Summer of Science -2023
Final Report

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Computer Vision
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1. Introduction:
Object detection is a fundamental problem in computer vision, enabling machines to identify and localize objects within images or video frames. Over the years, deep learning-based approaches have shown remarkable progress in this area. Among these approaches, YOLO (You Only Look Once) stands out as a widely-used and efficient algorithm for real-time object detection.

2. Object Detection in Computer Vision:
Object detection is a challenging task that involves two main objectives: localization and classification. Localization aims to determine the spatial location of objects within an image by predicting bounding boxes around them. On the other hand, classification involves identifying the object's category or class within each bounding box. Traditional object detection methods often relied on handcrafted features and multi-stage pipelines, making them computationally expensive and less accurate.

3. Introducing YOLO:
The YOLO algorithm, introduced by Joseph Redmon et al. in 2015, revolutionized object detection by approaching it as a regression problem. Unlike conventional methods that use sliding windows and complex feature extraction, YOLO processes the entire image in one pass and directly predicts bounding boxes and class probabilities. The algorithm divides the input image into a grid of cells and makes predictions at each cell's level, enabling it to be efficient and fast.

4. YOLO Architecture:
The YOLO architecture consists of a deep neural network with multiple convolutional layers, leading to end-to-end learning. The network takes an input image and produces a fixed number of bounding boxes and corresponding class probabilities for each box. The key components of the YOLO architecture are as follows:

a. Grid Cell Division: YOLO divides the input image into a grid of cells, and each cell is responsible for predicting objects within its region.

b. Bounding Box Prediction: Each grid cell predicts bounding boxes (usually 4) associated with objects present within the cell's region. These bounding boxes are defined by their center coordinates (x, y), width, height, and confidence score, representing the probability of containing an object.

c. Class Prediction: For each bounding box, YOLO predicts class probabilities for different object categories. This enables the algorithm to handle multiple object detections within the same cell effectively.

d. Non-Maximum Suppression (NMS): After generating multiple overlapping bounding boxes, YOLO uses NMS to eliminate redundant detections, retaining only the most confident and accurate ones.

5. Advantages of YOLO:
a. Real-Time Performance: YOLO's architecture allows for parallel processing, enabling real-time object detection even on resource-constrained devices like embedded systems and drones.

b. Simplicity and Efficiency: YOLO's single-stage detection approach makes it more straightforward and computationally efficient compared to multi-stage methods.

c. Strong Generalization: YOLO exhibits robustness across various object categories and performs well across different datasets, making it versatile for diverse applications.

6. YOLO Versions and Improvements:
Since its initial release, YOLO has seen several improvements and versions. YOLOv2 introduced better object localization with anchor boxes, while YOLOv3 improved overall detection performance with a feature pyramid network. YOLOv4 further enhanced accuracy and introduced architectural innovations like CSPDarknet53 and PANet. Researchers continue to build upon the YOLO framework to push the boundaries of real-time object detection.

7. Applications of YOLO:
a. Autonomous Vehicles: YOLO is used in self-driving cars to detect and track pedestrians, vehicles, traffic signs, and other objects in real-time, enabling safer and more efficient driving.

b. Surveillance Systems: YOLO finds applications in security and surveillance systems to monitor public spaces, airports, and other areas for unauthorized access or suspicious activities.

c. Industrial Automation: YOLO can be employed in manufacturing industries to inspect products for defects or ensure quality control on production lines.

d. Healthcare: YOLO has the potential to assist medical professionals in detecting anomalies and abnormalities in medical images, aiding in the diagnosis process.

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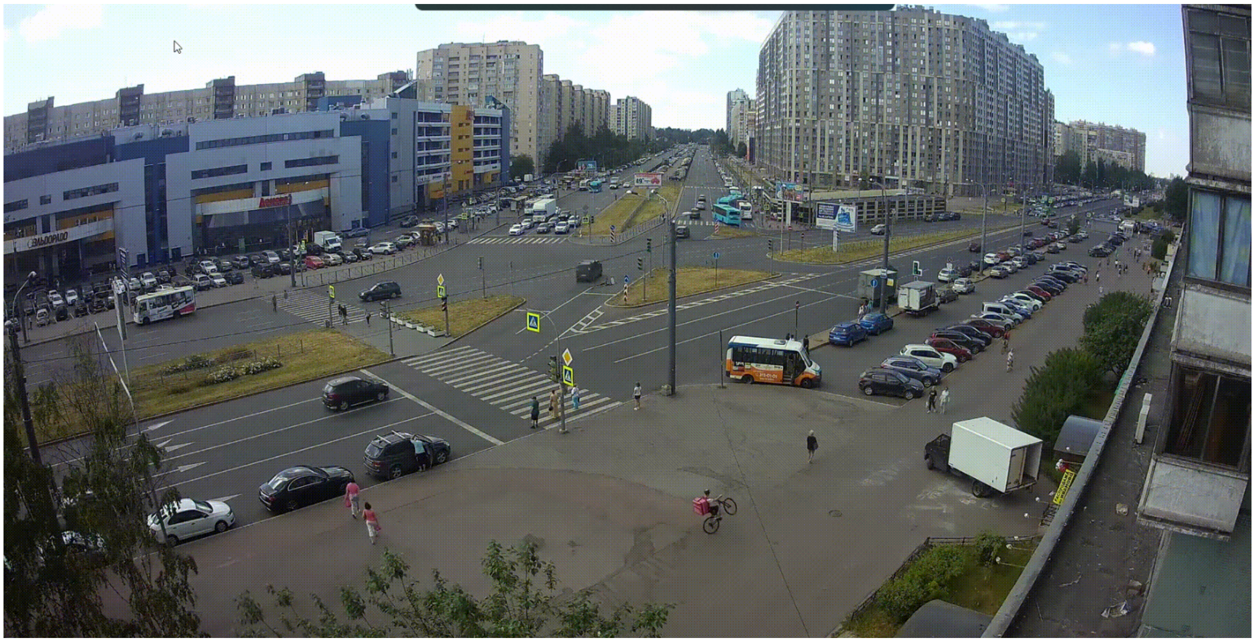
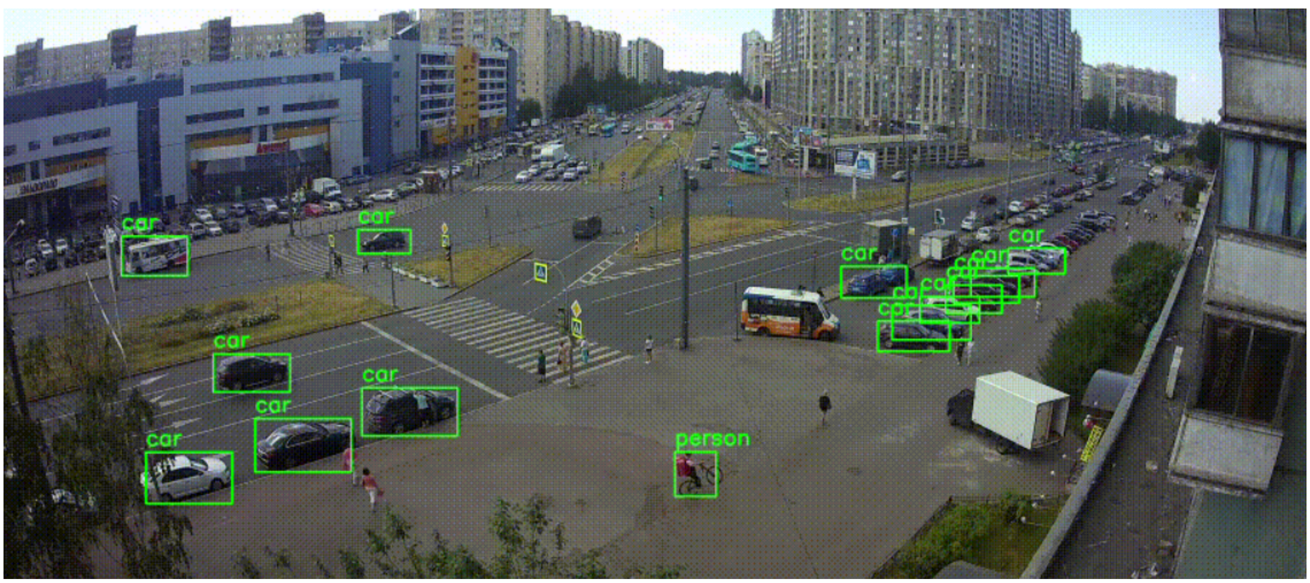
8. Results:





Link to code files and documentation -
https://drive.google.com/drive/folders/1JynwP_jE7GiP3ZnEuAdk3lcbMLx2BMg9?usp=drive_link

9. Conclusion:
Object detection using computer vision has witnessed significant advancements, and YOLO has emerged as a prominent solution for real-time and accurate detection. Its efficiency, simplicity, and robustness have made it widely adopted in various industries and applications. As the field of deep learning continues to progress, we can expect further improvements and innovations in YOLO and other object detection algorithms, opening new opportunities for computer vision-based solutions in different domains