Unsupervised Anomaly Detection in Traffic Videos

Akshaya Surendran

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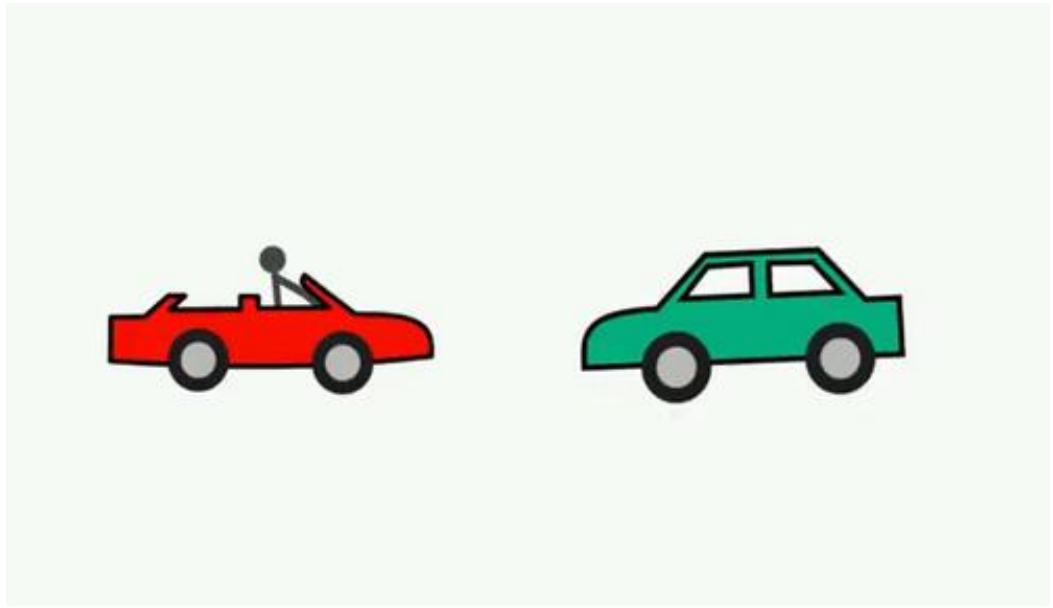
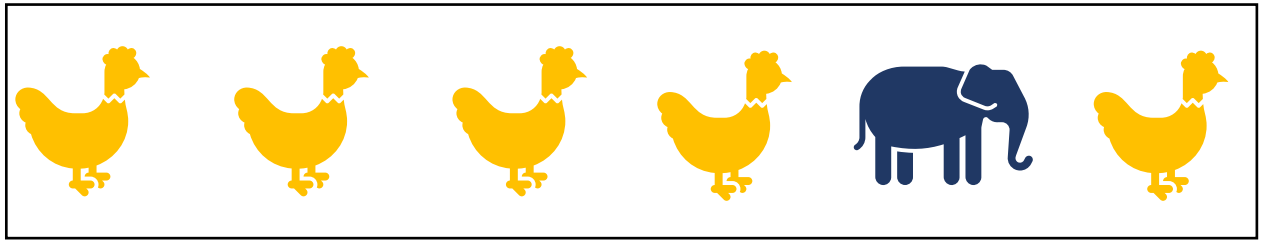
Introduction

NVIDIA AI CHALLENGE 2020

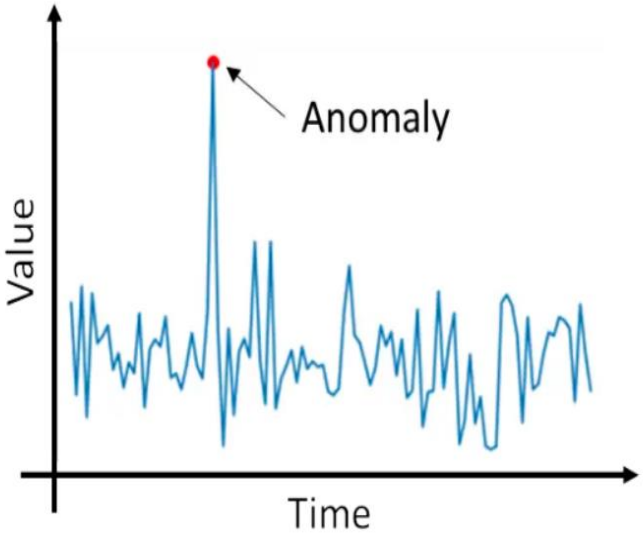


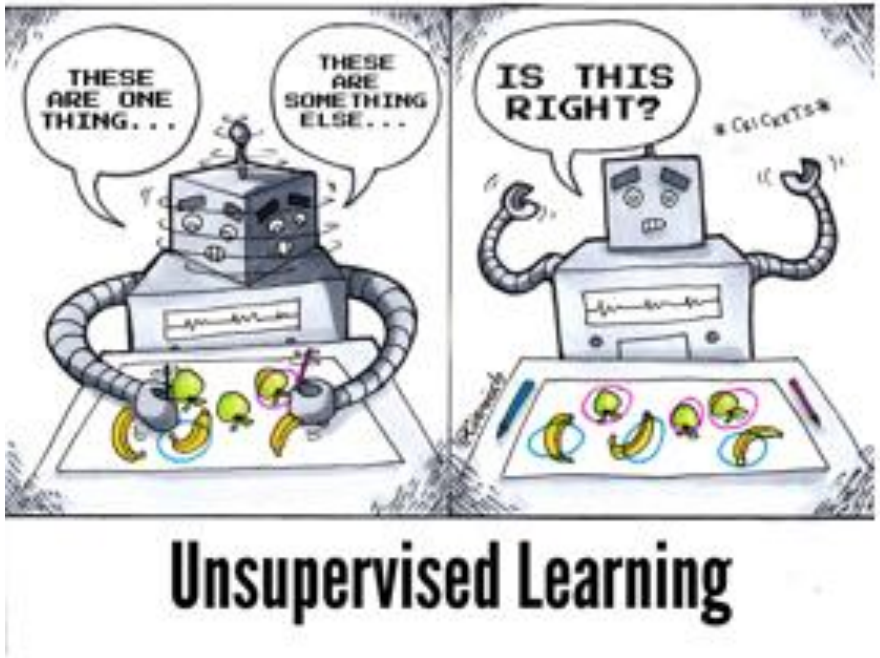
Robbery thief robber burglar steal money bag Vector Image (vectorstock.com)
https://tenor.com/search/animated-car-crash-gif-gifs
https://www.pinterest.de/pin/850969292074119390/

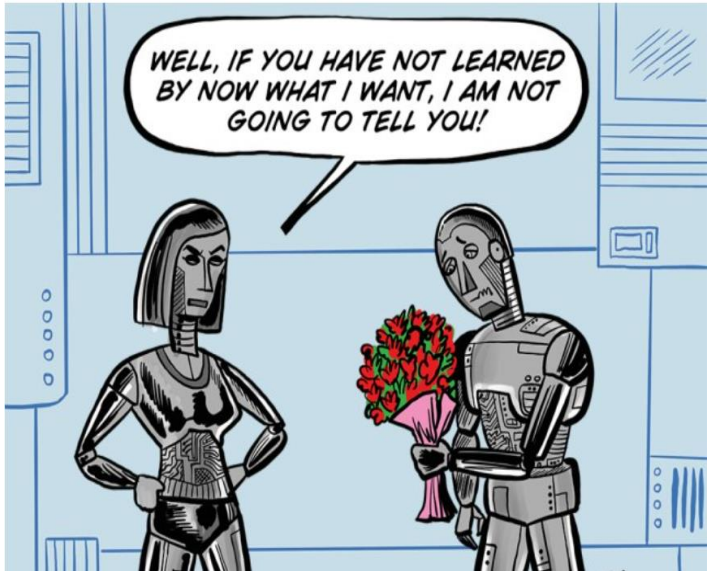
What is Anomaly Detection?



Anomaly detection (also outlier detection) is the identification of rare items, events or observations which raise suspicions by differing significantly from the majority of the data.

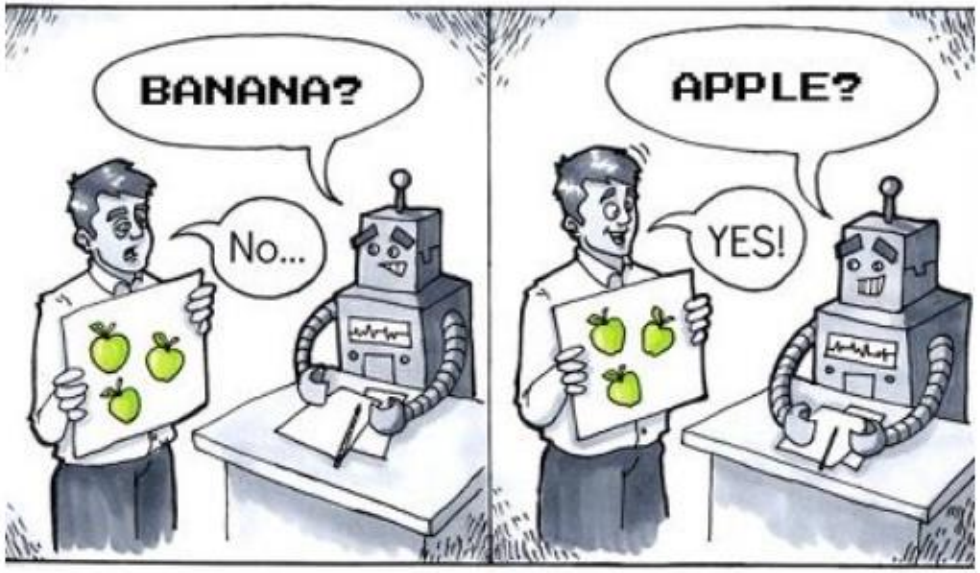


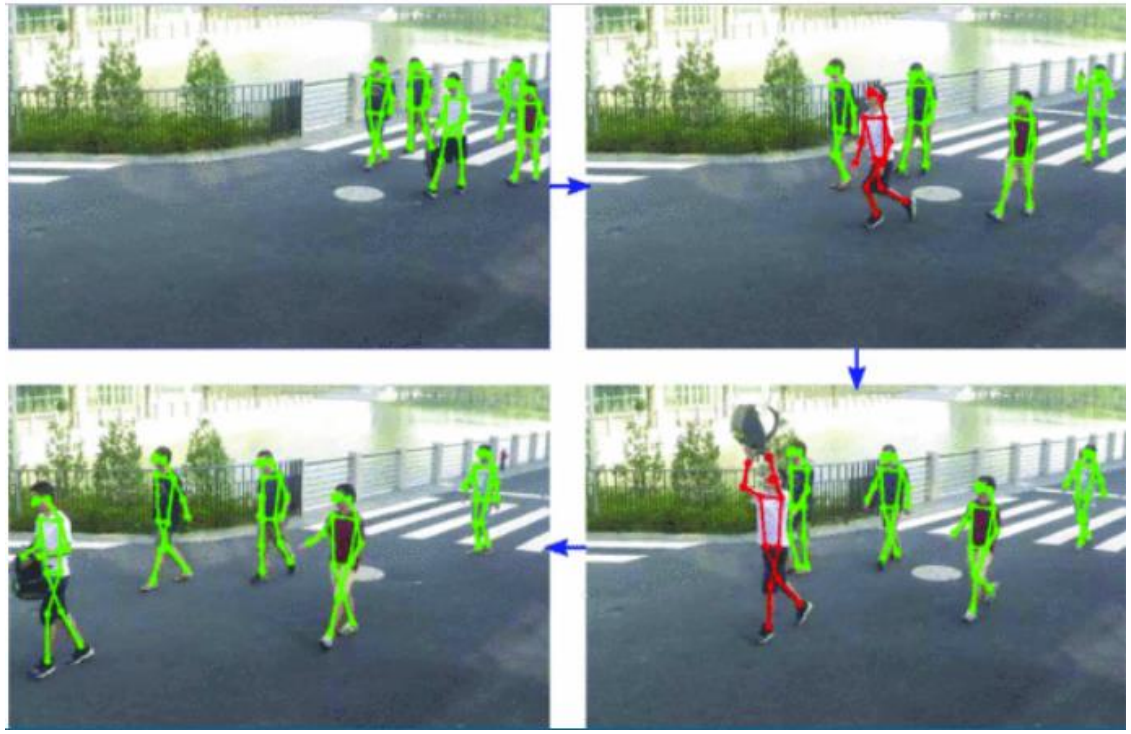




Anomaly Detection: Industrial Asset Insights Without Historical Data | Engineering.com
https://twitter.com/athena_schools/status/1063013435779223553
Cartoon: Machine Learning Problems in 2118 - KDnuggets

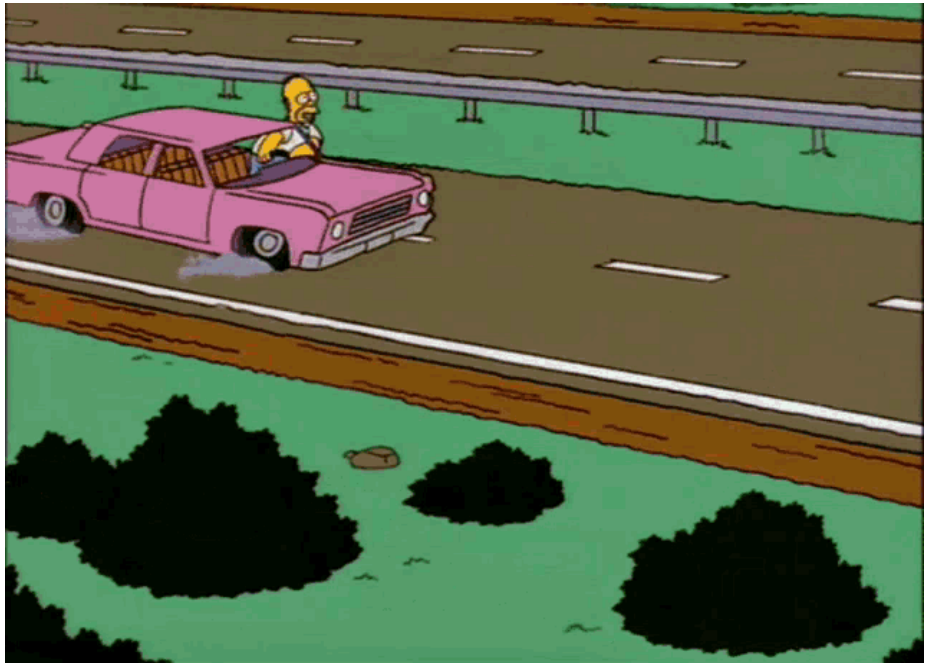
Related Work





https://twitter.com/athena_schools/status/1063013435779223553
https://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=1530127
https://arxiv.org/pdf/1903.03295.pdf

Proposed Work

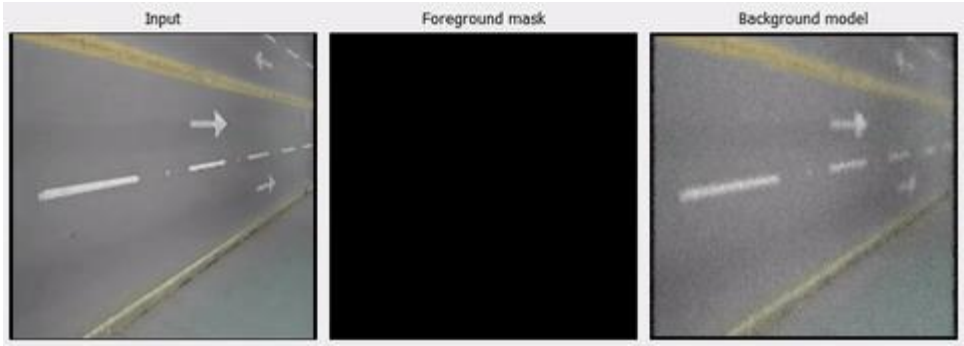


Preprocessing → Candidate Selection → Backtracking Anomaly Detection

https://tenor.com/view/the-simpsons-homer-simpson-car-accident-explosion-slam-breaks-gif-20458413

Preprocessing

I. Background Modelling:

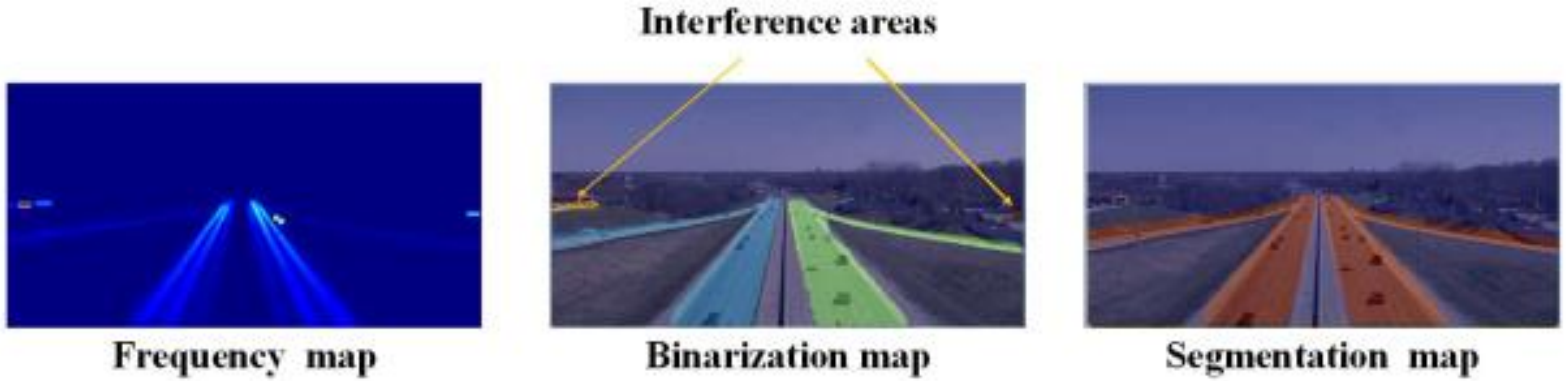


https://www.researchgate.net/publication/51938197_Online_Robust_Subspace_Tracking_from_Partial_Information
https://github.com/mohiitaa/background-subtraction

Preprocessing

II. Road Segmentation:

The image is normalized to perform binarization to extract the segmentation map (S)



https://openaccess.thecvf.com/content_CVPRW_2019/papers/AI%20City/Bai_Traffic_Anomaly_Detection_via_Perspective_Map_based_on_Spatial-temporal_Information_CVPRW_2019_paper.pdf

Preprocessing (contd.)

III. Object Detection:

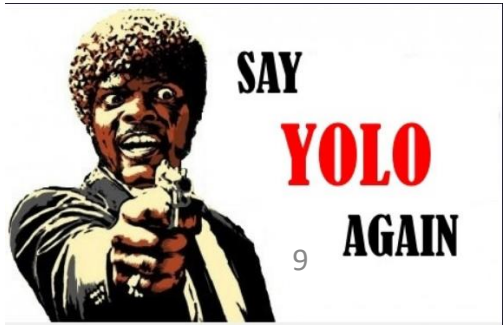
YOLO (**Y**ou **O**nly **L**ook **O**nce**)**

YOLO is an algorithm that uses neural networks to provide real-time object detection.

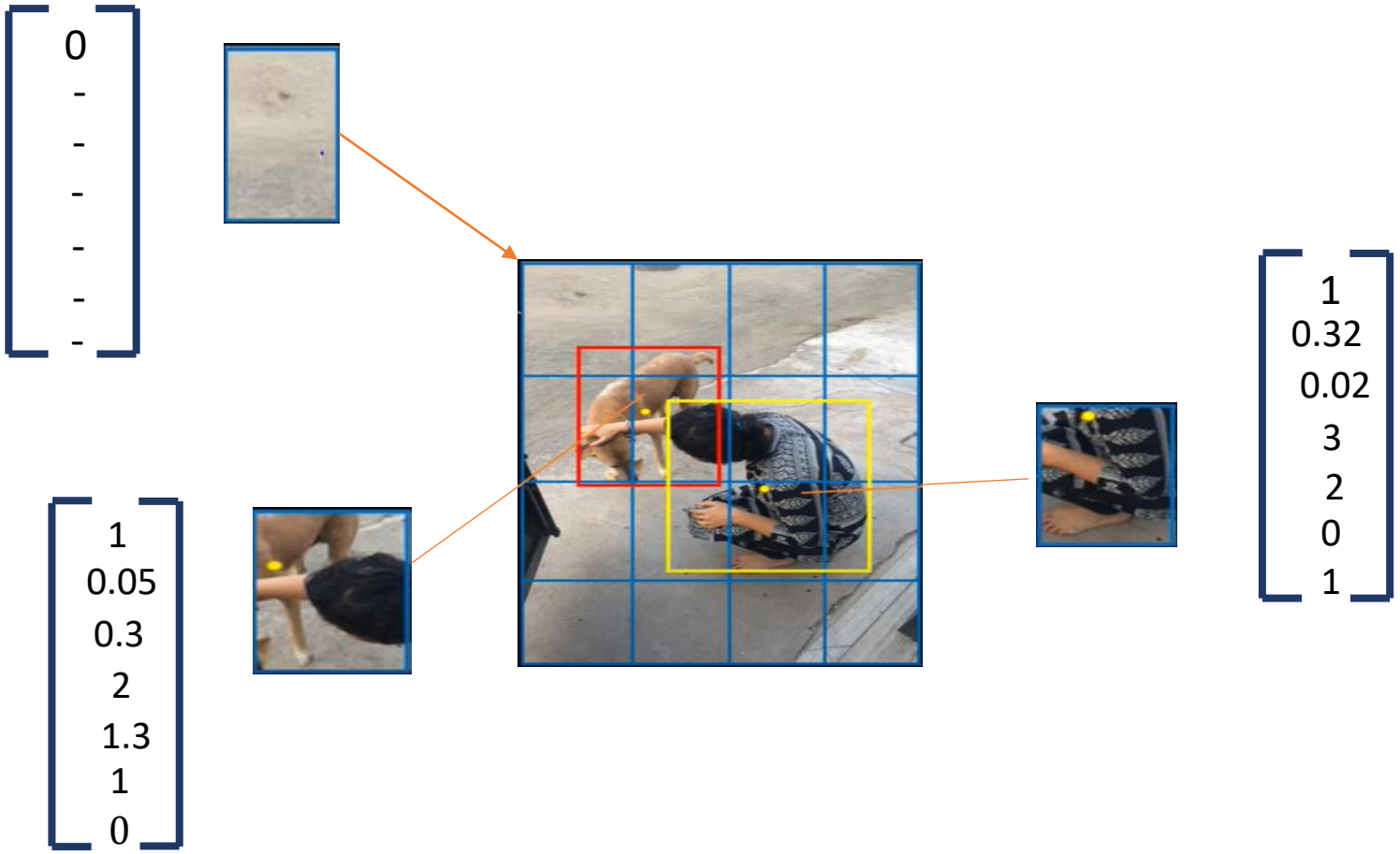
$$\begin{bmatrix} P_c \\ C_x \\ C_y \\ W \\ H \\ C_1 \\ C_2 \end{bmatrix} \quad \begin{bmatrix} 1 \\ 50 \\ 70 \\ 60 \\ 70 \\ 1 \\ 0 \end{bmatrix}$$

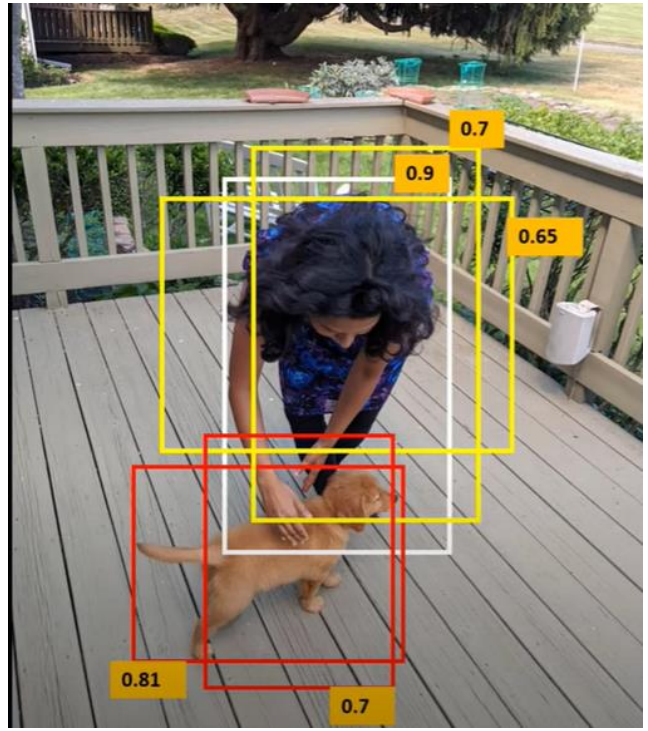
C_1 Dog Class

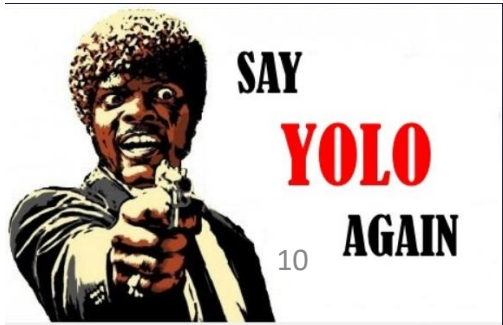
C_2 Person Class



Preprocessing (contd.)





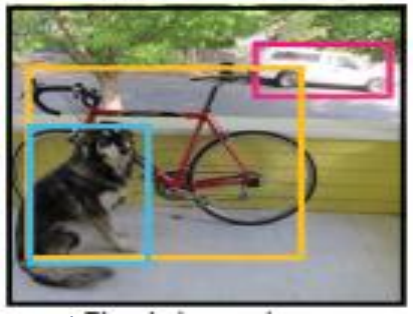


Preprocessing (contd.)

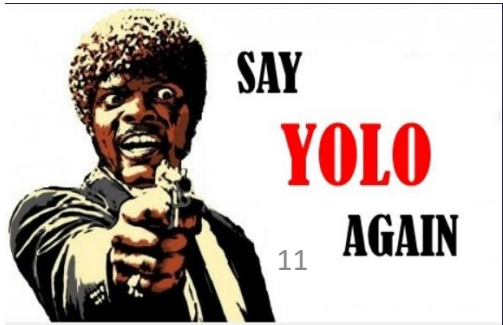
S X S grid on input

Bounding box + Confidence

Class probability map

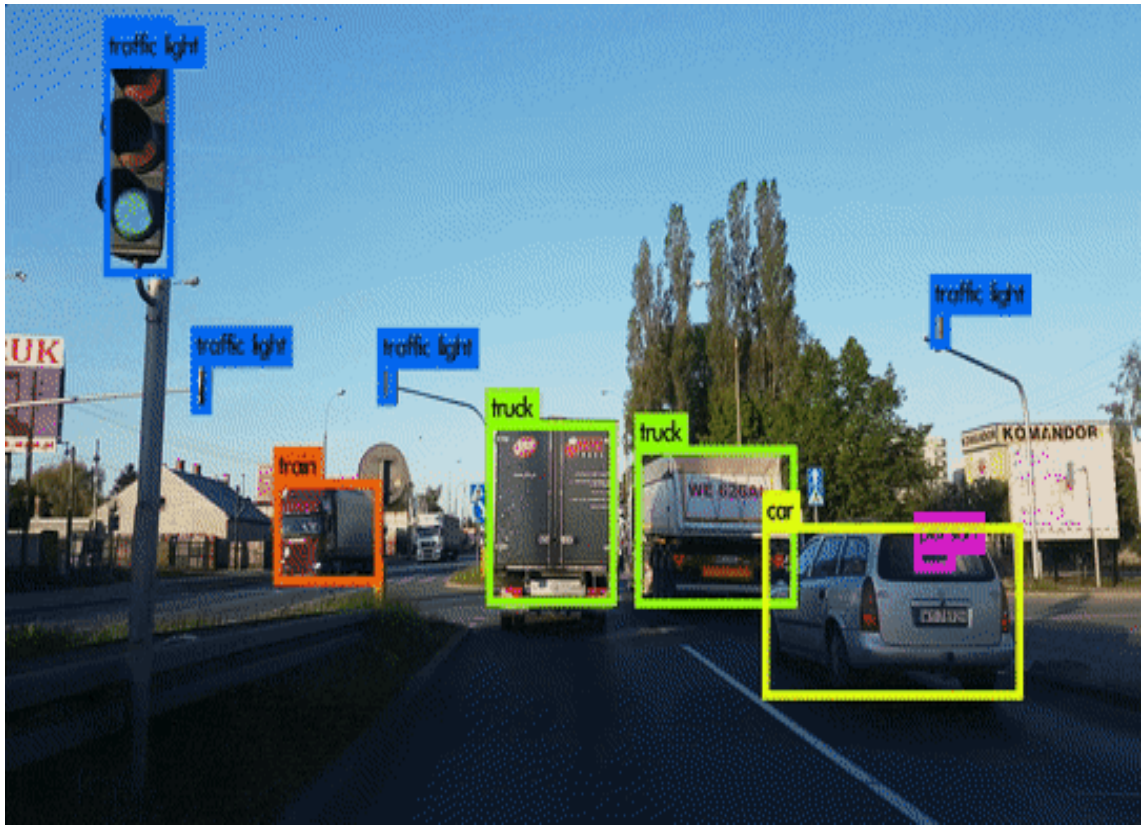


Final Detections

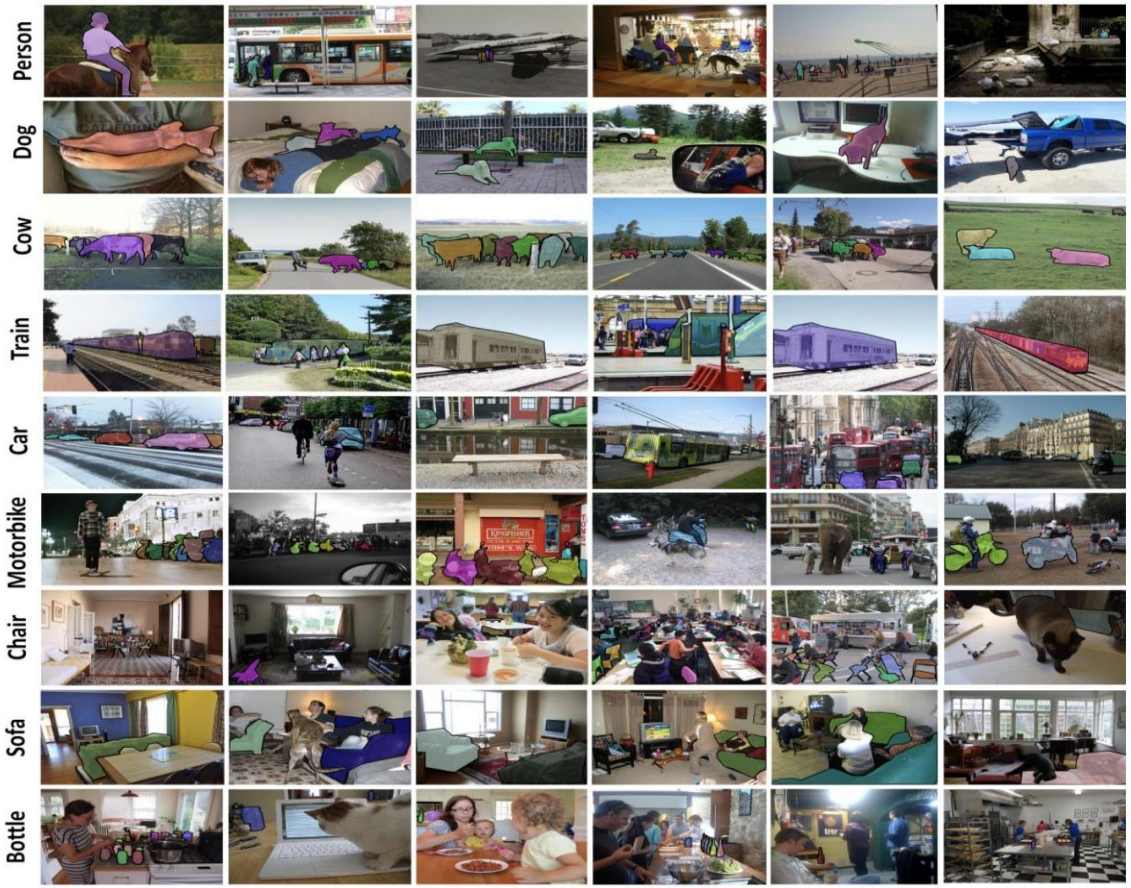


https://www.cv-foundation.org/openaccess/content_cvpr_2016/papers/Redmon_You_Only_Look_CVPR_2016_paper.pdf

Preprocessing (contd.)



MS COCO is a large-scale object detection, segmentation, and captioning dataset by Microsoft



$$C^{XY}=\{(c^{t}_{xi}, c^{t}_{yi}), \ldots.\}$$
$$L^{XY}=\{(w^{t}_{xi}, h^{t}_{yi}), \ldots.\}$$

https://gfycat.com/gifs/search/yolo+object+detection
https://cocodataset.org/#home

Preprocessing (contd.)

Background Modeling

Frame Segmentation

Video Frames

Segmentation Map

Detected Objects

Preprocessing Pipeline

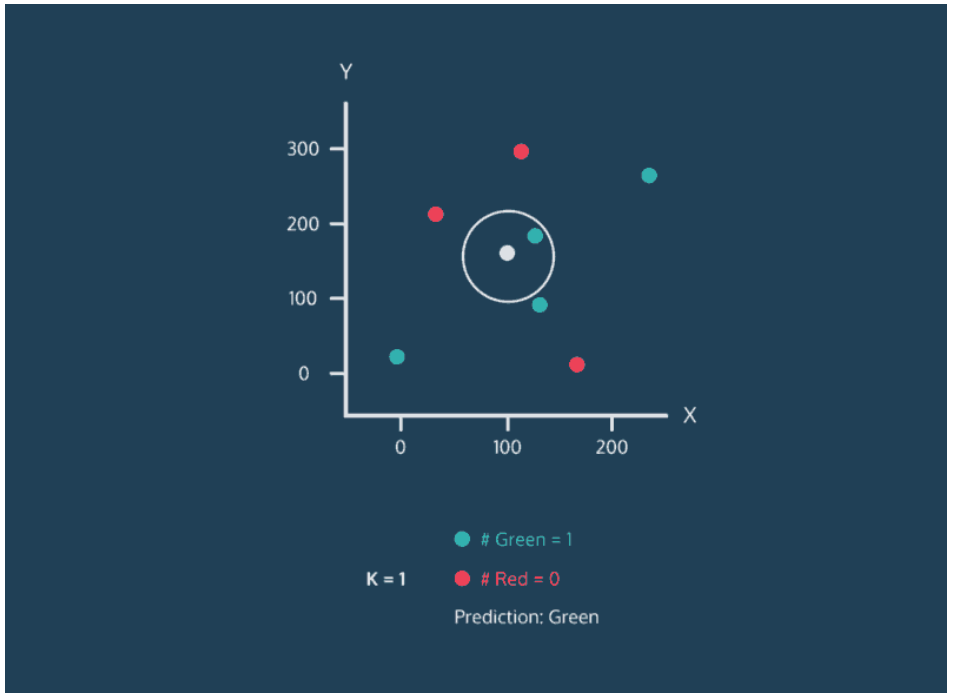
https://openaccess.thecvf.com/content_CVPRW_2020/papers/w35/Doshi_Fast_Unsupervised_Anomaly_Detection_in_Traffic_Videos_CVPRW_2020_paper.pdf

Candidate Selection

I. Outlier Detection:

- K - Nearest Neighbor

K Nearest Neighbor is a simple algorithm that stores all the available cases and classifies the new data or case based on a similarity measure.



A point (c^t_{xi}, c^t_{yi}) (center of the bounding box for an object *i* detected at each time instance t) as misclassified if

$$d^t_{xi,yi}(k_1) \leq l_1$$, and as a slow-moving vehicle if

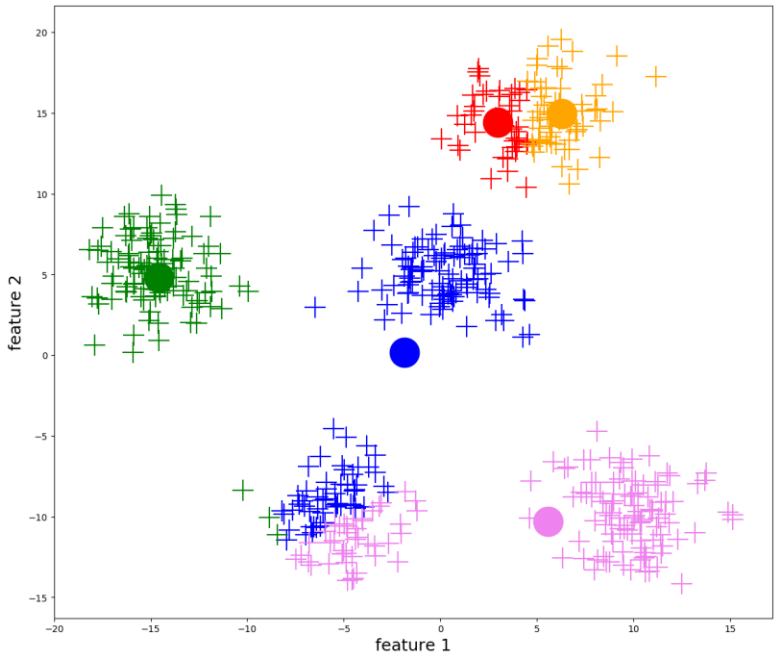
$$d^t_{xi,yi}(k_2) \geq l_2$$

https://vinaypaspula.substack.com/p/deep-dive-into-k-nearest-neighbors-classifier-699bf81ede89

Candidate Selection (contd.)

- II. Hotspots Detection:

K – Means Clustering



K- Means Clustering is an unsupervising learning method that aims to partition n observations into k clusters in which each observation belongs to the cluster with the nearest mean (cluster centers or cluster centroid), serving as a prototype of the cluster.

Select K using elbow method

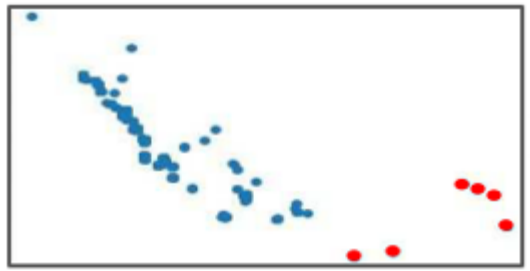
if Centroid not in the Segmentation Map, then Remove.

For each time instance t and each K. The B-box centers are compared with centroids.

Declare t as potential anomaly onset time tK for centroid K

https://ai.plainenglish.io/understanding-k-means-clustering-hands-on-visual-approach-c2dc46f0ed18

Candidate Selection (contd.)



Nearest Neighbor Approach

Clustering based candidate selection

Potential Region of Interest

Candidate Selection Pipeline

https://openaccess.thecvf.com/content_CVPRW_2020/papers/w35/Doshi_Fast_Unsupervised_Anomaly_Detection_in_Traffic_Videos_CVPRW_2020_paper.pdf

Backtracking Anomaly Detection

Stalled Vehicle

No

Yes

Very low Structural Similarity

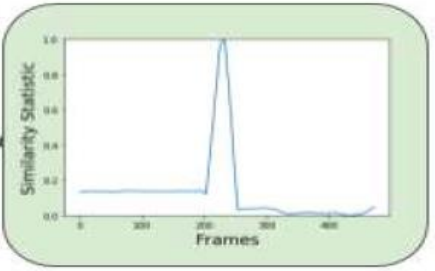
Dramatic increase in the Structural Similarity

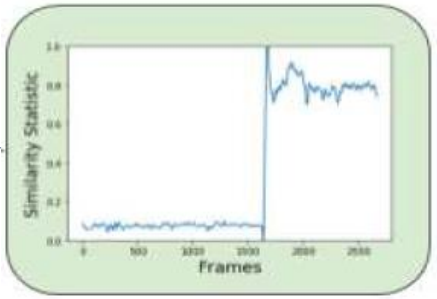
Region of Interest 1

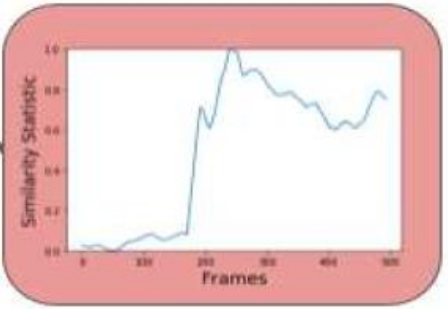
Region of Interest 2

Region of Interest 3

Anomaly Detector







Stalled Car Stock Illustrations – 22 Stalled Car Stock Illustrations, Vectors & Clipart – Dreamstime

https://openaccess.thecvf.com/content_CVPRW_2020/papers/w35/Doshi_Fast_Unsupervised_Anomaly_Detection_in_Traffic_Videos_CVPRW_2020_paper.pdf

Experiment

- Dataset
- 2 Evaluation Criteria:
  I. Detection delay measured by the root mean square error (RMSE)
  II. the detection performance measured by the F1 score.

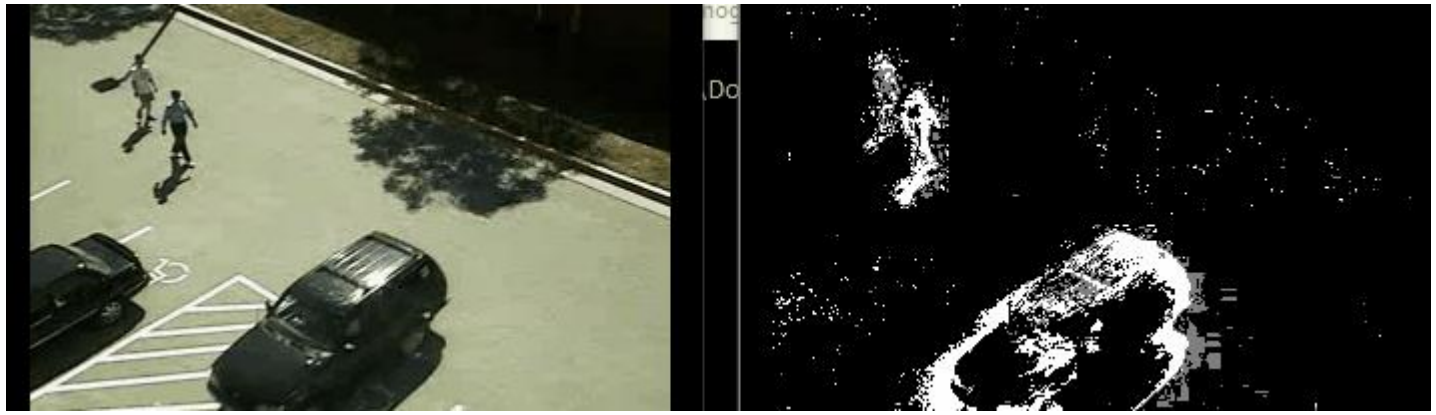
$$S_4 = F_1(1 - NRMSE)$$

F1 Score	RMSE	S4 Score
0.5926	8.2386	0.5763

https://tenor.com/view/second-place-the-simpsons-applause-clap-gif-10691011

Improvements

- Object Detection
- Background Modelling
- Segmentation Map



Background Subtraction using Stauffer and Grimson Algorithm - Inderjot Saggu (ijssaggu.github.io)
https://docs.microsoft.com/en-us/cognitive-toolkit/object-detection-using-faster-r-cnn

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