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DSBA

SuperCase Challenge

Worksite Monitoring

Team 16

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CentraleSupélec

ESSEC BUSINESS SCHOOL

TABLE OF CONTENTS

1 The Problem At Hand

2 Our Methodology

3 Model Performance

4 limitations/Scope for improvement

5 Business Implications & Final Thoughts

Problem at Hand

A total of 1,008 construction workers died on the job in 2020.

In 2020, there were 174,100 cases of injuries in the construction sector

Total workplace injury costs exceed $170 billion each year.

Our proposal

Building a worksite monitoring solution to evaluate and mitigate risks on worksite.

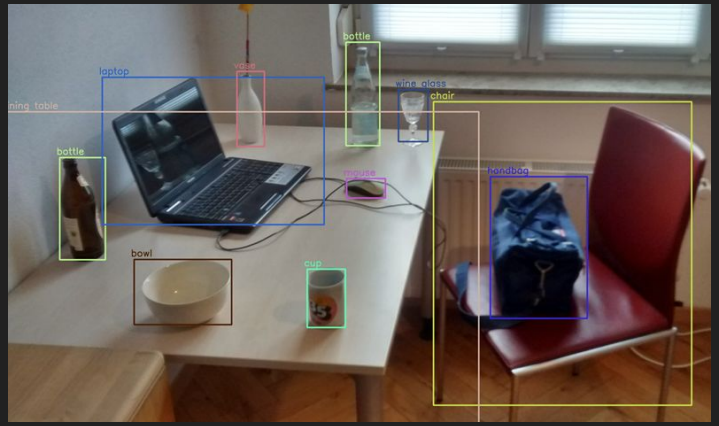
Methodology

Object Detection:

- ❑ What is the object?
- ❑ Where is it?

Different types of object detection algorithms:

- ❑ R-CNN
- ❑ Fast R-CNN
- ❑ Faster R-CNN
- ❑ SSD – Single Shot Detector
- ❑ Retina-Net
- ❑ YOLO (You Only Look Once)



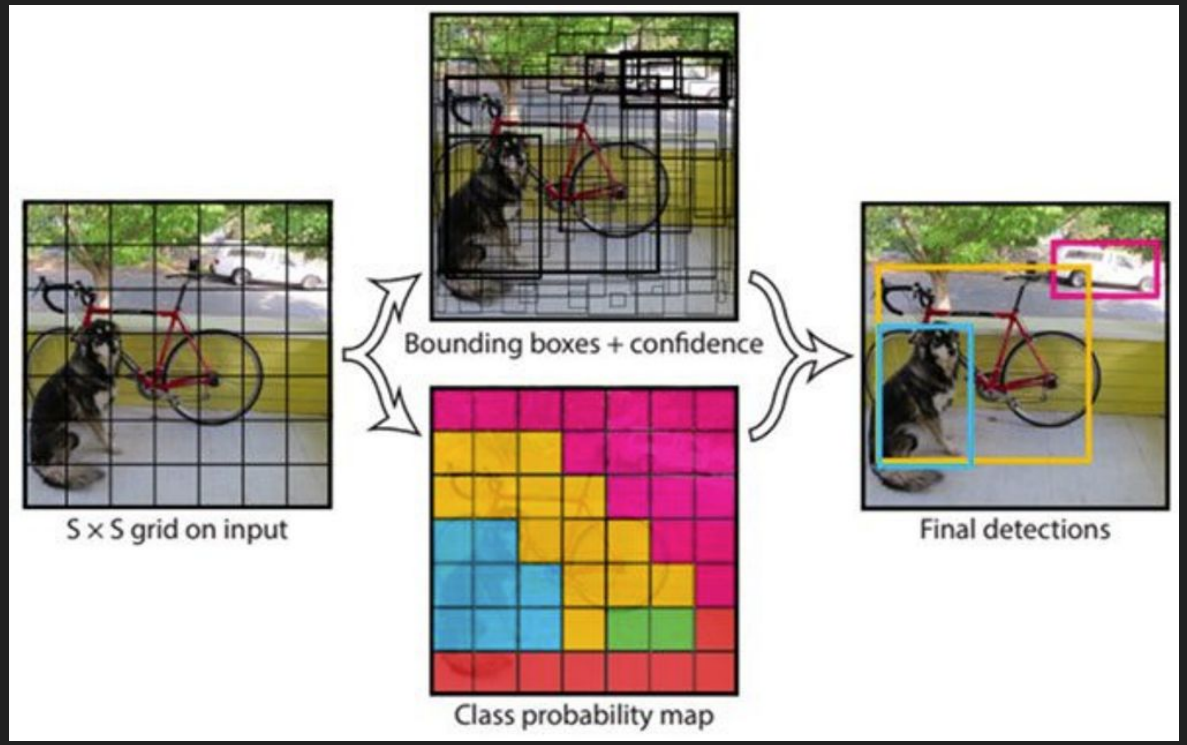
Methodology

Why YOLO?

- Just looks at the object once
- Speed
- Less background errors
- Highly generalizable

Methodology

How does it work?



Methodology

Exploration

The dataset contains:

- 1559 images (jpg)
- 1580 JSON files

4 classes:

- People
- Mixer Truck
- Concrete pump hose
- Vertical formwork

Image sources: concreteconstruction.net; dreamstime.com; concretepumphose.com; formworkscaffoldingsystems.com

Methodology

Pre-processing

```
0  0.480109 0.631250 0.692969 0.713278
0  0.741016 0.522222 0.314844 0.933333
27 0.785937 0.506944 0.039062 0.151030
```

YOLO expects annotations for each image in form of a .txt file.
We converted the information in the JSON files about the bounding boxes to text files where each line of the text file describes a bounding box.

Methodology

Testing the annotations

Partition the dataset

Next we partition the dataset into train and validation, keeping 85% for training.

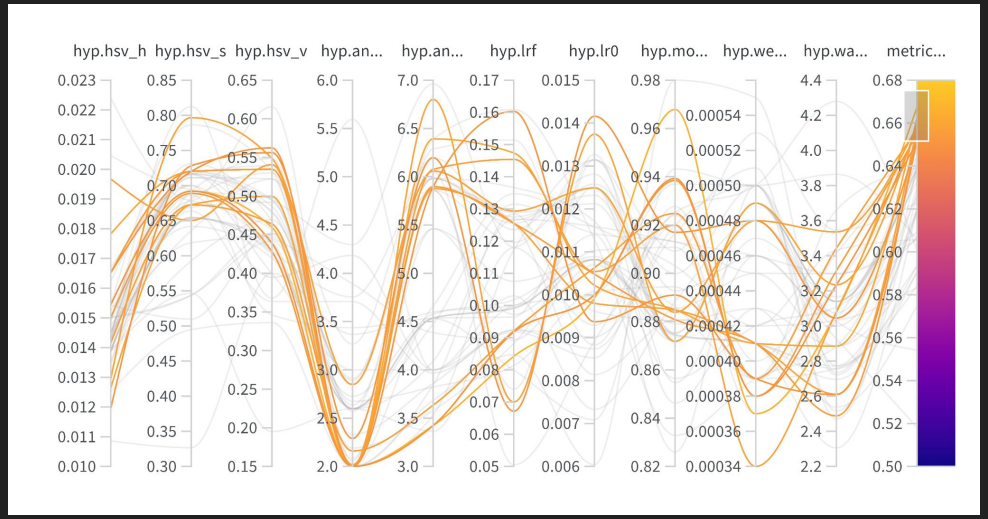
Training the Network

We use a batch size of 16 and 50 epochs and resize images to 640 x 640 to train the network, after a selection of hyperparameters and models.

Hyperparameter Optimization

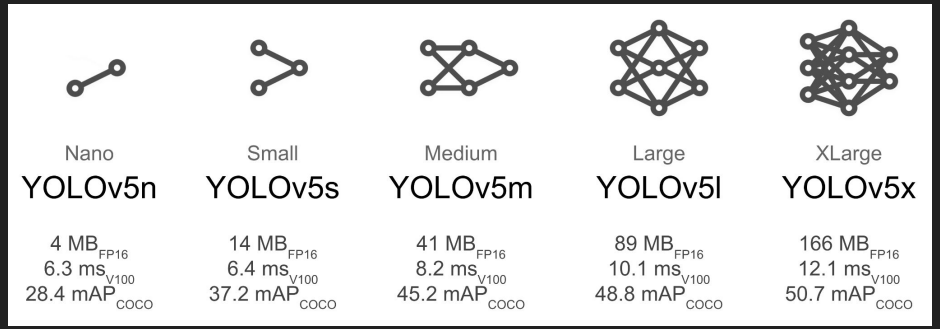
Hyperparameter evolution
A method of Hyperparameter Optimization using a Genetic Algorithm (GA) for optimization

Although for YOLO models, a minimum of 300 generations of evolution is recommended for best results, we set 50 generations, each with 10 epochs, for fine-tuning due to time and technical limitations. As can be seen in the model performance, such setting is good enough to get better hyperparameters than default ones.



Best-performing sets of hyperparameters

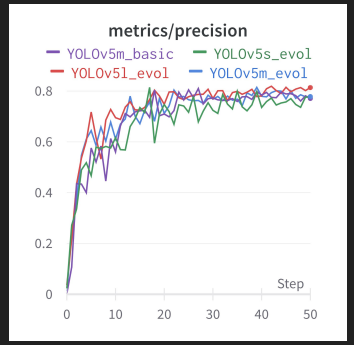
Model Performance



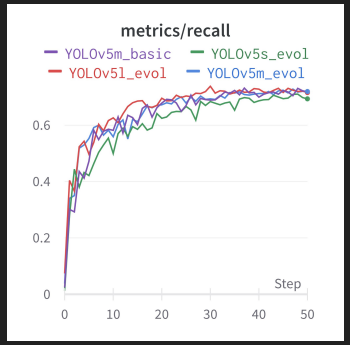
Pretrained models in YOLOv5

We trained the following 4 models in total, and their performance is presented on the right.

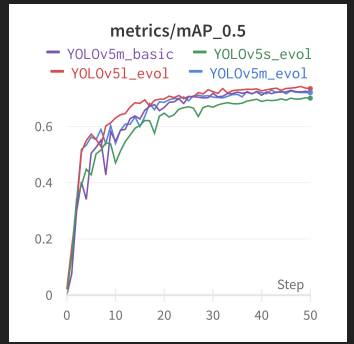
- ❑ YOLOv5m with default hyperparameters
- ❑ YOLOv5s with optimized hyperparameters
- ❑ YOLOv5m with optimized hyperparameters
- ❑ YOLOv5l with optimized hyperparameters



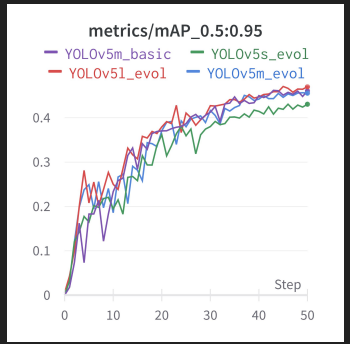
Precision



Recall



mAP@0.5



mAP@[0.5:0.95]

Object Detection Results

The output images show the bounding boxes and the confidence of correct detection and classification

Object Detection Results

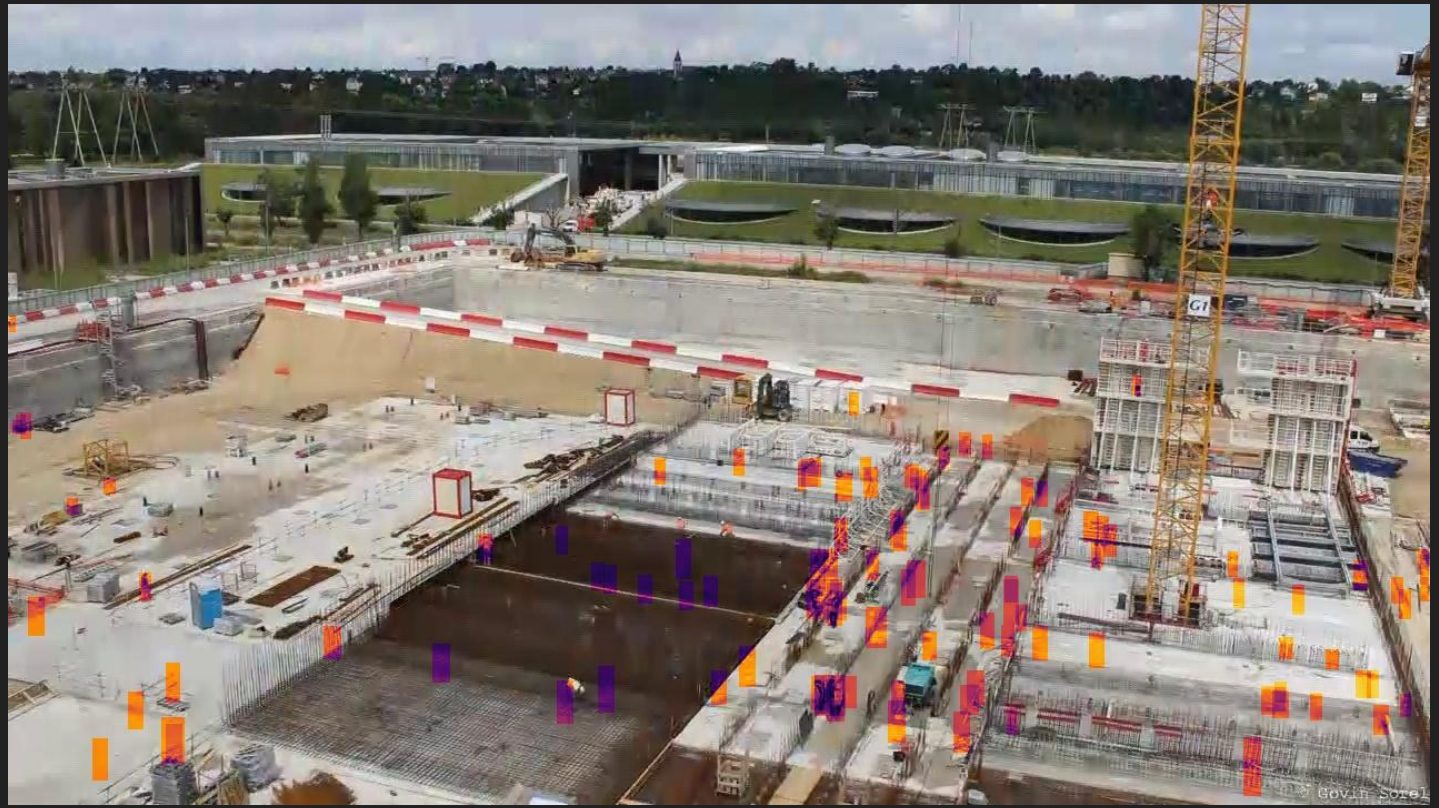
The output images show the bounding boxes and the confidence of correct detection and classification

Heat Maps

Combining bounding boxes from all images belonging to same camera cluster, and drawing heat map on single image

Heat Maps

Few more examples



Heat Maps

Few more examples

Heat Maps

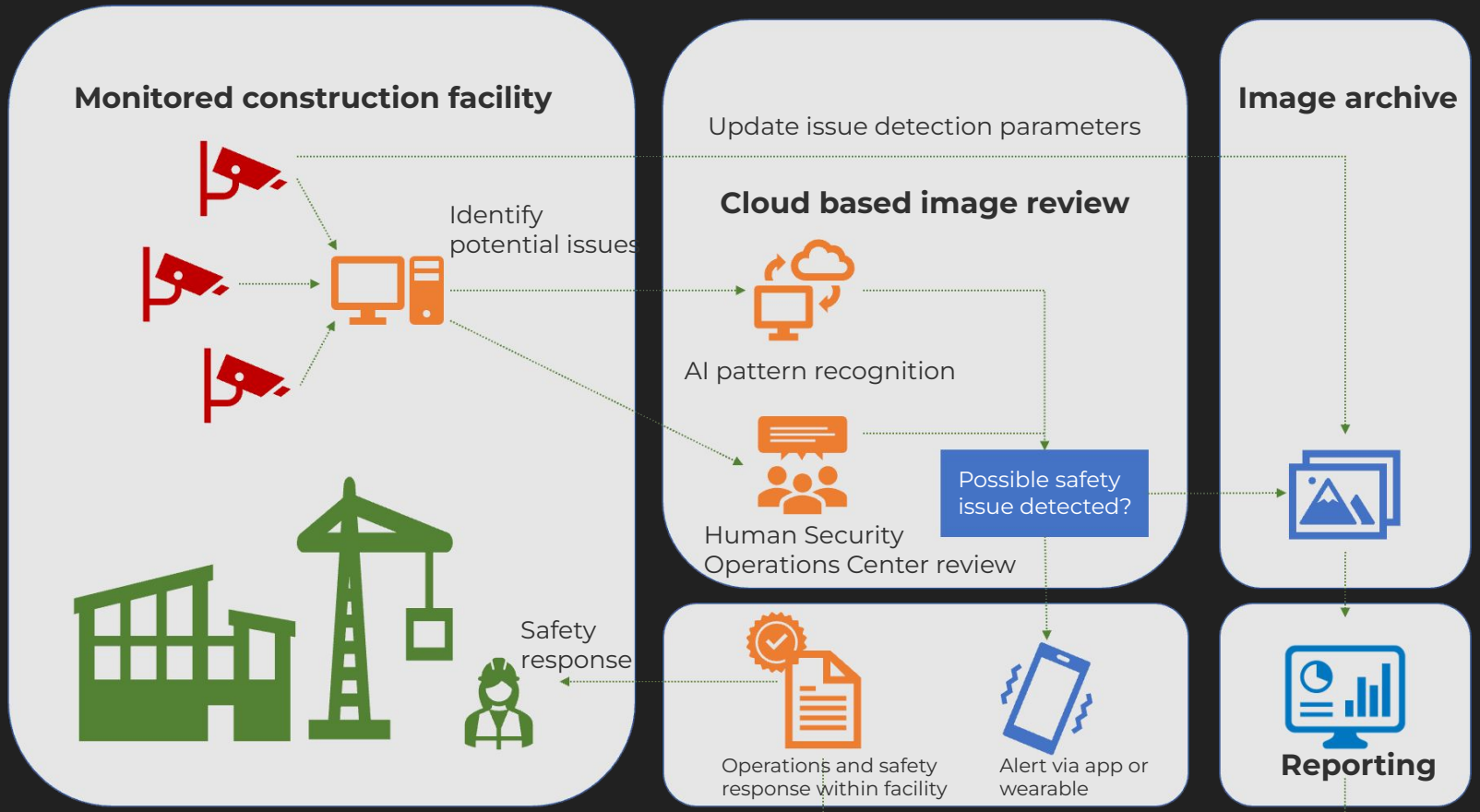
Few more examples (Grayscale)

Business Implications

Computer Vision Applications on Monitoring Sites:

- Detect Workers' activities (unsafe behavior and postures)
- Detect Interaction between workers and external environment (monitoring of collision accidents, monitoring fall accidents)

Our Business Solution



Business Recommendations

Essential construction KPIs to improve safety, production and profits

Accidents due to human error vs. Accident due to environment

Construction incidents account for **19%** of all occupational deaths in year 2016

Density of Workers per Unit Area

Gauge Risk Incidence in certain Areas

Total Recordable Injury Frequency Rate (TRIFR)

Number of injuries/hours worked per worker - Identifies overworked workers

Challenges & Additional scope

- Challenges
  - Non-static images for one camera
  - Hardware and time limitation to train models

- Additional scope
  - Improving accuracy / exploring other models
  - Time based heat maps
  - Density measurement
  - Detection of hazardous objects

Thank you for your attention !

Any questions?

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