi-layer convolutional neural network. These attributes predict bounding boxes and object classes for each grid cell. The system can detect several objects in a single image or video frame, regardless of size or aspect ratio. YOLOv7 is faster, more accurate, and can perform real-time object detection workloads. Surveillance, driverless vehicles, robotics, and others employ the algorithm.

YOLOv7 is a fast, accurate object detection method. Ultrasonic sensors precisely recorded distance and position relative to the user's left, right, or centre. Audio and tactile feedback warned the user of obstacles. With real-time system input, users may safely navigate products. Despite noise, audible and tactile feedback were clear. The ultrasonic-sensored YOLOv7 indoor and outdoor navigation assistance system helps visually impaired persons live independently. Users can securely and autonomously navigate barriers with real-time item recognition and position information. YOLOv7 object detection and ultrasonic sensors allow the system to successfully locate items indoors and outdoors. Even in noisy environments, the system's aural and haptic feedback is obvious. This system's belt or vest may bother some users. The ultrasonic sensor-based YOLOv7 indoor and outdoor navigation assistance system could improve visually impaired people's freedom and quality of life. Development could make the technology a popular navigation tool.



(a)



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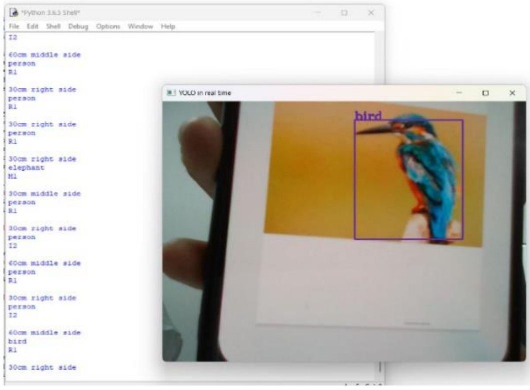

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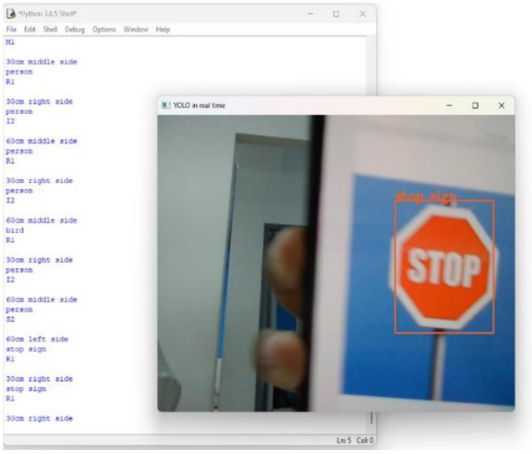

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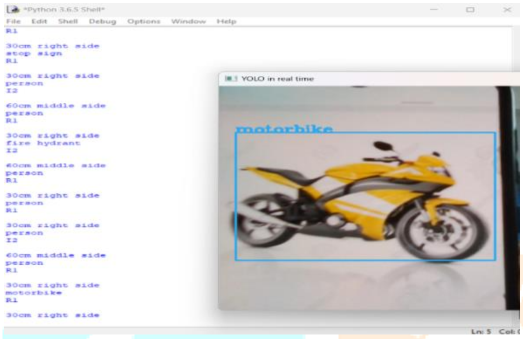

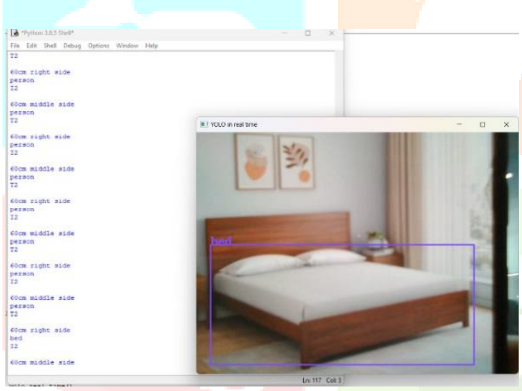

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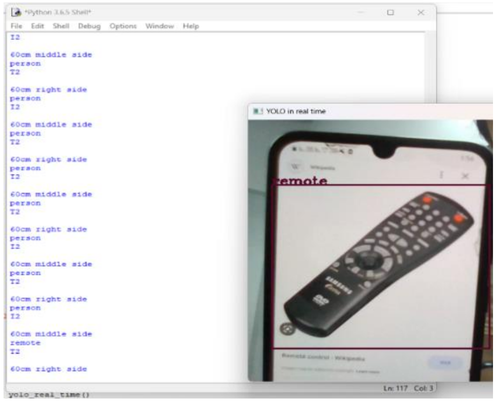

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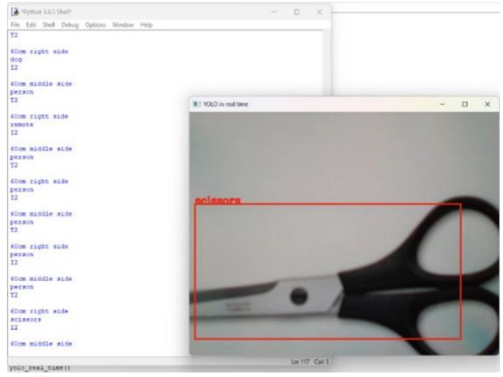

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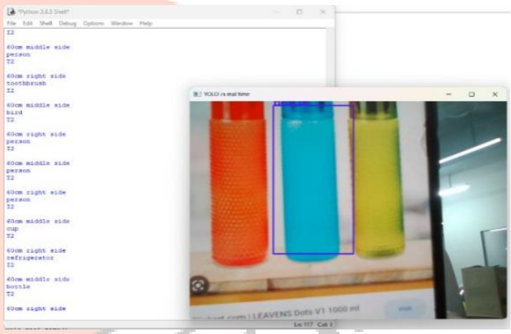

(j)

Fig.3: Image detected using Proposed YOLOv7 algorithm

V. CONCLUSION

YOLOv7 algorithm on hardware improves performance and prediction time. To improve speed, this work develops a reconfigurable object detection framework. This study attempts to bring smart devices into the present, with some success. With modest design changes, the prototype might become a product. The device can also help many visually challenged people, including those who lost their sight due to accidents or diseases. The popular object recognition method YOLOv7 divides an image into cells and predicts bounding boxes, class probabilities, and objectness scores for each cell. Real-time YOLOv7 detection is precise and rapid.

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