Patrolling robot for detection of unattended luggages

22AIE214 - Introduction to AI Robotics

22MAT230 - Mathematics for Computing 4

CO3

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Problem Statement and Objective

- In crowded areas such as airports, bus stations, and railway terminals, unattended luggage poses a significant security risk.
- Traditional surveillance systems rely on human operators who may miss such threats due to fatigue or information overload.
- This project aims to address the challenge of detecting unattended luggage in real time using a mobile robot equipped with obstacle avoidance, object detection capabilities, and interactive alert mechanisms.
- Main objective is to develop a patrolling robot that detects unattended luggage using YOLOv11, navigates autonomously with obstacle avoidance, and raises vocal alerts to enhance security in crowded areas.

Literature review

paper title	methodology used	advantages	disadvantages	challenges
Abandoned Object Detection and Classification Using Deep Embedded Vision [1]	Proposed ConvLSTM classifier categorised frames as suspicious or not. If suspicious, then YOLO-v8l identified the objects in the frame. Thereby only detecting unattended luggages.	Accurate detection and identification. Two-step approach reduced false positives and improved reliability. Transfer learning on YOLOv8 ensured high accuracy with minimal data. Scalable and adaptable system.	Dependent on preprocessing; poor-quality frames affect accuracy. Struggles with false positives in dynamic scenes. Limited contextual understanding. Performance drops in crowded or cluttered environments.	Difficulty in crowded or occluded scenes. Reduced accuracy with motion blur or poor-quality frames. High computational requirements hinder real-time deployment. Imbalanced dataset impacts performance. Lack of contextual reasoning limits nuanced decision-making.

paper title	methodology used	advantages	disadvantages	challenges
Detecting Abandoned Luggage Items in a Public Space [2]	Surveillance footage from a static camera is processed. MCMC tracking estimates object positions. Luggage is associated with nearby individuals based on movement. Continuous monitoring checks if the person and luggage stay linked. An alarm triggers if the luggage is abandoned for a set time.	Automated detection of abandoned luggage. Single-camera system simplifies deployment. Probabilistic tracking adapts to dynamic scenes.	Limited differentiation between people and luggage. Ownership based on proximity may lead to errors. Fixed camera setup limits flexibility.	Crowded scenes complicate tracking. Lighting and occlusions affect accuracy. Real-time processing requires high computational power. Lack of training data impacts detection performance.

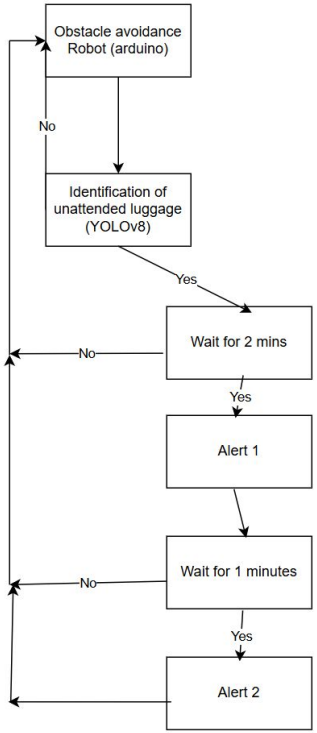
paper title	methodology used	advantages	disadvantages	challenges
Real Time System for Unattended Baggage Detection[3]	Uses Gaussian mixture model for background separation. Object detection via cascade of CNN	Handles occlusions by dual time thresholds - static time threshold and occlusion time threshold	Occlusions in highly crowded areas, Sudden variations in lightning, processing frames of video, especially with CNN	Occlusions, Noisy foreground masks
An edge-based method for effective abandoned luggage detection in complex surveillance videos[4]	Uses Moving edge detection + Temporal Detection to form stable edges Clustering algorithm to create bounding boxes. Ojectness and staticness scoring for classification.	Compared to pixels, edges are most likely to be unfazed by sudden light variations, Introduced Objectness and Staticness scoring, to confirm whether a bounding box encloses a true abandoned object	Handling highly static people, Dataset-Specific Fine-Tuning (thresholds and parameters), scenarios with a lot of overlapping objects	false alarms, occlusions, Staticness misclassification: differentiating static abandoned objects from stationary people or other objects with small internal movements.

paper title	methodology used	advantages	disadvantages	challenges
Abandoned Object Detection via Temporal Consistency Modeling and Back-Tracing Verification for Visual Surveillance[5]	combines temporal consistency modeling, which tracks object behavior over time, with a back-tracing verification process that validates whether an object is truly abandoned by cross-referencing it with previous frames	This approach enhances the accuracy of identifying the abandoned object by separating it from other stationary items and background clutter.	The method may face challenges in complex environments with high pedestrian traffic, where distinguishing between temporarily placed and truly abandoned objects becomes difficult.	Implementing real time processing and managing false positives may be difficult

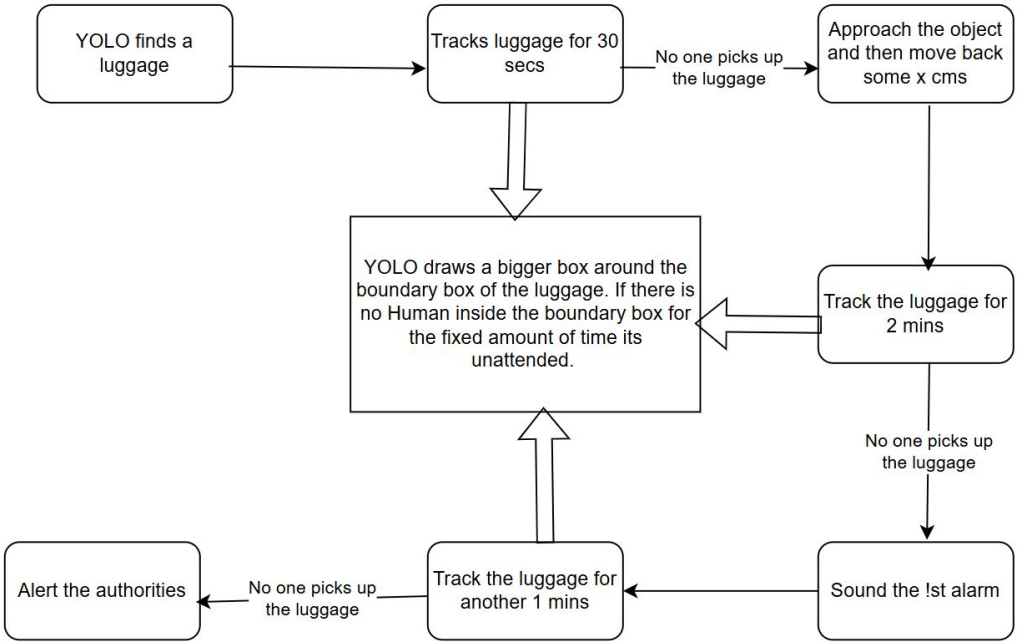
paper title	methodology used	advantages	disadvantages	challenges
Abandoned Object Detection Method Using Convolutional Neural Network[6]	A CNN model is used to classify objects as abandoned. It extracts spatial and temporal features from the input frames, processes and employs a threshold-based post-processing step to identify abandoned objects	The method demonstrates high accuracy. It is very effective in handling complex environments with diverse object appearances.	The reliance on large datasets for training and the computational complexity of CNNs can limit real-time applicability, especially in resource-constrained systems.	Challenges include managing occlusions, reducing false positives in crowded scenes, and ensuring efficient performance in real-time scenarios.

paper title	methodology used	advantages	disadvantages	challenges
Real-Time Abandoned and Stolen Object Detection Based on Spatio-Temporal Features in Crowded Scenes [7]	Background Subtraction and Blob Detection with Two-Level Detection :Spatio-Temporal Detection Methods and at last Owner Retrieval and Classification.	This method works good in Crowded Environments this paper reduced false alarm and adaptability to the real-Time Processing.	Subjectivity in Definitions: Definitions of "abandoned" or "stolen" objects may vary, introducing inconsistencies in detection.	Crowded Scene Complexity and Trade-Off Between Recall and Precision to increase the accuracy and Computational Overhead
Real-Time Deep Learning Method for Abandoned Luggage Detection in Video [8]	Firstly the paper did the Static Object Detection (SOD) involves Background subtraction and Abandoned Luggage Recognition using Convolutional Neural Networks	Handles variations in lighting, angles, and occlusions well. Optimized for fast, real-time video analysis.Better at reducing false positives than traditional methods.	Models may need continuous retraining or fine-tuning to adapt to new environments or evolving threats, requiring ongoing maintenance efforts.Performance depends on data quality and diversity.	Identifying whether a person is near or far from a bag, especially in 2D camera views, is difficult. Incorporating depth information or calculating angles to assess proximity is complex.

Methodology flowchart



Identification of unattended luggage



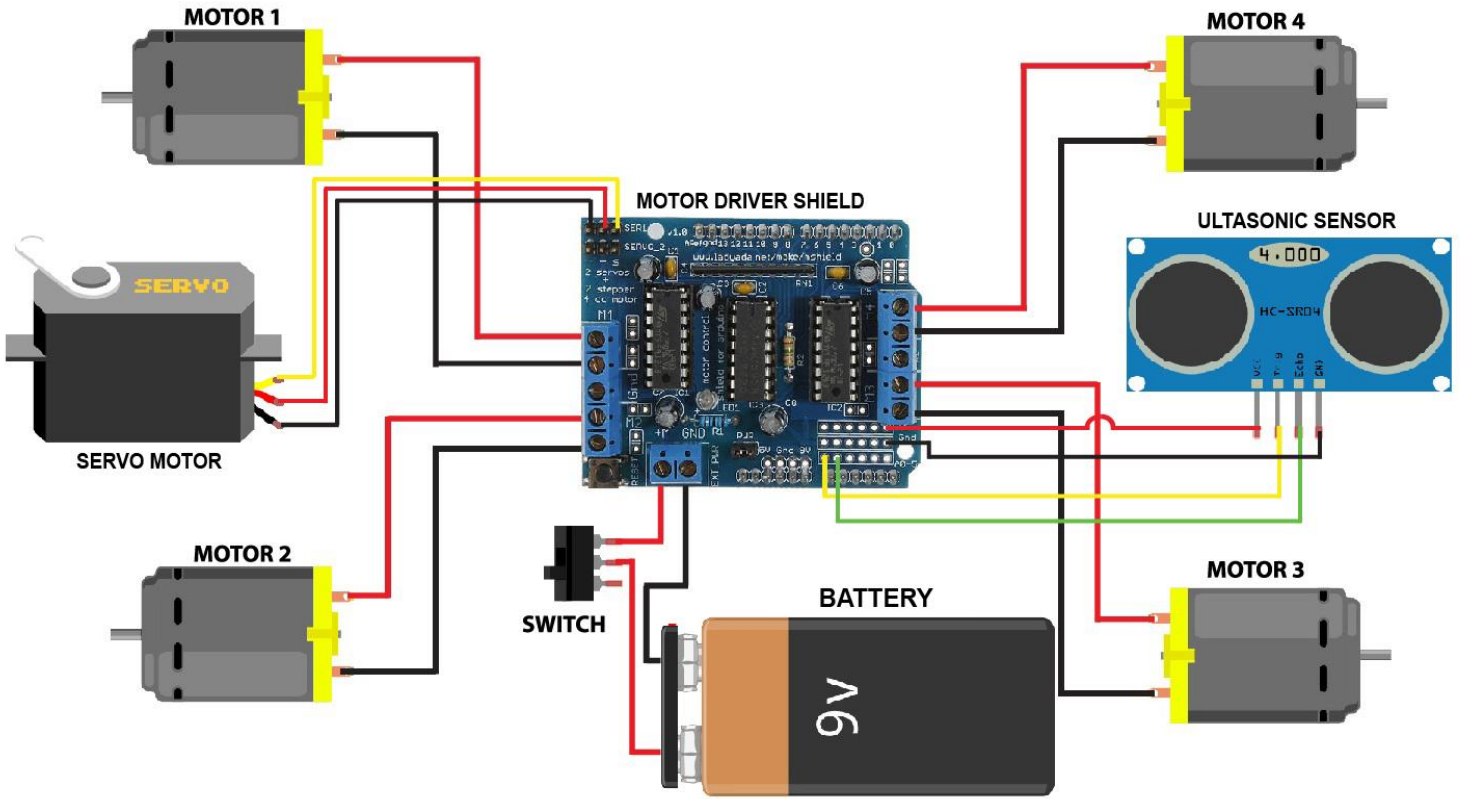
YOLO (You only look once)

1. Feature Extraction :
   - Uses C3k2 Block for efficient feature extraction. Captures edges, textures,object structures.
   - Uses C2PSA Block (Spatial Attention) for focusing on the higher important areas
   - Uses SPPF (spatial pyramid pooling fast) for processing the image at different zoom levels
   - Outputs a feature map with rich details for detection.

2. Feature Aggregation :
   - Goes through C3k2 block again
   - Uses C2PSA Block (Focuses on important areas using attention).
   - Uses SPPF Block to extract multi-scale features for detecting small and large objects).
   - Creates a feature representation that improves accuracy.

3. Head Prediction
   - Grid-Based Detection: Divides image into grid cells.
   - Each grid cell predicts bounding boxes, class probabilities, and confidence scores.
   - Uses Non-Maximum Suppression (NMS) to remove duplicate boxes and keep the best one.

Circuit Diagram for Arduino based Obstacle Avoidance Robot



Hardware Components

1) Arduino Uno
2) Motor Driver Shield
3) TT Gear Motor and wheels set
4) Servo Motor
5) Ultrasonic Sensor
6) 18650 Li-on Battery (2x)
7) 18650 Battery Holder
8) Male and Female Jumper wire
9) Acrylic Sheet
10) DC Power Switch
11) Webcam

Timeline

Week 1 - running YOLO v11 on laptop

Week 2 - fine-tuning yolo for luggage detection

Week 3 - building of obstacle avoidance robot using arduino

Week 4 - connecting the luggage detection and avoidance robot and test driving it

Week 5 - integrating GPS with the alert system and fine tuning the robot based on its performance

Week 6 - final functioning robot

References

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[3] Narwal, Pulkit, and Rahul Mishra. "Real time system for unattended Baggage detection." Proceedings of the International Research Journal of Engineering and Technology (IRJET) 6, no. 11 (2019).

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