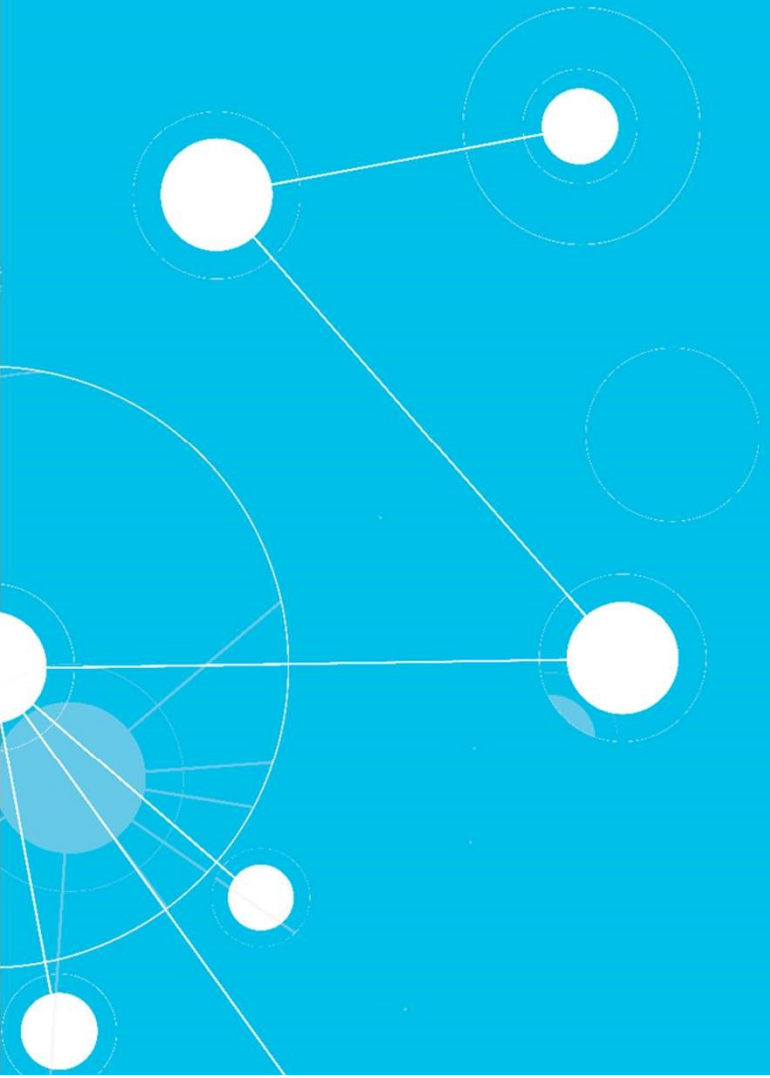


AI@5RO

Artificial Intelligence for safety

I&N Iberia / HSEQ Iberia

Digital Hub I&N / HSEQ Factory

Digital Hub S&G / Data Competence Center

Enel

September 2019

Agenda

- Enel and project organization
- Project overview
- Data characteristics and labeling
- Computer vision and deep learning
- Architectural details
- Timeline
- Results
- Ethical challenges
- Next steps

Enel Today

We are a leader in the new energy world

#1 network operator
73 mln ***end users***
2,2 mln ***km of network***

#1 renewable player
43,4 GW ***installed capacity***

#1 for retail customers
70 mln ***customers***

#1 in the management of *active* demand management
6.2 GW ***demand response***

Enel is the second utility in the world in terms of capitalization (~ 59 bln)

#28 FORTUNE CHANGE THE WORLD 2018

Note: Positioning of Enel among private operators in the industry
Fortune 100 updated to 2017

Project Organization

Key people in the project

PROJECT DIRECTION


MARIA DEL MAR SAENZ DE BURUAGA MOLINA
Head of HSE and Quality Iberia

CIRO VERDE
Head of Suppliers, Log, Task Accounting & HSEQ DF

FOLLOW-UP COMMITEE


ANGEL ARIAS FERNANDEZ
Head of Health, Safety and Environment Iberia

OSCAR TORRES LOPEZ
Head of Supply Chain Management Platform

DATA SCIENTIST

MARIO NAMTAO SHIANTI LARCHER
Data Competence Center

TECHNICAL TEAM

accenture

PROJECT MANAGER

NAYIBE-ISABEL MARIN SANTOS
Supply Chain Management Platform

TECHNICAL MANAGER

ATTILIO NICOLA NOCERA
Supply Chain Management Platform

AI@5RO

Project description and goal

5RO (*5 Reglas de Oro*) application is a **mobile and web solution** used to guarantee the fulfillment of the 5 Golden Rules during voltage duties by uploading pictures proving every step of the way. **The main goal is to guarantee safety at work**.

AI@5RO is an initiative of **Artificial Intelligence** that analyzes thousands of photographs that arrive every day to our systems through the 5RO mobile App. With the latest algorithms of **Machine Vision** and **Deep Learning**, this project has created a **business tool that identifies bad practices and improves security**.

1RO

Opening with effective cut of all sources of tension

2RO

Locking and signalization of the cut

3RO

Verification of the absence of tension

4RO

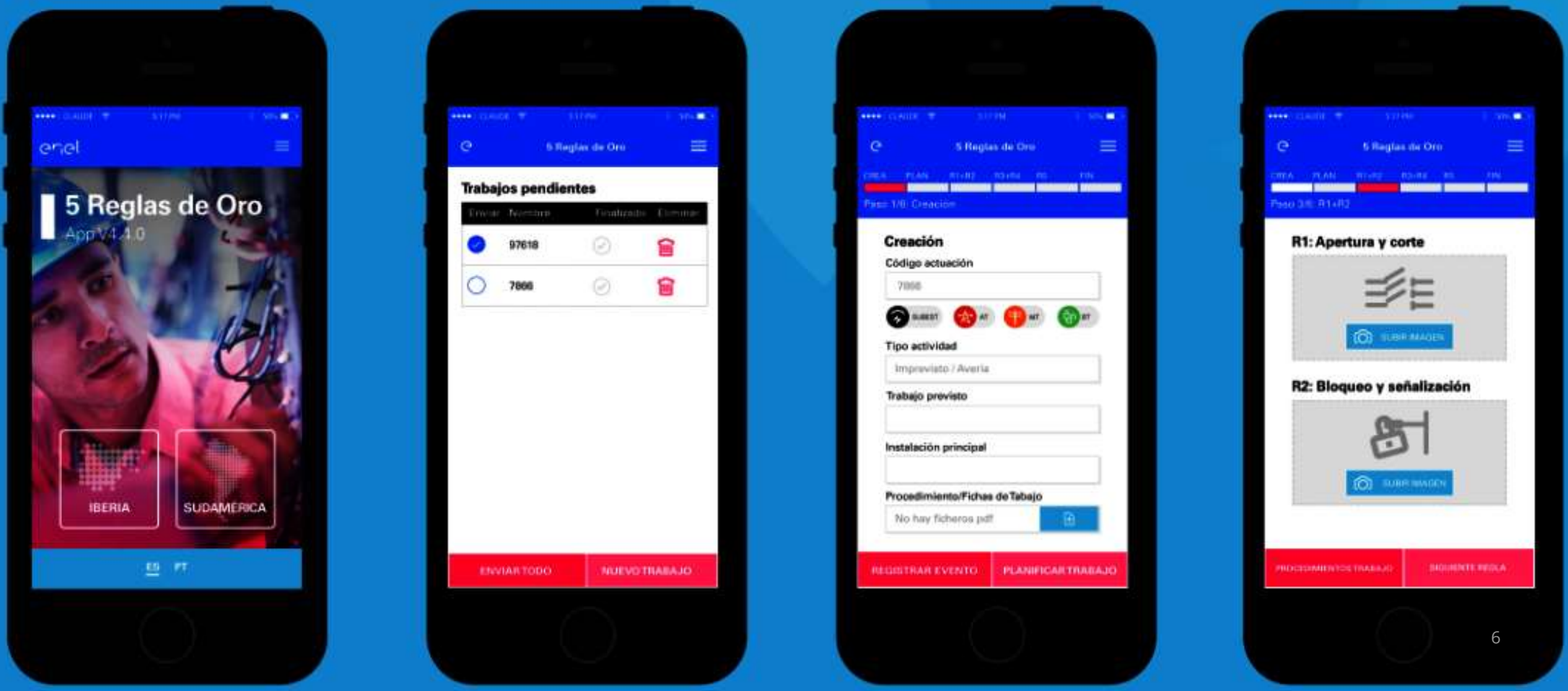
Grounding and short circuit

5RO

Signalization and delimitation of working area

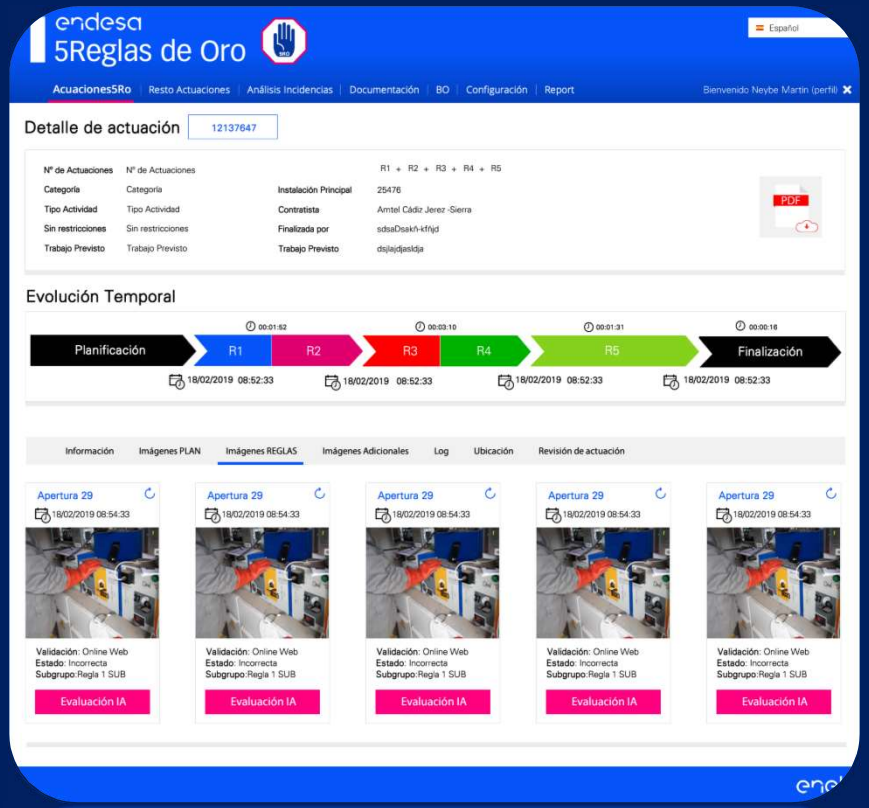
5RO Mobile App

5 Reglas de Oro mobile application



5RO Web App

5 Reglas de Oro web application



General process

Necessary steps to increase safety using AI

* Only during the pilot.

Examples CORRECT

Compliance with the rules

All three phases of the line are connected to the metal support structure (electrical pylon)

All three phases are short-circuited and grounded to the grounding cable

HIGH VOLTAGE

The red line of the synoptic is connecting to the ground

All three phases are short-circuited and grounded

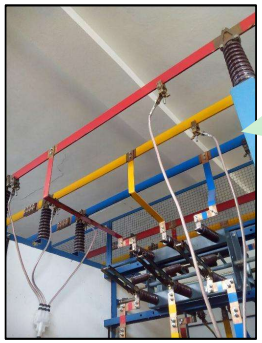
MEDIUM VOLTAGE

All three phases are short-circuited and grounded

LOW VOLTAGE

All three phases are short-circuited and grounded

All three phases are short-circuited and grounded



All Three phases are short-circuited and grounded

SUBSTATIONS

Examples

WRONG!

Non-compliance with the rules

HIGH VOLTAGE

The grounding can't be seen

The grounding can't be seen

The photo must be taken before anyone works on the electrical pylon

MEDIUM VOLTAGE

The higher part with the three phases short-circuited can't be seen

The higher part with the three phases short-circuited can't be seen

LOW VOLTAGE

Signs don't let us see the connection between the three phases

The grounding can't be seen

SUBSTATIONS

Only a phase is grounded

Data labeling

The importance of data labeling for machine learning

Our images are difficult to classify, which is why labeling is performed by Business Experts

TYPICAL PROBLEMS

- Different subjective criteria
- Different rules in different areas
- Distraction errors

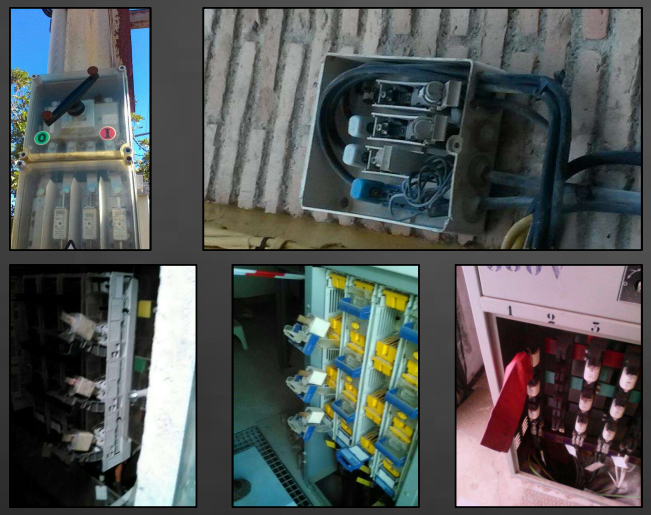
SOLUTION

- Initial brainstorming
- Analysis of a first set of labeled images
- **Labeling guidelines**

Main challenges posed by our data

Main challenges posed by our data

Heterogeneity



Examples of images for the 1° golden rule, low voltage.

Imbalanced data

Labeling errors

Non-informational negatives

Examples of non-informational negatives.

Distance of the main subject

Rare events

Different subjective criteria

Sampling bias

Photo quality

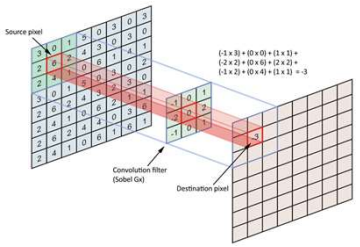
Different rules in different areas

High labeling cost

Small datasets

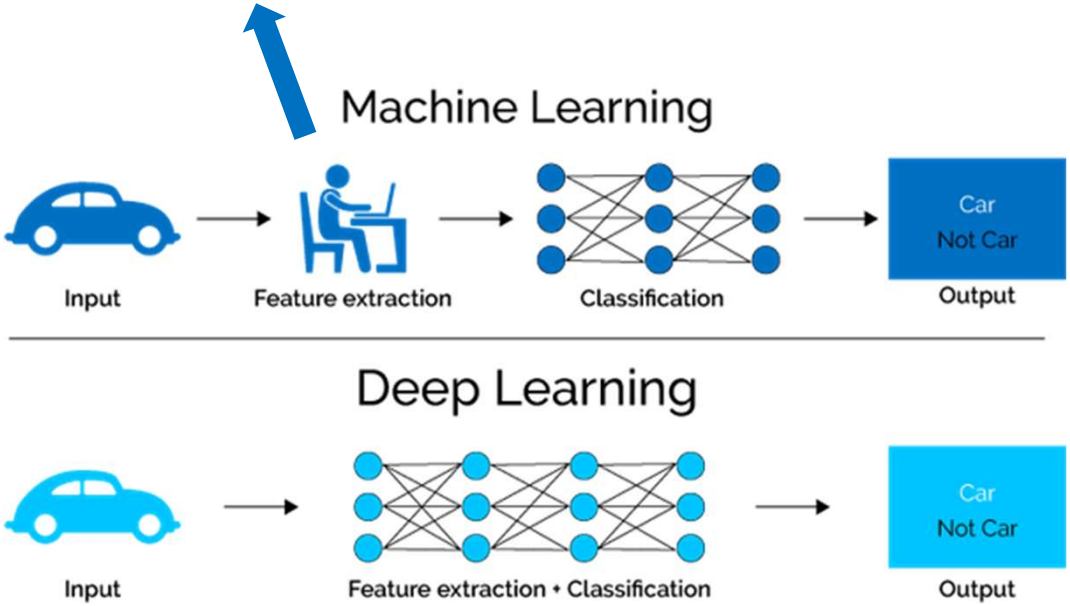
What's New in Deep Learning?

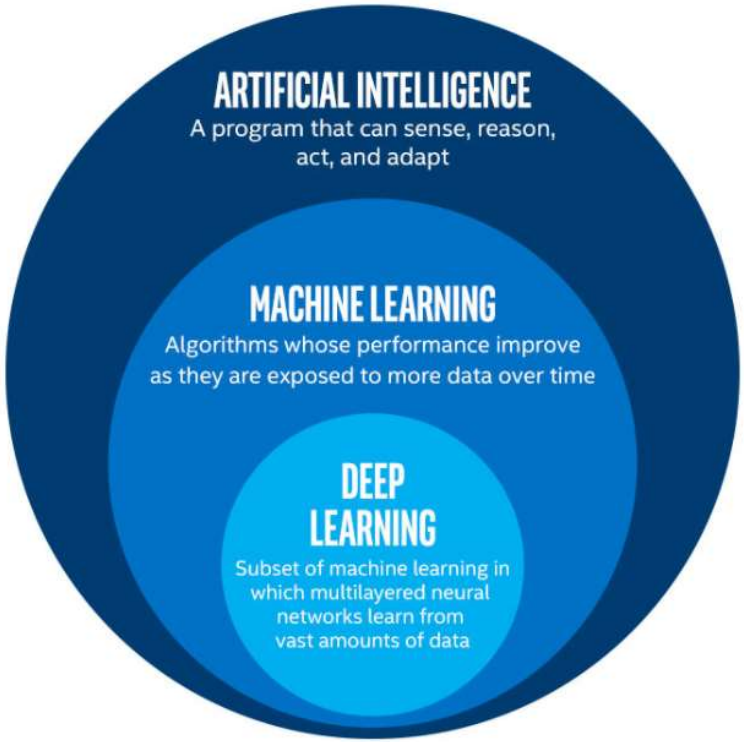
Main differences compared to a traditional machine vision approach



-1	0	1
-2	0	2
-1	0	1

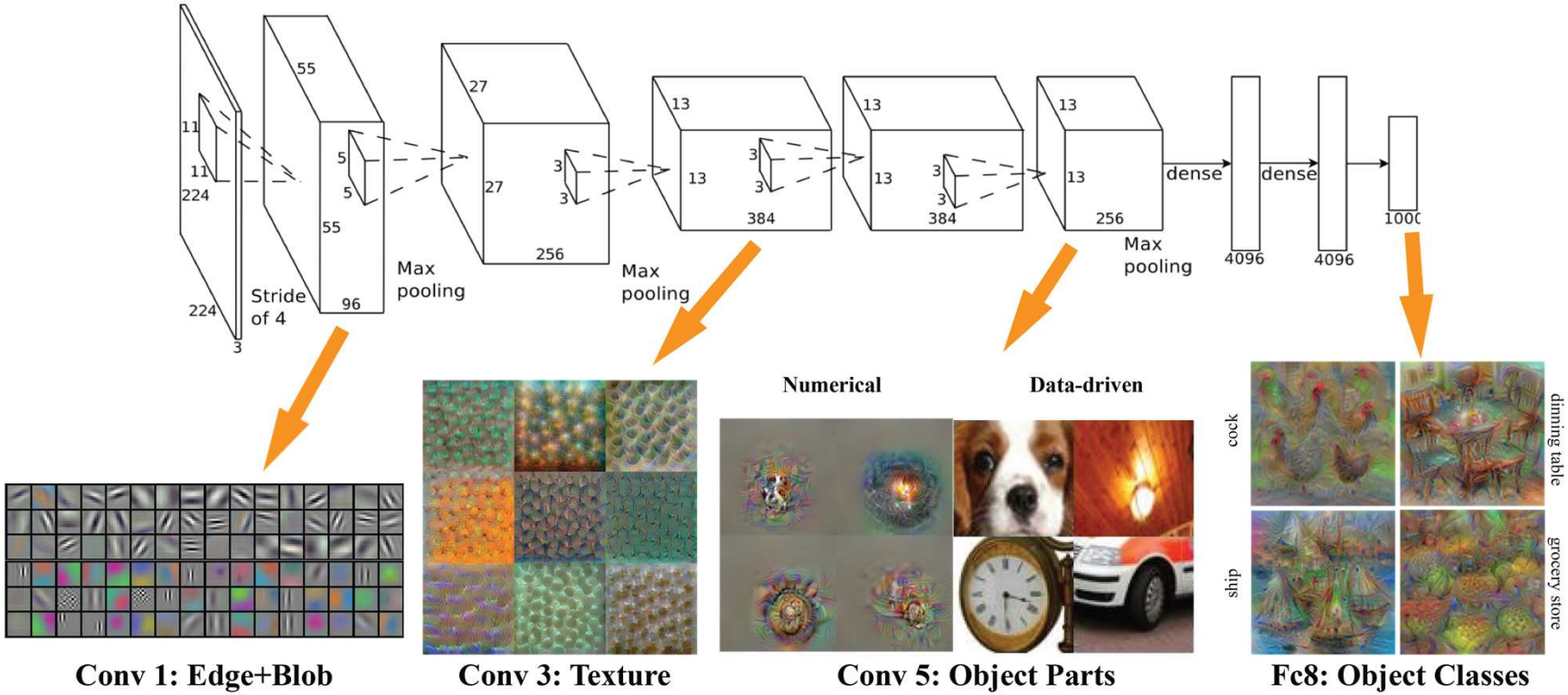
Left: The **Sobel Gx filter**, an example of feature extractor used in machine vision.





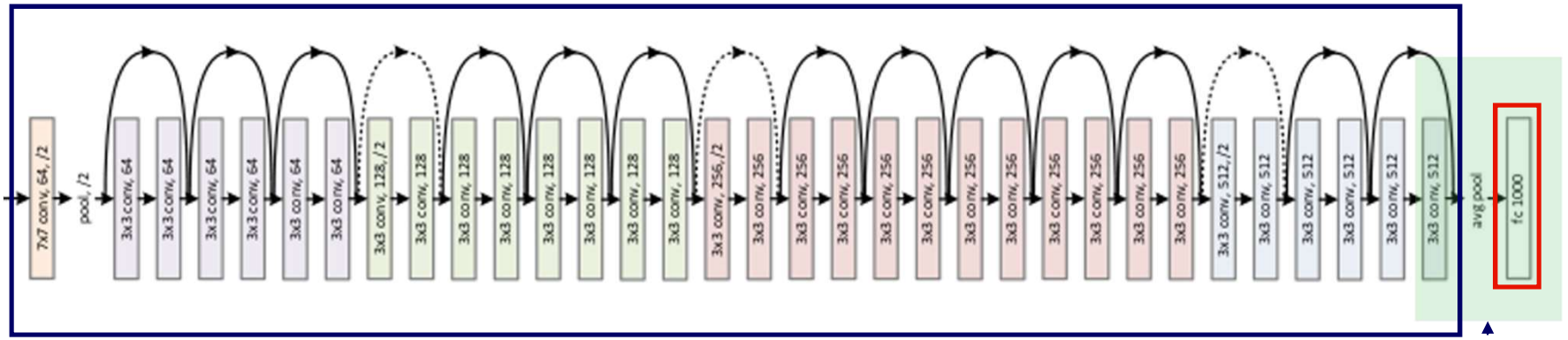
Convolutional Neural Networks

The class of neural networks that have revolutionized computer vision



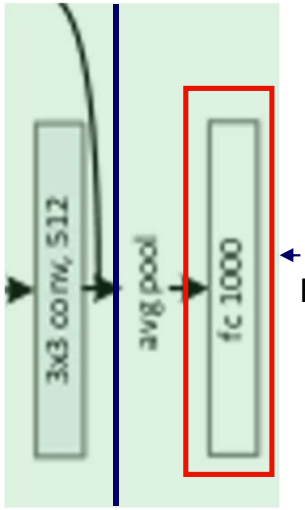
Transfer Learning

How to exploit the benefits of Deep Learning with little data



Keep these layers. Weights have already been learned by training the algorithm on a large data set like ImageNet.

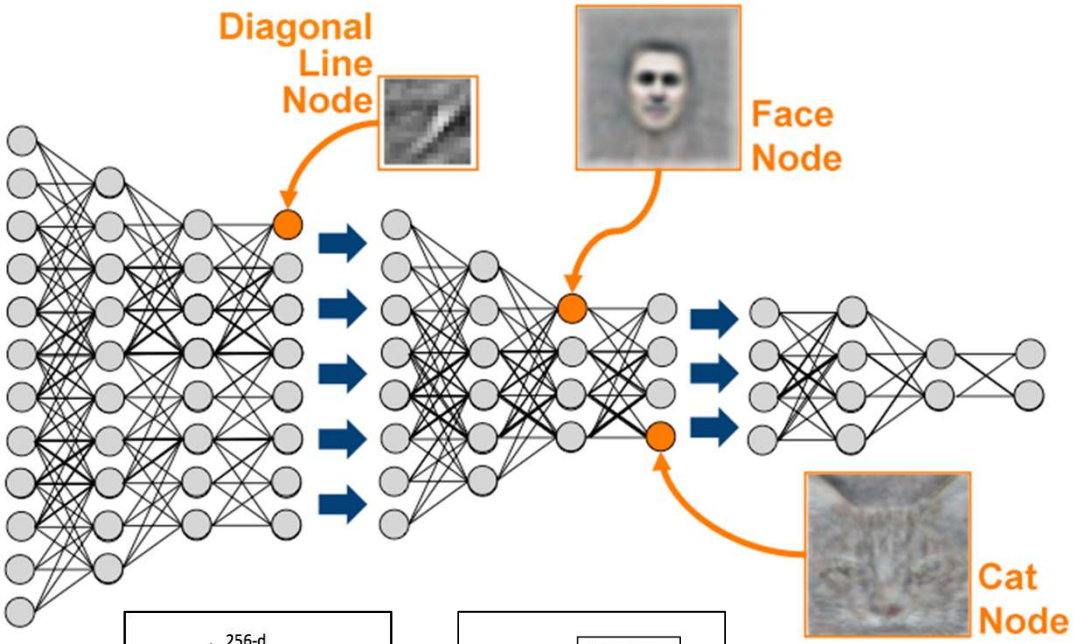
ResNet50 has more than 25 million parameters, ***a large data set is needed to train an algorithm like this form scratch***

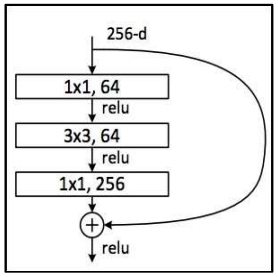


Replace this layer.

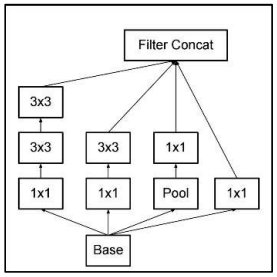
Image Classification

Does the image show that the *5 reglas de oro* have been respected?





Residual block



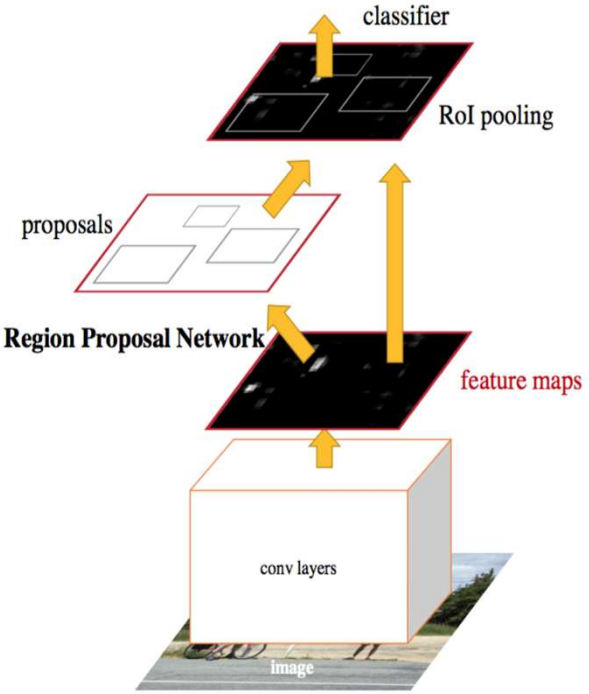
Inception block

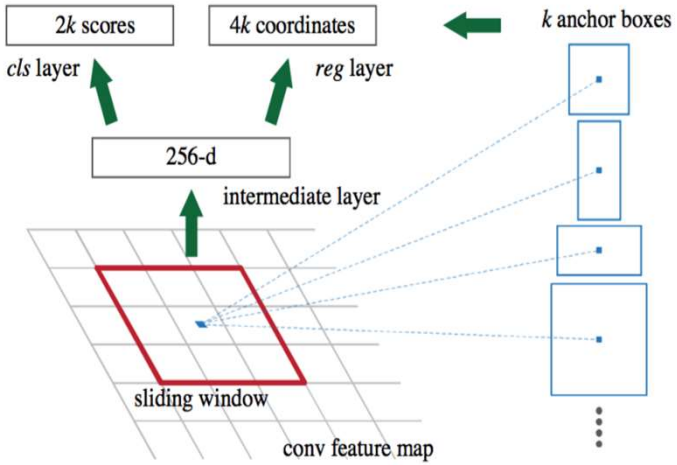
Left: General **Deep Learning** architecture for image classification with two famous blocks used in this project.

Bottom: An example of classification task.

Object Detection

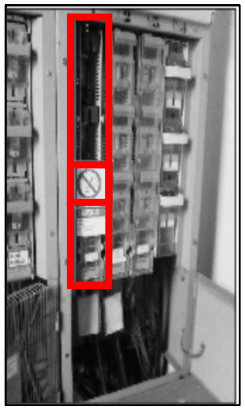
Identification of the elements necessary for compliance with the rules





Right: An example of object detection.

Bottom: the **Faster R-CNN** architetture*.



* Faster R-CNN: Towards Real-Time Object Detection with Region Proposal Networks, Shaoqing Ren, Kaiming He, Ross Girshick, Jian Sun. IEEE Transactions on Pattern Analysis and Machine Intelligence (TPAMI), 2016

Human Pose Estimation

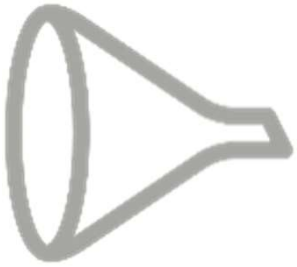
Check for the presence of personal protective equipments

Original image

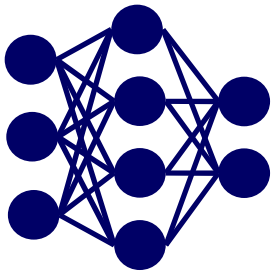
Image rotation based on **EXIF metadata**

Head detection, pose estimation using **Part Affinity Fields***

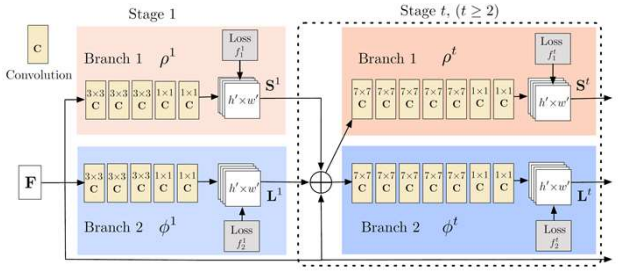
Crop extraction



Feature extraction using **ResNet50**



Crop classification using a **MLP**

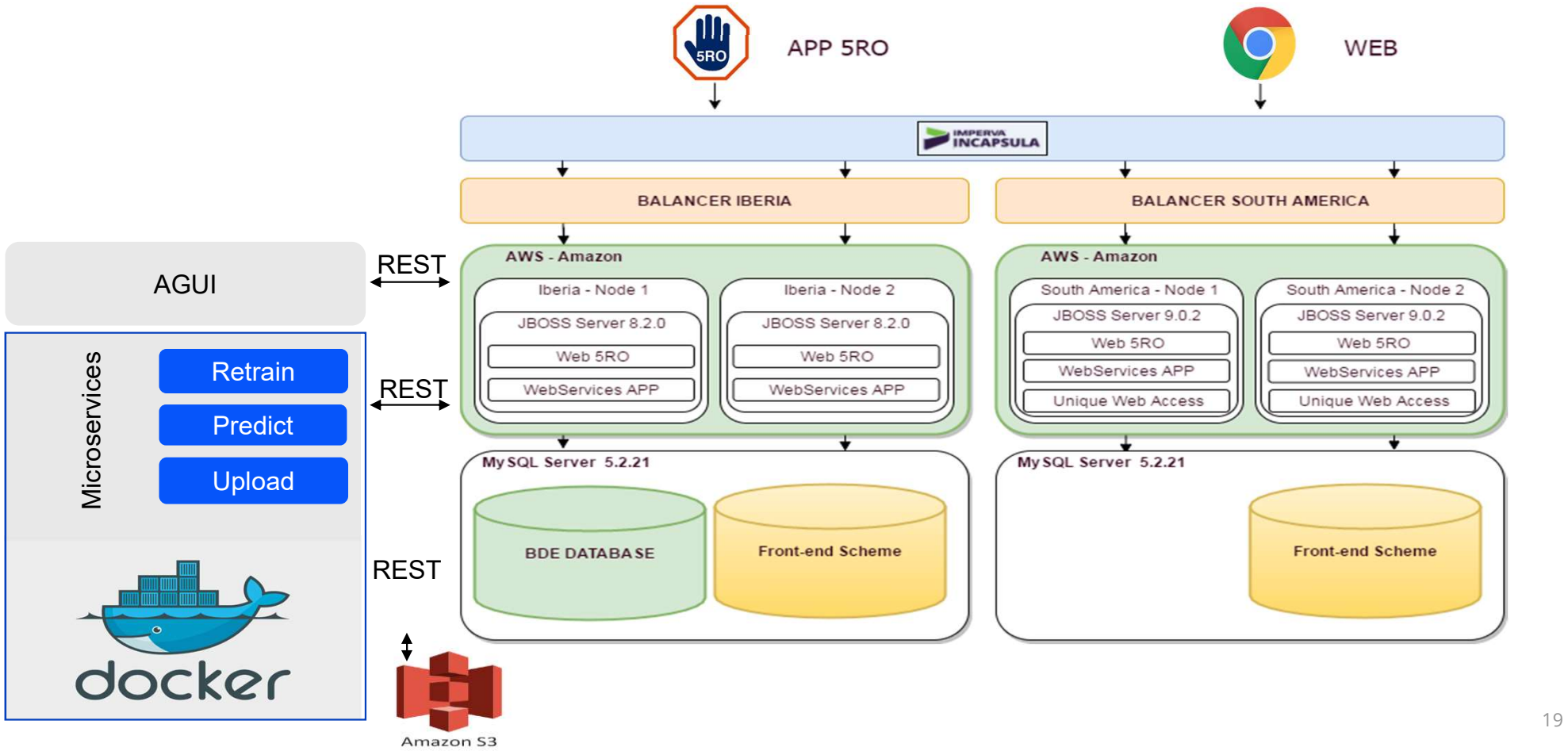


*Architecture of the two-branch multi-stage CNN used to jointly predict confidence maps for body part detection.**

* Z. Cao, T. Simon, S.-E. Wei, and Y. Sheikh, Realtime multi-person 2d pose estimation using part affinity fields, in CVPR, 2017

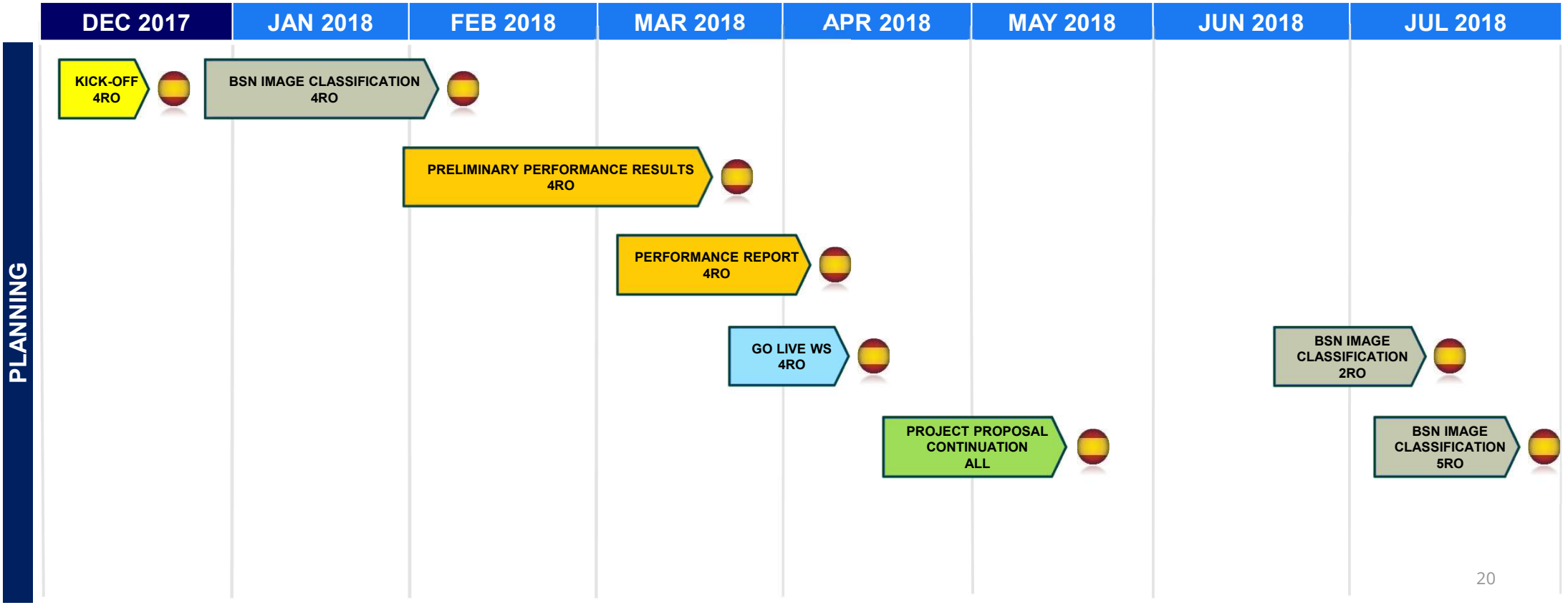
Architecture

A microservices approach



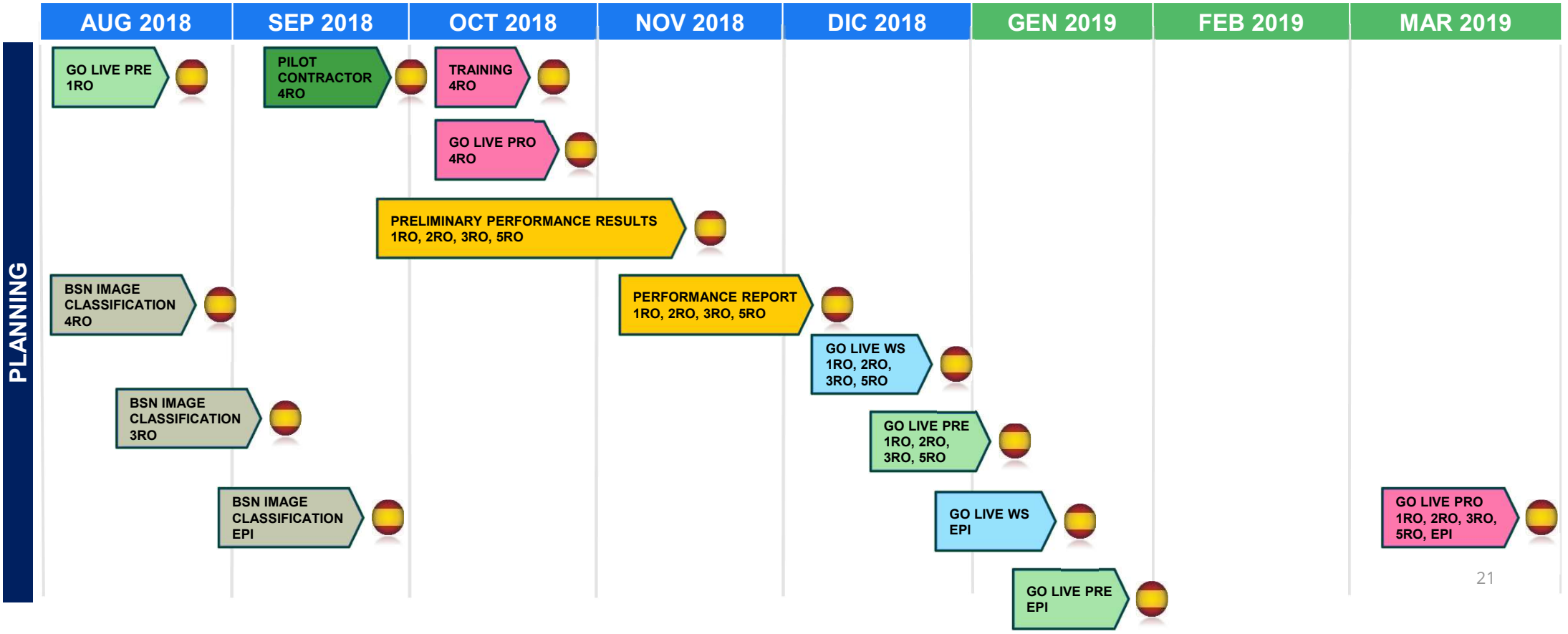
Timeline

Milestones and go lives



Timeline

Milestones and go lives



Backtest results

Promising results for a difficult problem

METRIC	RO #1	RO #2	RO #3	RO #4	RO #5	EPIs
Precision	80%	77%	78%	77%	77%	88%
Recall	68%	87%	78%	76%	70%	86%
F1-Score	74%	82%	78%	77%	73%	87%

Precision: How often is the alarm generated by the AI correct?

Recall: How many times when a picture is taken incorrectly or shows a bad practice does the AI issue an alert?

F1-Score: Average (harmonic) between Precision and Recall. It strongly penalize if one of the two metrics is too low.

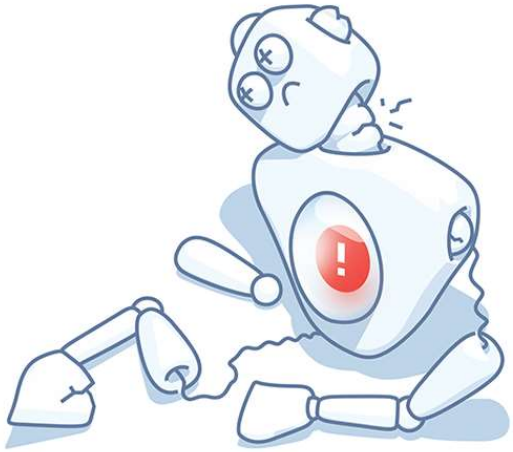
Ethical challenges

What happens when the AI fails?

Tesla driver dies in first fatal crash while using autopilot mode

The autopilot sensors on the Model S failed to distinguish a white tractor-trailer crossing the highway against a bright sky

Does the approval of the AI reduce the attention of workers?



Self-driving Uber kills Arizona woman in first fatal crash involving pedestrian

Tempe police said car was in autonomous mode at the time of the crash and that the vehicle hit a woman who later died at a hospital

Who is responsible when AI fails?

Next steps

How to improve the current solution

1) Labelling of new images

Outsource the classification of a new set of images for all categories (or part of them) with the help of the defined labeling guidelines. The main goal is to group quality and quantity.

2) Retrain the models on more images

Retrain the models using more labeled data and, if necessary, improve the models.

3) Organize pilots on controlled production contexts

In this way we can try different models in a real world context and collect information in order to introduce improvements in the models and in the image labeling process.

3) Warnings activated only for certain rules

Display of warnings generated only by the best models (the predictions are practically always correct). For images of rules harder to classify, collect the information in background without showing warnings.

THANK YOU!

QUESTIONS?