# 3D Pedestrian Detection Using LiDAR Data COSE416 (2024 Fall) - Homework 1

https://github.com/Taha-ElBoauzidi/20242R0136COSE41600

- **Objective**
- The project aims to develop a method for detecting pedestrians in 3D LiDAR point cloud data, utilizing efficient point cloud processing and clustering approaches. By focusing on computational optimization, the method processes data in intervals, achieving responsiveness close to real-time operation.

# Approach

- **Interval Processing**:
- The system processes data every 5 frames instead of continuous frames. This reduces redundant computations, allowing focus on meaningful pedestrian motion.
- **Traditional Point Cloud Techniques**:
- No deep learning methods are used, relying solely on geometrical clustering and efficient filtering mechanisms.
- **Data Preprocessing**:
- The workflow starts with the following steps:
  - **Point Reduction**: Voxel-based downsampling to decrease data density.
  - **Noise Elimination**: Radius-based filtering removes scattered noise points.
  - **Ground Plane Extraction**: Ground points are segmented using the RANSAC algorithm.

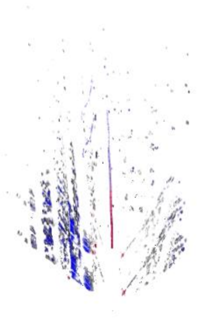
- **Detection Pipeline:**
- **Motion Analysis:**
  - Movement between frames is identified by comparing nearest-neighbor distances using KDTree. Points with displacement beyond a threshold are marked as moving.
- **Clustering**:
  - Detected moving points are clustered using the DBSCAN algorithm, focusing on motion consistency.
  - Clustering parameters
- **Bounding Box Creation**:
  - Each cluster undergoes a filtering stage to ensure it meets criteria for a pedestrian:
    - Width, height, and depth thresholds are applied.
    - Height constraints are relaxed to include crouching or crawling pedestrians.
  - Valid clusters are encapsulated in 3D bounding boxes.

# Results

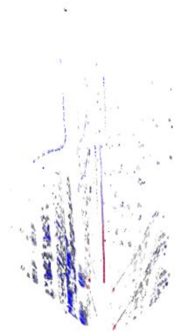
- **Performance Metrics:**

| Scenario | Files Processed | Bounding Box Time | Total Time (with saving) |
|---|---|---|---|
| Straight Walk | 224 | 19s | 2m 37s |
| Zigzag Walk | 294 | 25s | 3m 18s |
| Crawl | 724 | 50s | 6m 16s |
| Duck Walk | 467 | 37s | 4m 54s |

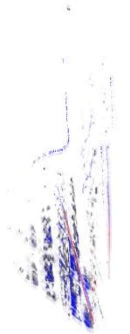
# Observations:



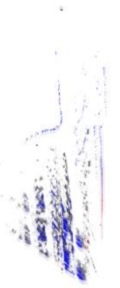
straight walk



Straight duck walk



straight crawl



zigzag walk

## High-Illumination Scenarios:

- Pedestrian motion was detected effectively in well-lit environments, with a clear distinction between clustered points (blue) and bounding boxes (red).
- Walking and zigzag patterns yielded the best results, showcasing stable bounding boxes.

## Low-Illumination Scenarios:

- Reduced lighting led to higher noise levels, affecting the accuracy of clustering and motion detection.
- Challenges were observed for low-height movements like crawling, where bounding box generation struggled to meet size constraints.