Novosibirsk State University
*THE REAL SCIENCE

Department of Mechanics & Mathematics

Recognition of Different Objects of Oilfield Infrastructure by Machine Learning Methods

Novosibirsk State University

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Objective: The study aimed to implement computer vision and deep learning architectures to identify objects that appears on as-built engineering piping and instrumentation diagram (PID). The algorithm then tasked to classify and create parent-child structure between the objects identified based on ISO14224 standard.

Problem Statement

Why is is important?

- Manual and laborious work to identify and record each plant asset into database manually.
- General accurate source and cheapest way to record is to refer as-built engineering drawings, which is still very time consuming.
- Example of plant assets:
  - Manual valves.
  - Instruments (Transmitters, Actuators).
  - Turbomachineries (Compressors, Turbines).
  - Static Equipment (Tanks, Vessels)
  - Electrical Items (Control Panels, Transformers).

Semester 1 Recap

All the previously done tasks in Semester 1

1 - Literature Review

Perform detailed review for 17 related work

2 - Hardware Setup

All high GPU computation were being prepared to run in NSU Lab Facilities remotely

3 - Data Collection

Piping and instrumentation drawings (PID) data were collected in addition to ISO14224 Classification data

Hardware

Computer Specifications

Personal Laptop

CPU AMD Ryzen 7 2700U w/ Radeon Vega Mobile Gfx 2.20GHz, 16GB RAM, 476GB Storage with Windows OS

Remote Lab Computer

GPU NVidia Quadro M4000 with 8GB GPU Memory, CPU Intel Xeon(R) E5-1620 v4 with 31GB RAM, OS - Ubuntu 16.04.6

Software

Applications Specifications

Python

Python 3.6.12 and Python 3.8.9 installed for different purposes

Jupyter Notebook

Jupyter Notebook on lab computer forwarded to specific port and access using local web browser

Tensorflow and Pytorch

Installed Tensorflow 2.3.1 with CUDA 10.1. Pytorch 1.7 yet to be installed.

Architectures

Computer Vision Existing Models to be used

YOLOv3

You Only Look Once (YOLO) version 3 by Joseph Redmon - this has been implemented

Faster R-CNN

Faster R-CNN (Region-based Convolutional Neural Networks) considered to be used to detect smaller look-alike objects

YOLOv5

Ultralytics new version of YOLO with Pytorch implementation, recently released on July 2020.

Data Conditioning

Processing of raw data

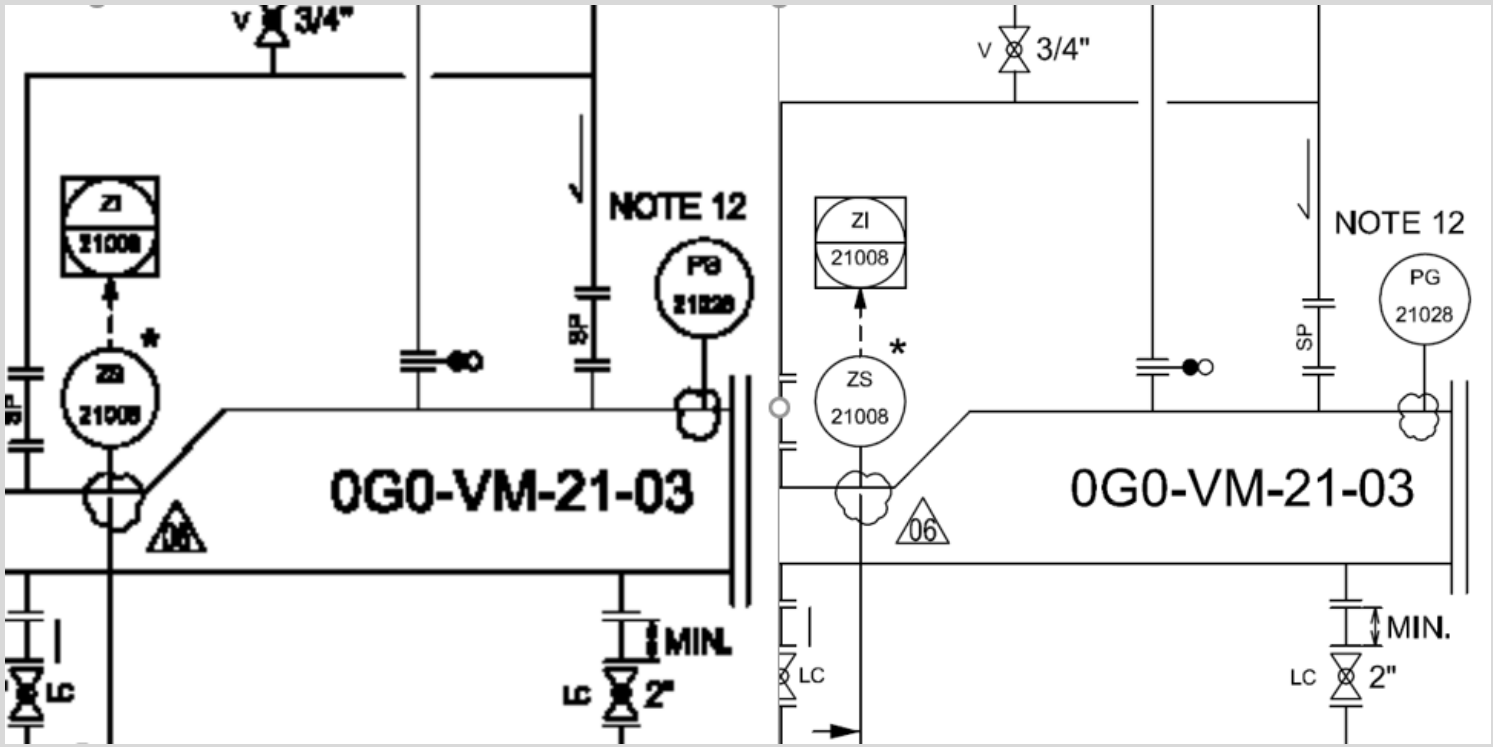
1. Original data comes in high-resolution PDF format, some of them having multiple pages.
2. The data then being split into several snip manually using Snipping Tool on Windows (average 4 sections per drawing page).
3. The snipped image saved into PNG format for annotation activities.

Note: Bulk conversion of PDF to PNG using Adobe produced a low quality output. Any suggestions?

Data Conditioning

Processing of raw data

Quality comparison between full conversion vs snipping



Data Annotation

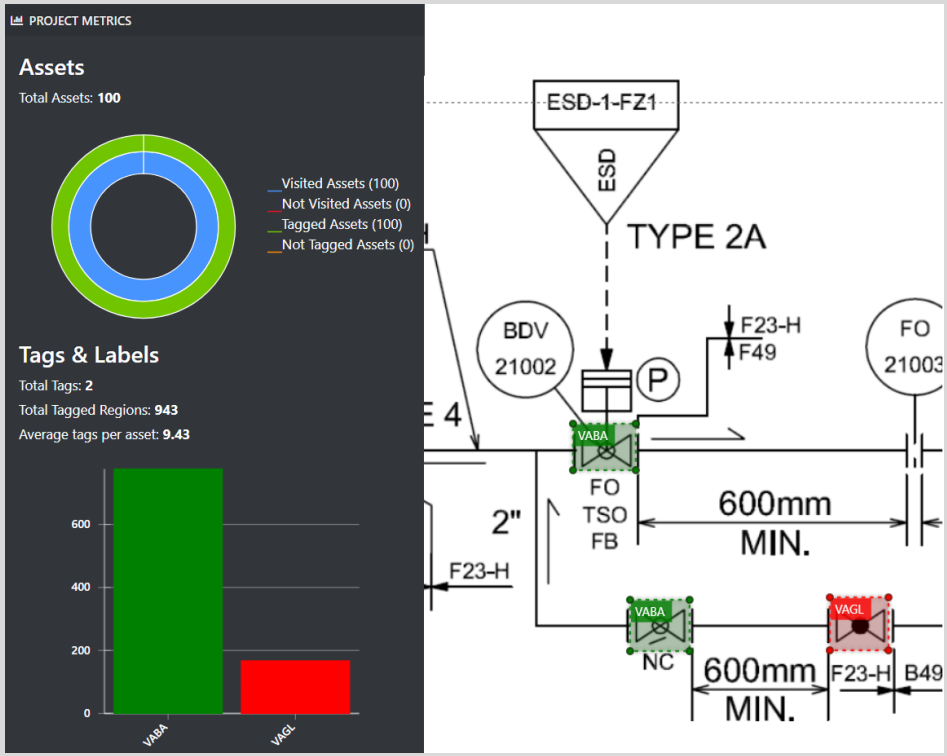
Labelling of training data

- Tool used: Visual Object Tagging Tool (VoTT) from Microsoft
- Only 2 classifications is currently being used:
  1. Ball Valve (VABA)
  2. Globe Valve (VAGL)
- Other classifications will be used (target total 5-20):
  - Centrifugal Pump (PUCE)
  - Heat Exchanger (HEST)
  - Pig Launcher (VEPT)

Data Annotation

Labelling of training data

Overview of current annotated data



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Detection Activities

Model Implementation into Dataset

Detection 1 - 16 Feb 2021

Only 14 images used for training. Only 1 class used (VABA). Test data is only 2 images. Training time taken: 30 minutes with 102 epochs

Detection 2 - 18 Mar 2021

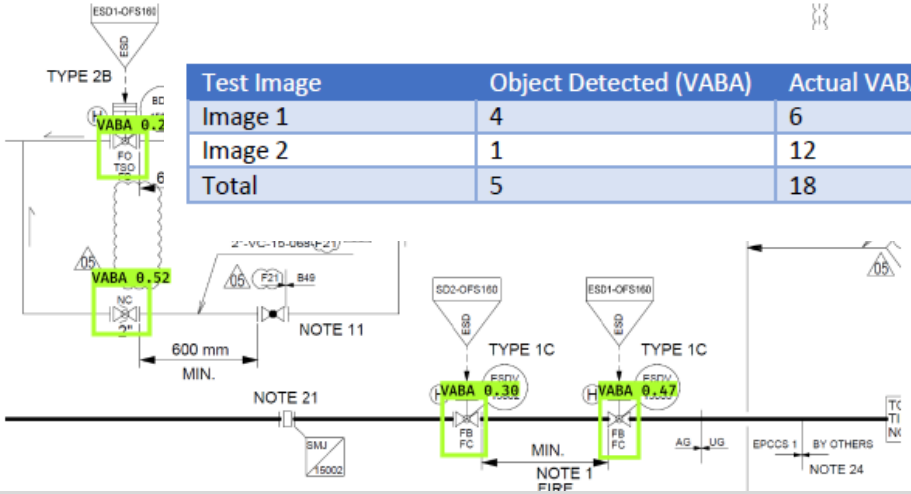
100 images used for training. 2 classes was used: VABA VAGL. Test data is 10 images. Training time taken: 30 minutes with 76 epochs

Detection 1

First detection to test the procedure

Objective: To understand the end to end process for image recognition activities using YOLO with small amount of data

```
Found 4 boxes for img
VABA 0.25 (164, 230) (258, 319)
VABA 0.30 (789, 712) (876, 823)
VABA 0.47 (1076, 712) (1154, 827)
VABA 0.52 (155, 508) (263, 604)
Time spent: 1.278sec
```

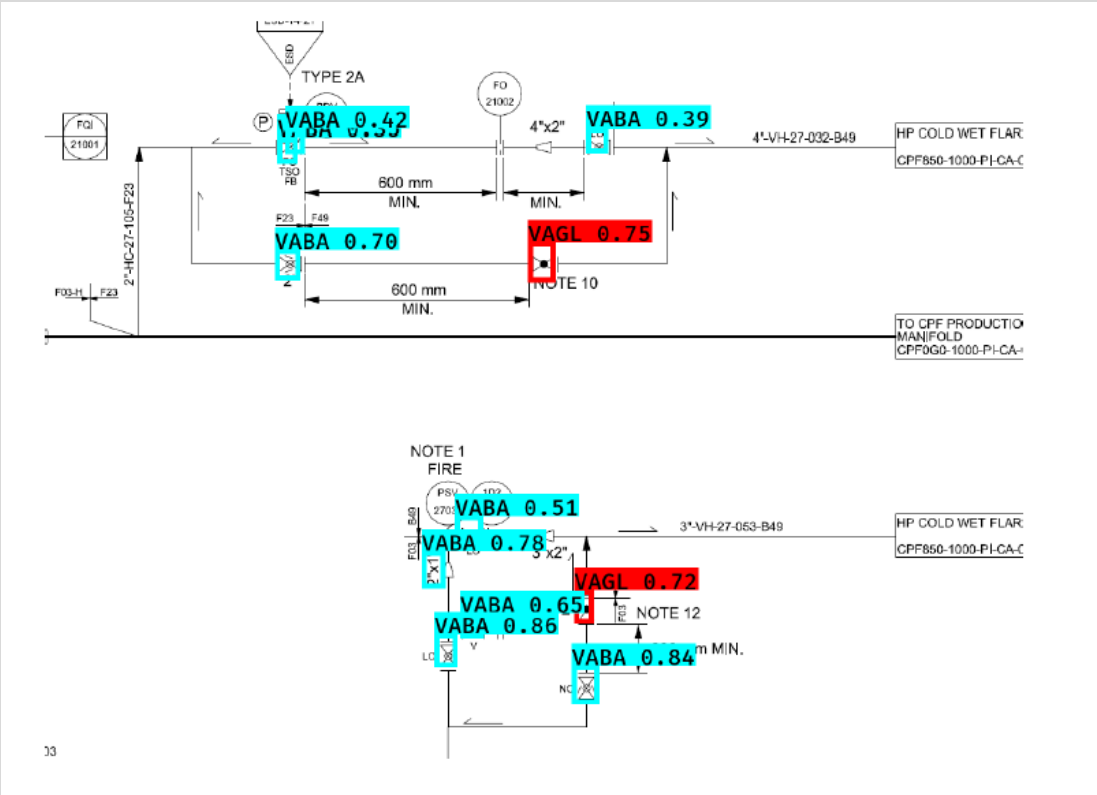


Test Image	Object Detected (VABA)	Actual VABA Count	Accuracy
Image 1	4	6	66.6%
Image 2	1	12	8.3%
Total	5	18	27.7%

Detection 2

Detection using decent training data count with 2 classes

Objective: To perform a better detection using adequate amount of training data. Also to see how the 2 classes affect the detections



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Detection 2

Detection using decent training data count with 2 classes

VABA

Test Image	Object Detected (VABA)	False Detection of VABA	Actual VABA Count	Accuracy
Image 1	4	0	15	27%
Image 2	7	1	7	86%
Image 3	8	3	8	63%
Image 4	15	4	15	73%
Image 5	8	2	8	75%
Image 6	7	3	7	57%
Image 7	15	1	16	88%
Image 8	0	9	1	-900%
Image 9	2	1	8	13%
Image 10	2	7	13	-38%
TOTAL	68	31	98	38%

VAGL

Test Image	Object Detected (VAGL)	False Detection of VAGL	Actual VAGL Count	Accuracy
Image 1	0	0	0	N/A
Image 2	2	0	2	100%
Image 3	0	0	1	0%
Image 4	1	0	3	33%
Image 5	0	0	1	0%
Image 6	1	0	2	50%
Image 7	6	0	7	86%
Image 8	0	0	1	0%
Image 9	0	0	1	0%
Image 10	0	0	2	0%
TOTAL	10	0	20	50%

Challenges

Challenges faced during experiments

- Data preparation and annotation is very time consuming.
  - Solution plan: annotate all objects is scope when reviewing a single image instead of folder based. Reduce classes in scope.
- Detection of small objects using YOLO version 3.
  - Solution plan: use Faster RCNN or YOLO version 5
- Challenges in determining OCR region to extract the object ID from drawing and match to object.

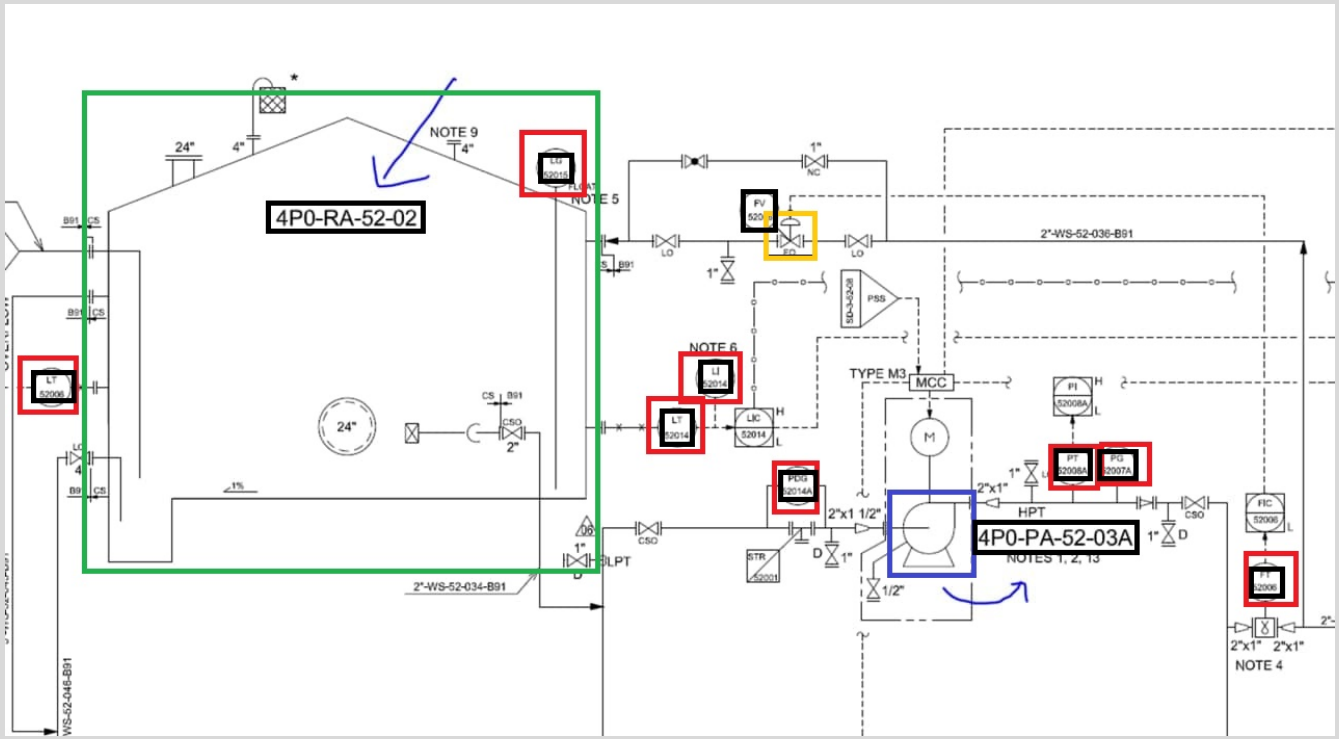
Next Strategy

Plan to solve Challenge #3

1. Find bounding box for the OCR region by applying filters ,erode dilate, then find contours.
2. Apply OCR on the bounding box.
3. Match OCR bounding box to the Object bounding box using nearest Manhattan / euclidean distance of box center

Strategy Mockup

Illustration of the strategy



- Black - OCR Box, Colour - Object Box

AssetMiner

Read-only view, generated on 27 Apr 2021

Instagantt

	ACTIVITIES	ASSIGNEE	EH	START	DUE	%
	Thesis Writing:		-	01/Sep	31/Mar	76%
	Literature Review	Hami A...	-	01/Sep	13/Nov	99%
2	Paper Collection	Hami A...	-	01/Sep	16/Oct	100%
3	Paper Reading & Summarize	Hami A...	-	01/Oct	13/Nov	100%
4	Final Write-up	Hami A...	-			0%
	Methodology	Hami A...	-	01/Dec	31/Dec	92%
6	Initial Draft	Hami A...	-	01/Dec	31/Dec	100%
7	Revised Draft	Hami A...	-			0%
8	Final Draft	Hami A...	-			0%
	Abstract	Hami A...	-			0%
10	Initial Draft	Hami A...	-			0%
11	Revised Draft	Hami A...	-			0%
12	Final Draft	Hami A...	-			0%
13	Results	Hami A...	-			0%
14	Final Thesis	Hami A...	-	01/Mar	31/Mar	0%
	Data Collection & Labelling:		-	02/Nov	03/May	60%
16	Data Collection (EPCC1)	Hami A...	-	02/Nov	30/Jan	100%
17	Data Labelling (EPCC1)	Hami A...	-	01/Jan	03/May	30%
18	Data Collection (EPCC2)	Hami A...	-			0%
	Model Development & Training:		-	04/Feb	16/Jul	26%
20	Object Detection (YOLOv3)	Hami A...	-	04/Feb	03/Mar	100%
21	Detection 1 & Analysis	Hami A...	-	16/Feb	16/Feb	100%
22	Detection 2 & Analysis	Hami A...	-	18/Mar	18/Mar	100%
23	Tag Region Detection	Hami A...	-	12/Apr	26/Apr	30%
24	OCR the Tag Region	Hami A...	-	26/Apr	07/May	15%
25	Detection 3 & Analysis	Hami A...	-	04/May	04/May	0%
26	Object Detection (Faster RCNN)	Hami A...	-	03/May	17/May	0%
27	Detection 4 & Analysis	Hami A...	-	18/May	18/May	0%
28	Object Detection (YOLOv5)	Hami A...	-	17/May	31/May	0%
29	Detection 5 & Analysis	Hami A...	-	01/Jun	01/Jun	0%
30	Tag Region to Object Region Matching	Hami A...	-	01/Jun	18/Jun	0%
31	Tag to Parent Tag Matching	Hami A...	-	18/Jun	30/Jun	0%
32	Detection 6 & Analysis	Hami A...	-	01/Jul	01/Jul	0%
33	Customize output CSV	Hami A...	-	01/Jul	16/Jul	0%