# Dstl Safe Passage: Detecting and Classifying Vehicles in Aerial Imagery


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# Historical overview

December 2016 - March 2017

***Kaggle: Dstl Satellite Imagery Feature Detection***

Roman Solovyov, Artur Kuzin 2nd place ($30,000)

Vladimir Iglovikov, Sergey Mushinskiy 3rd place ($20,000)

- blog posts (rus, eng)
- meetup talks (rus, eng)
- paper (next week)

Organizers spent $465,000 and got state of the art solutions that they can not use.

# Historical overview

March 2017

- Press release: Dstl's Kaggle competition has been a great success
- DSTL pays BAE Systems to create their own Kaggle: https://www.datasciencechallenge.org and start two competitions (Computer Vision and Natural Language Processing)
- Problems are pretty good, but rules of the competitions are discriminatory (Everyone can participate, but only limited set of people can claim prize money)
- We got verbal and written promise from organizers that rules will be changed.

# Problem Statement

- RGB satelite images
- 2000x2000
- 5cm / pixel
- 600 train
- 600 test
- 9 classes

# Problem Statement: class distribution

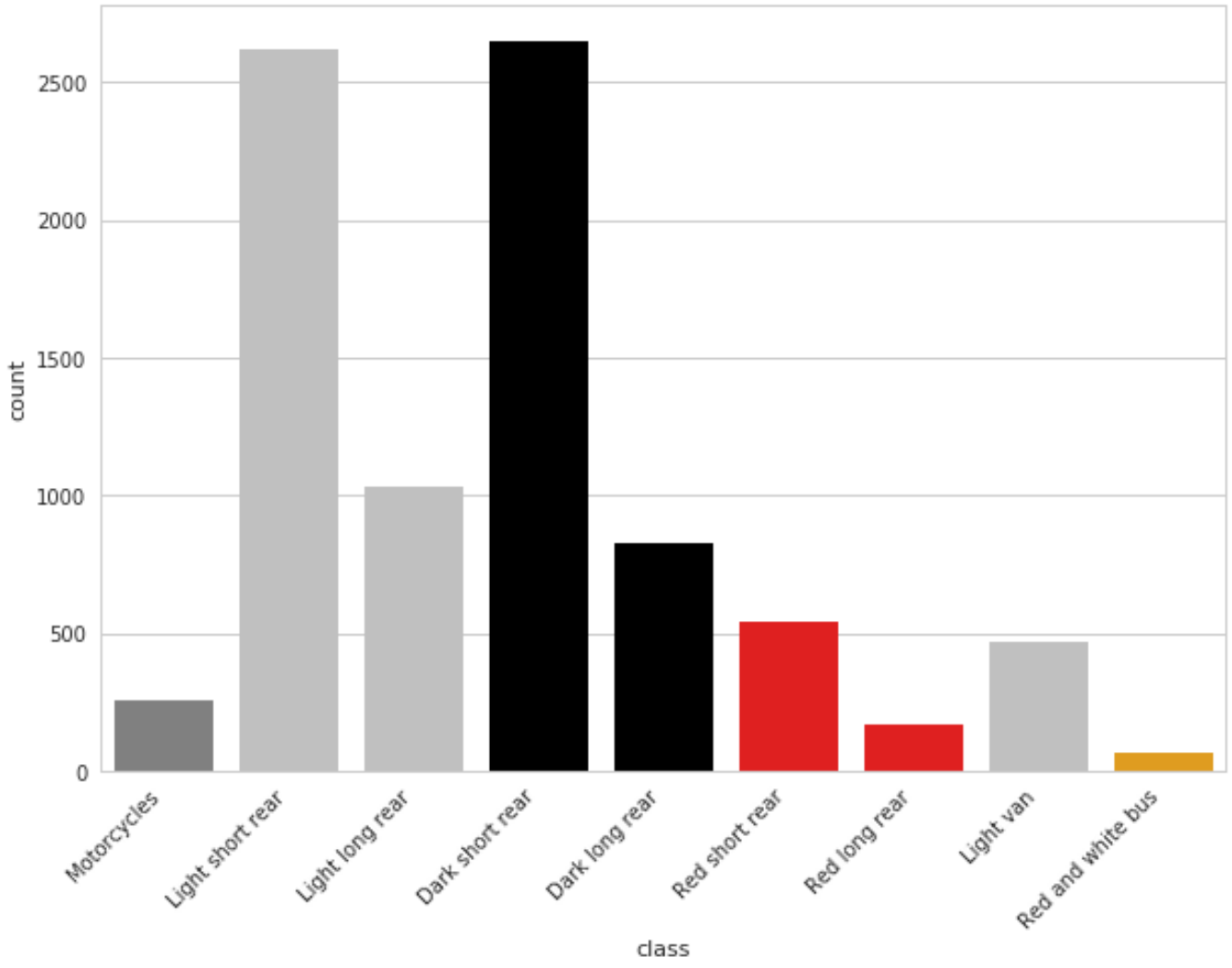



Figure by Vladislav Kassym

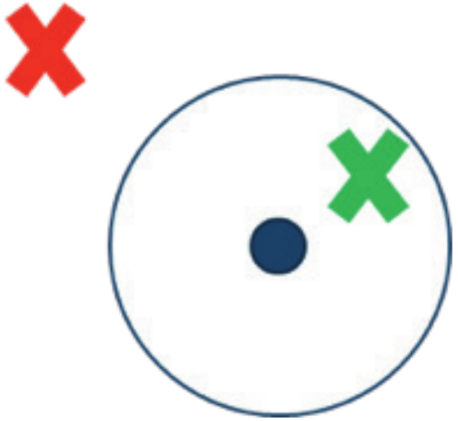
# Problem Statement

One quarter of one image

- train: 600 images
- test: 600 images
- 2000x2000
- 5 cm / pixel

# Evaluation Metric

$$Jaccard = \frac{TP}{TP+FN+FP}$$



| **Class** | **Radius** |
|---|---|
| motorcycle | 12 pixels (60 cm) |
| cars | 30 pixels (150 cm) |
| van | 40 pixels (200 cm) |
| bus | 45 pixels (225 cm) |

# Motivation

## Why participate?

- Very clean balanced dataset.
- Knowledge in Image Detection.
- Good amount of data. (Not too much, not too little.)
- No data leaks.
- Codebase will be reused in:
  - Kaggle: Cervix
  - Kaggle: Seals
  - ImageNet 2017

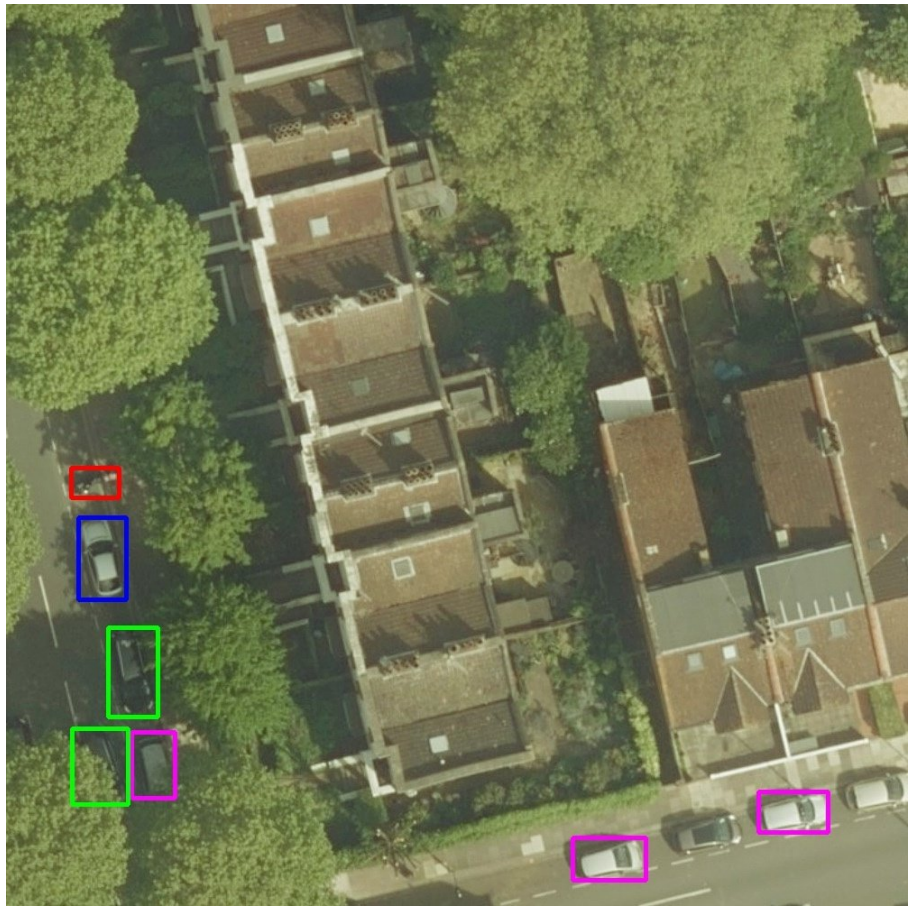
## Why not participate?

- No way to claim prize money.
- No community.
- Unknown platform. (Hard to sell results.)

# Step 1: bounding boxes

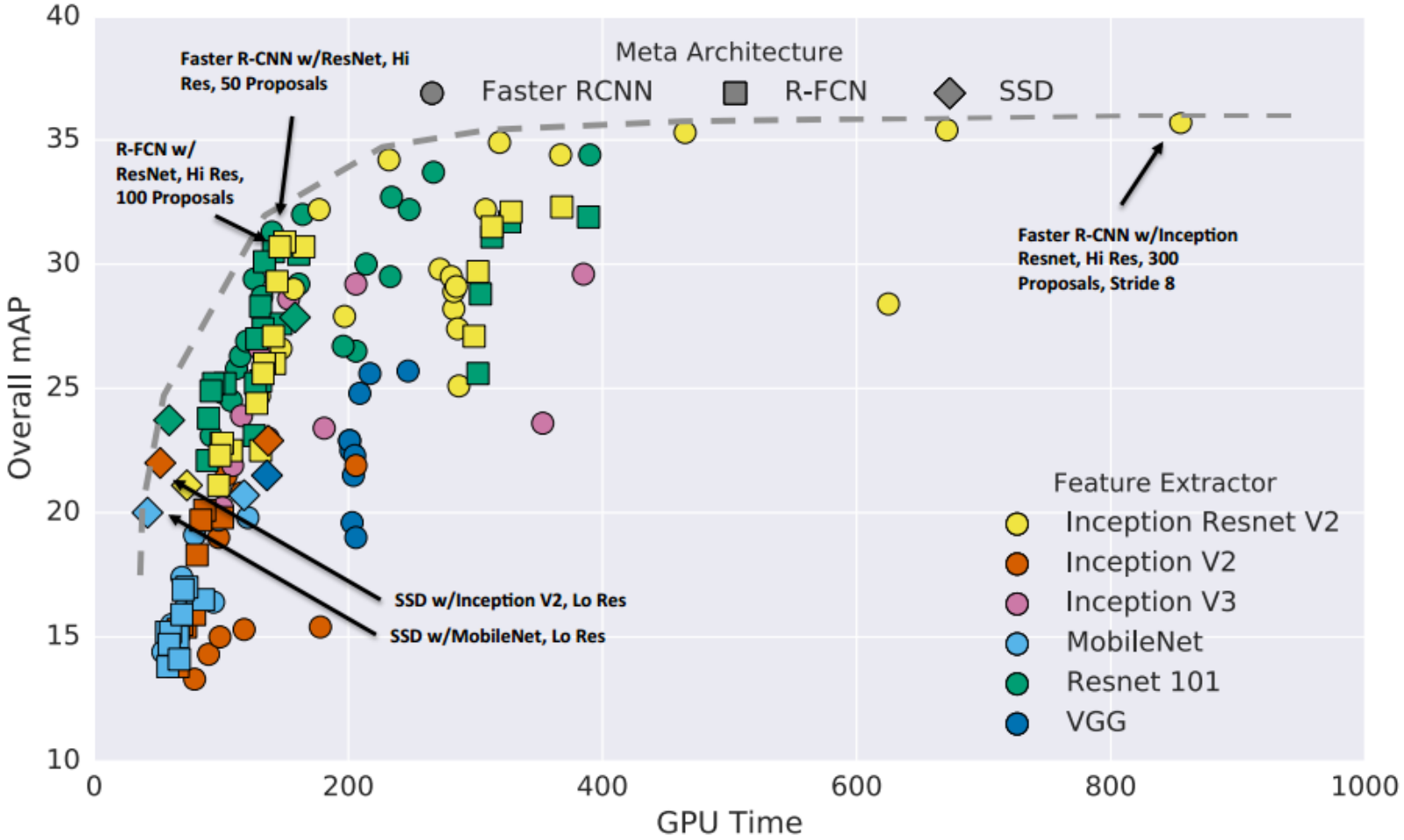
Before

After



~ 10 hours

# What network architecture to use?




Speed/accuracy trade-offs for modern convolutional object detectors

arXiv:1611.10012

# What network architecture to use?

## Faster RCNN

- Slow to train
- Slow to predict
- Accurate in general
- Accurate on small objects

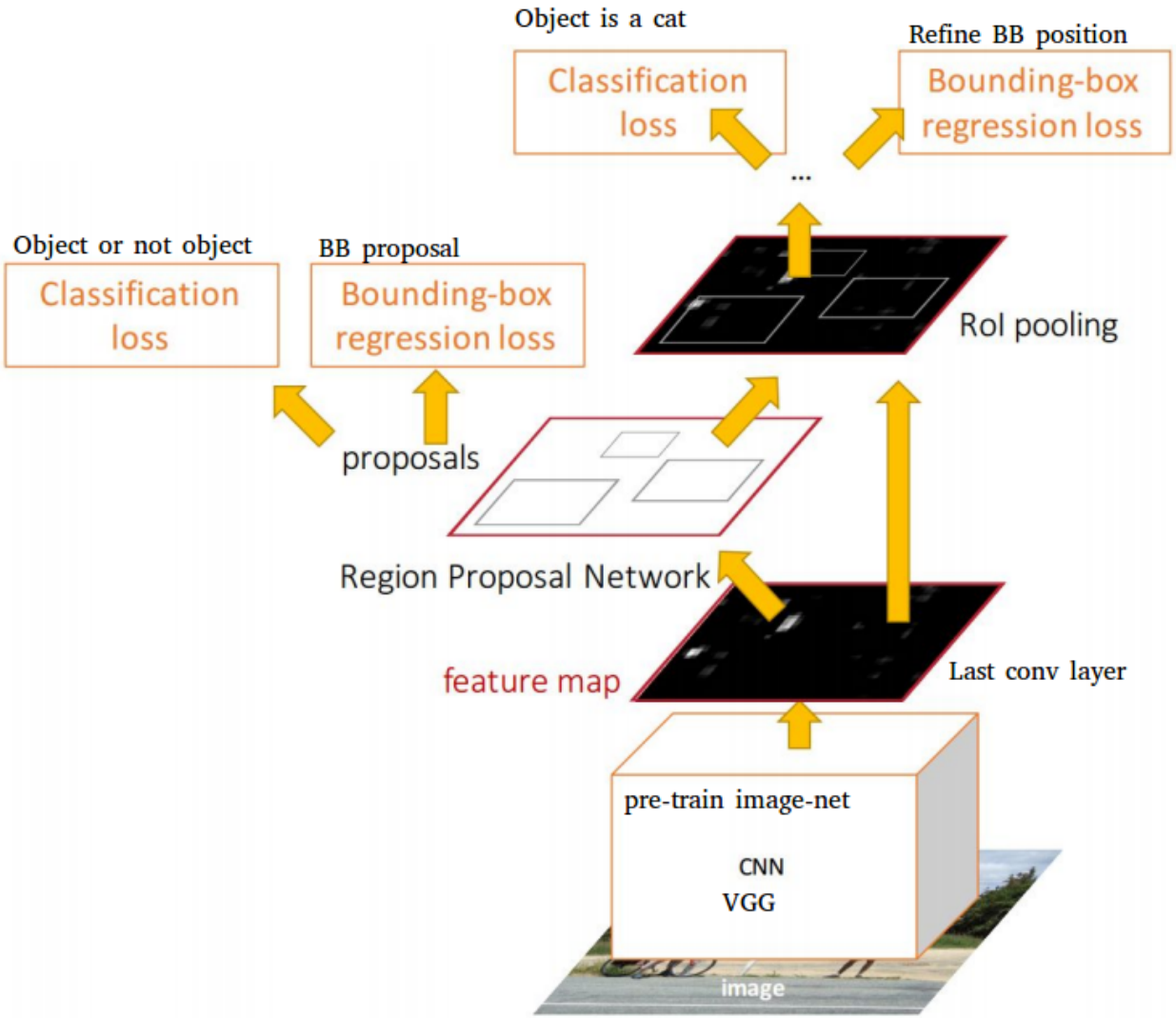
## SSD

- Fast to train
- Fast to predict
- Less accurate in general
- Pretty bad with small objects

=>

For this task winner: Faster RCNN

# Faster RCNN


Object is a cat
Classification loss
Refine BB position
Bounding-box regression loss
...
Object or not object
Classification loss
BB proposal
Bounding-box regression loss
RoI pooling
proposals
Region Proposal Network
feature map
Last conv layer
pre-train image-net
CNN
VGG
image

# What framework to use?

## Keras + TensorFlow

- Existing Faster RCNN implementation
- Familiar code base
- Good documentation
- Slow
- Pain to parallelize

## MXNet

- Existing Faster RCNN implementation
- Unfamiliar code base
- OK documentation
- Fast
- Zero pain with  parallelization

=>

For this task winner: MXNET

# Solution

Code - example from MXNet repository

## Train

- Faster RCNN + VGG16 base
- random crops 1000x1000
- D4 group augmentation

8 samples/sec

## Test

- overlapping tiles
- D4 group augmentation
- Non-Maximum Suppression

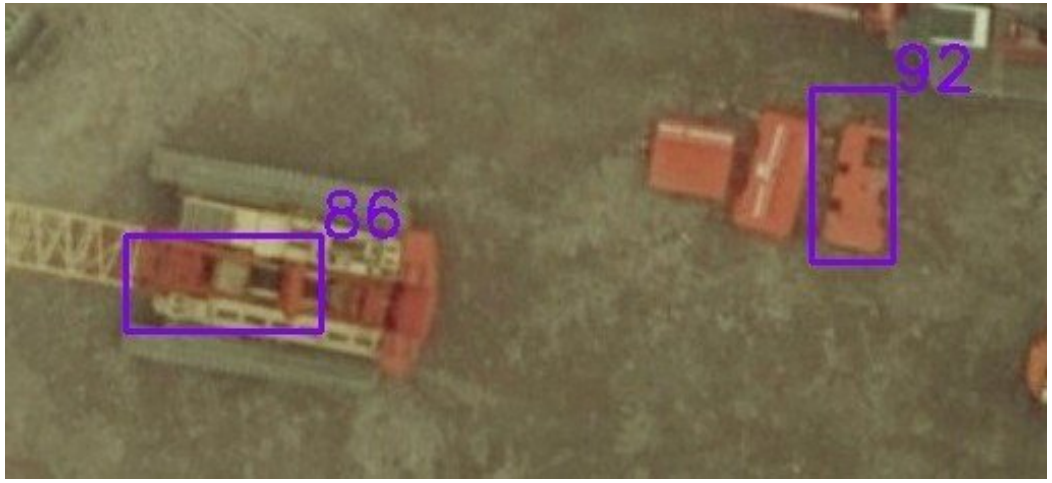
20 samples/sec

# Sources of mistakes: close- packed objects

# Sources of mistakes: trains like buses


# Sources of mistakes: debris as cars



# Main source of mistakes: misclassification

gray car in the shade <=> black car

gray car in the sun <=> white car

blue car in the shade <=> black car

white hatchback <=> white van

hatchback <=> sedan

=>

inconsistent labeling

low predictive power

## Top 10 entries

| RANK | USER | PUBLIC | PRIVATE | DATE | TREND | ENTRIES |
|---|---|---|---|---|---|---|
| 1 | gbarbadillo | 0.8662 | 0.8713 | 17 May 2017, 6:55PM BST | | 84 |
| 2 | ternaus | 0.8581 | 0.8569 | 17 May 2017, 4:47PM BST | | 31 |
| 3 | kit1 | 0.8633 | 0.8527 | 16 May 2017, 8:12PM BST | | 36 |
| 4 | jane.ostin | 0.8490 | 0.8477 | 14 May 2017, 8:40PM BST | | 22 |
| 5 | Xi_Lian | 0.8493 | 0.8455 | 16 May 2017, 11:33PM BST | | 8 |
| 6 | Kyle | 0.8320 | 0.8369 | 16 May 2017, 4:05PM BST | | 48 |
| 7 | vkassym | 0.8333 | 0.8325 | 14 May 2017, 8:22PM BST | | 17 |
| 8 | dlrocks | 0.8142 | 0.8189 | 17 May 2017, 10:46PM BST | | 20 |
| 9 | cogitae | 0.7964 | 0.8054 | 17 May 2017, 9:03PM BST | | 48 |
| 10 | codewarrior | 0.8043 | 0.8000 | 04 May 2017, 11:09PM BST | | 16 |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# Summary

- Centers of cars => bounding boxes (manually)
- Faster RCNN + VGG16, MXnet
- D4 group train and test time augmentation

# Hardware

- Intel i7
- 32Gb RAM
- 2 x Titan X (Pascal)

# Many thanks to:

- Sergey Mushinskiy
- Vladislav Kassym
- Sergey Belousov