
Webinars
Drill Bit Forensics and Dull Grade Measurements
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SPE International

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Outline

Webinars

01 **Introduction**

Challenges, Objective, Literature Review

02 **Methodology**

Drill Bit Forensics and Dull Grade Measurements

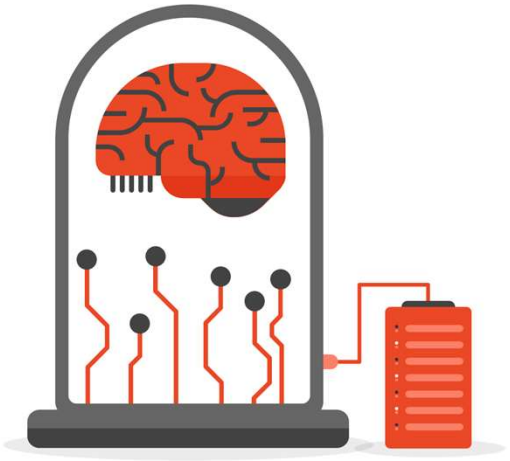
03 **Results**

Testing, functionality and implementation

04 **Software Demo**

Load, run both models

05 **Conclusion and Future Work**



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Introduction

- The drill bit is the element in the bottom hole assembly (BHA) designed to drill the rock.
- A PDC (Polycrystalline diamond compact) bit is a drill bit fitted with industrial diamond cutters.
- PDC bits condition after runs provides information that can be applied to design, cutters improvement, and BHA optimization.

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2

Introduction

- To standardize the PDC bits evaluation after runs, the IADC presented a dull grading system designed explicitly for fixed cutter bits (Clark et al., 1987).

BF - Bond Failure	LN - Lost Nozzle
BT - Broken Cutters	LT - Lost Cutters
BU - Balled Up	NO - No Dull Characteristics
CR - Cored	NR - Not Rerunnable
CT - Chipped Cutters	PN - Plugged Nozzle/Flow Passage
DL - Delaminated Cutters	RO - Ring Out
ER - Erosion	RR - Rerunnable
HC - Heat Checking	WO - Washed Out
JD - Junk Damage	WT - Worn Cutters
LM - Lost Matrix	

Cutting Structure				Bearing	Gauge	Remarks	
1	2	3	4	5	6	7	8
Inner Rows	*Outer Rows*	*Dull Character*	*Location*	*Bearings Seals*	*Gauge*	*Other Dull Char*	*Reason Pulled*
0-8	0-8	BT – Broken Cutters CT – Chipped Cutters ER – Erosion RO – Ring Out WT – Worn Cutters	A – All areas C – Cone N – Nose G – Gauge S – Shoulder	X – unrelated to PDC bits	I – in gage 1 - 1/16" 2 - 2/16" 3 - 3/16" 4 - 4/16"	The second main dull character. Refer to column 3.	BHA - BHA change DT – Tool Failure PR – Low ROP TQ – High TQ TD – Total Depth

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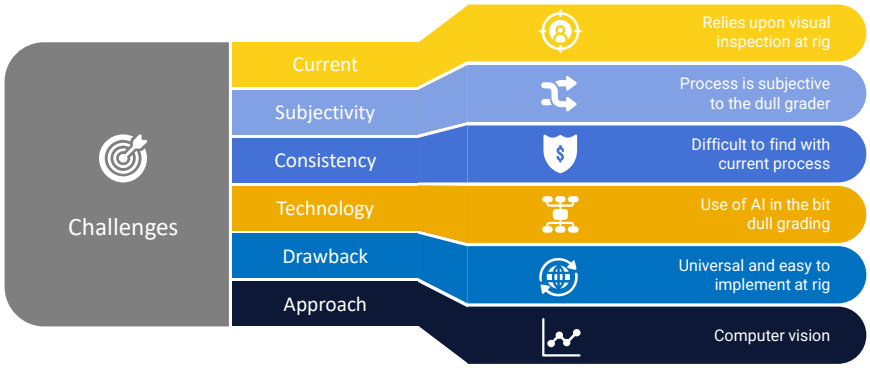
Challenges



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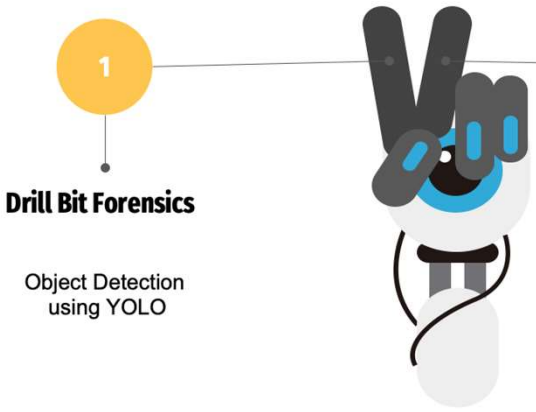
Proposed Approach



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Drill Bit Forensics

Object Detection using YOLO

2

Dull Grade Measurements

Semantic Segmentation using U-Net

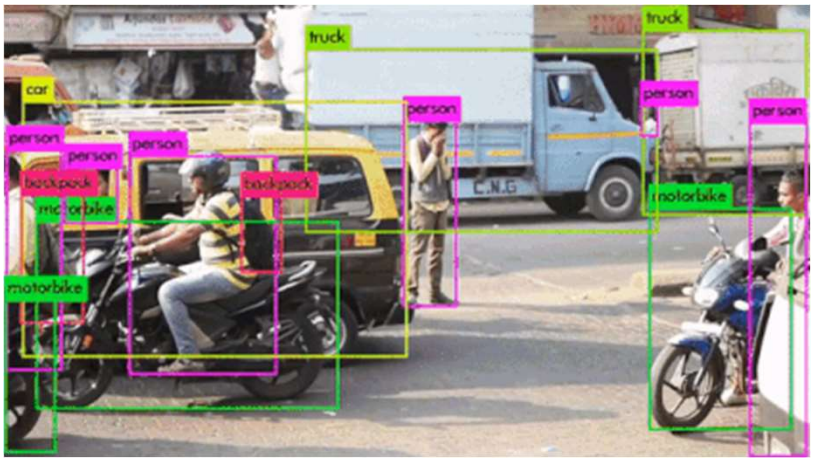
Measurements using OpenCV

Models

5

5

You Only Live Once (YOLO)



YOLOv3
Fully convolution
Darknet-53
Binary Cross Entropy
FPN

YOLOv4
Fully convolution
CSPDarknet53
Binary Cross Entrop
SSP and PANet

YOLOv5
Fully convolution
CSPDarknet53
Binary Cross Entrop
PANet

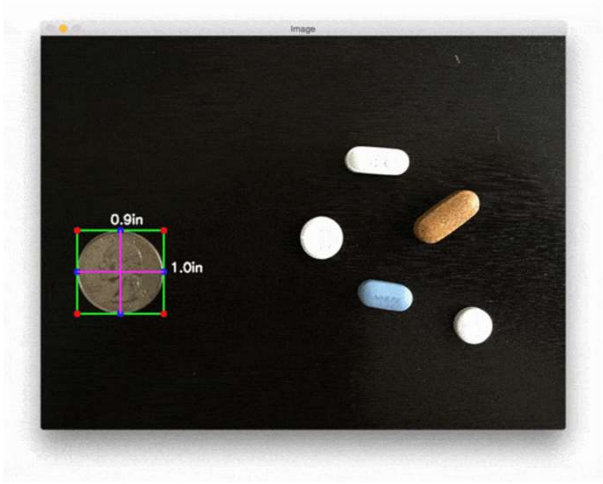
6

6

Semantic Segmentation using U-Net

7

Measurement using OpenCV U-Net



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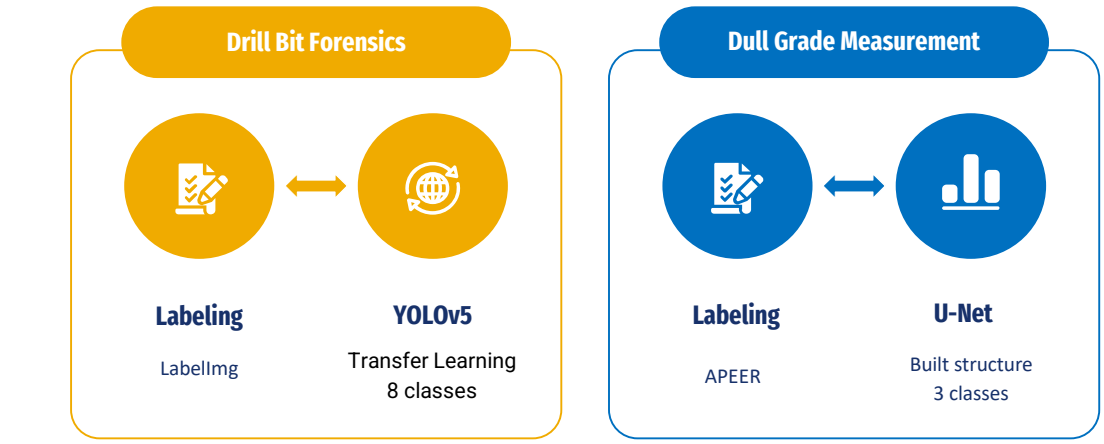
Methodology



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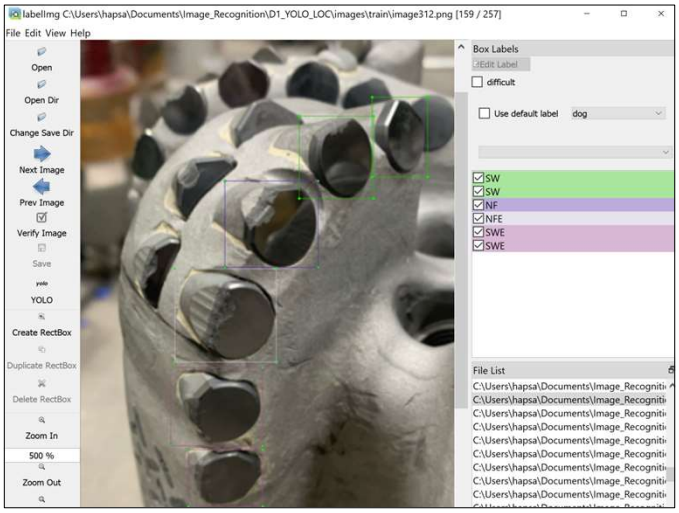
Drill Bit Forensics - Labeling

Classes	Cause of Damage	Bit Damage
IS_TOP	Interfacial Severity – Top	Ring Out
IS	Interfacial Severity	Ring Out
SW	Smooth Wear	Worn Cutter Heat Cracking Erosion
NF	Normal Fracture	Chipped Cutter Delamination Bond Failure Lost Cutter
TF	Tangential Fracture	Broken Cutter
SWE	Smooth Wear – External	Worn Cutter Heat Cracking Erosion
NFE	Normal Fracture – External	Chipped Cutter Delamination Bond Failure Lost Cutter
TFE	Tangential Fracture – External	Broken Cutter



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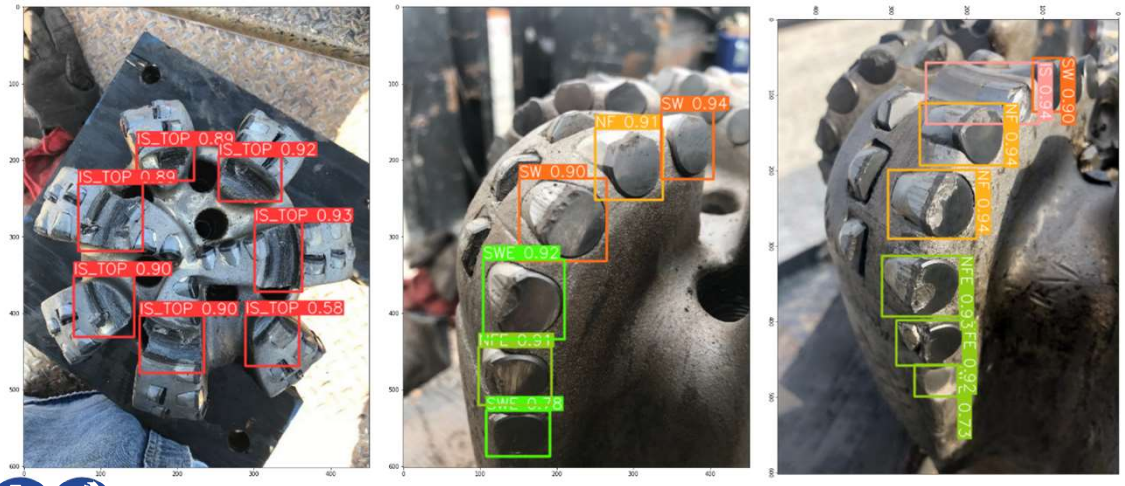
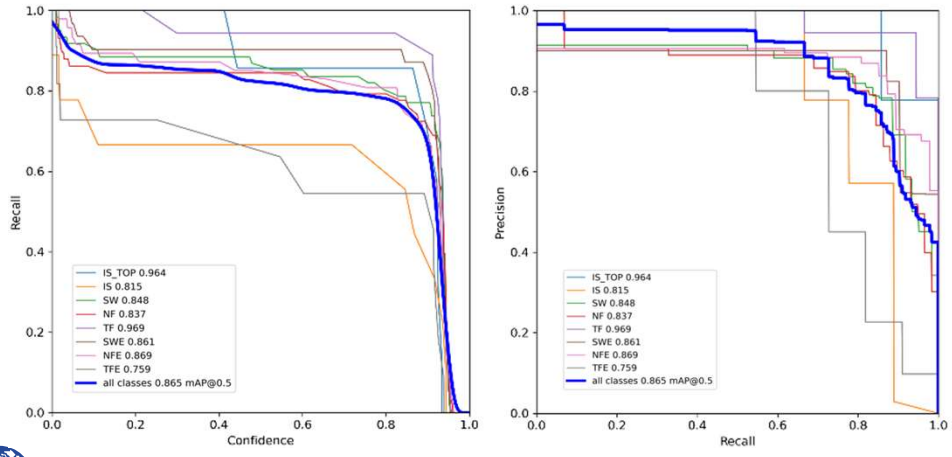
Drill Bit Forensics – YOLOv5



Drill Bit Forensics – Evaluation



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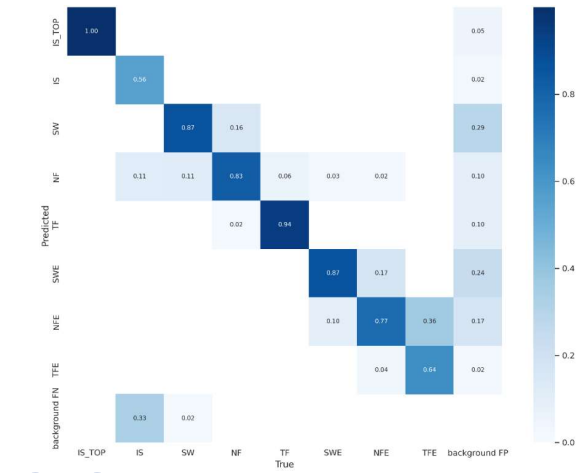
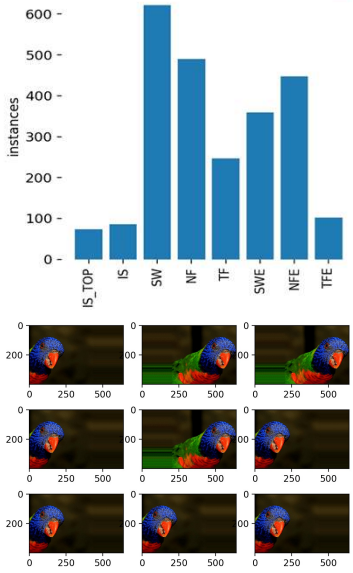
Drill Bit Forensics – Classification





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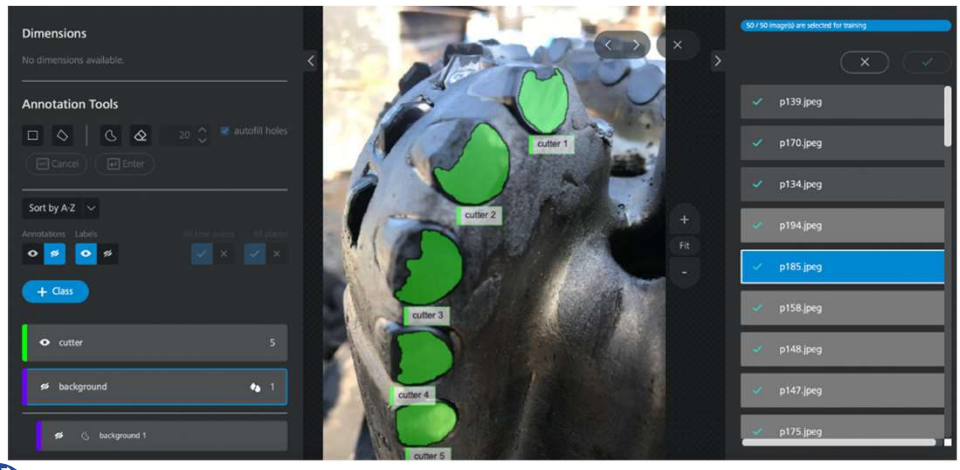
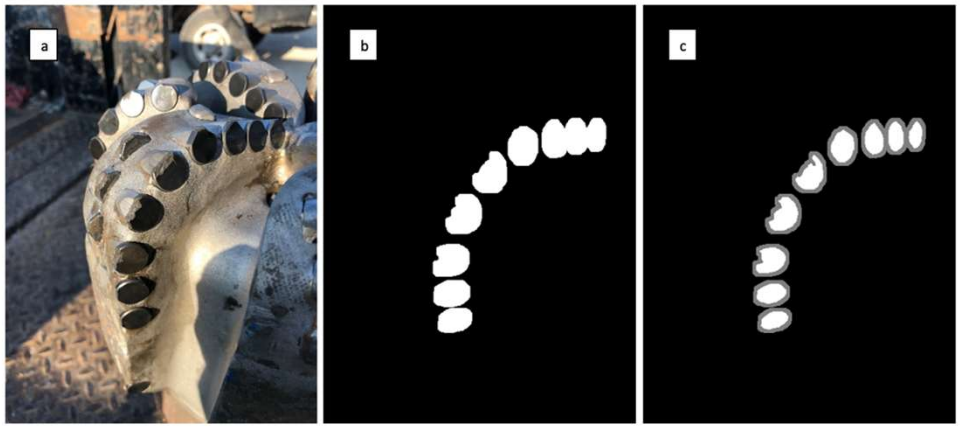
Dull Grade Measurement – Labeling



Dull Grade Measurement – Border Class



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Dull Grade Measurement – Architecture

Webinars

Library
Semantic Segmentation Models

3 classes
Cutter, border and background

Images
RGB input. Resize to 256x256

Parameters
Adam, LR 0.0001, SoftMax, Dice and focal loss

Dice loss
Address imbalance problem

Focal loss
Cross entropy that focus on misclassified

IOU
Interception Over Union

FScore
Precision and Recall

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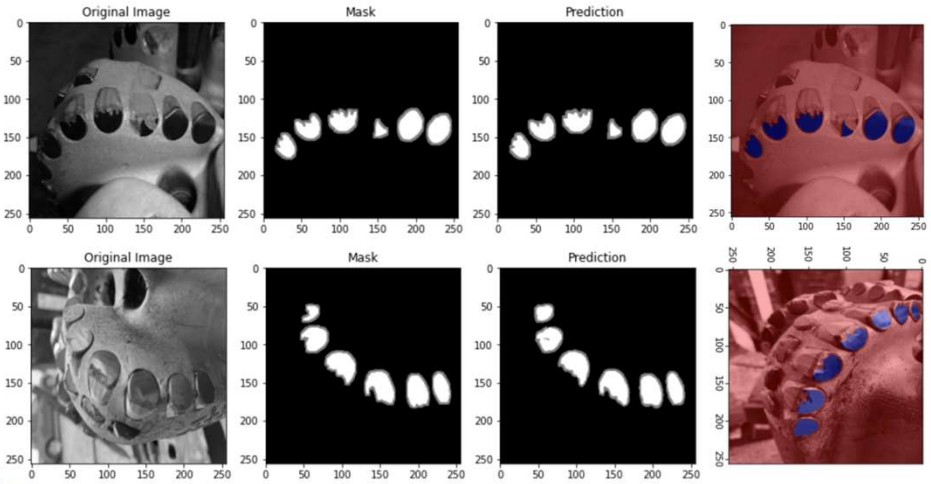
Dull Grade Measurement – UNet



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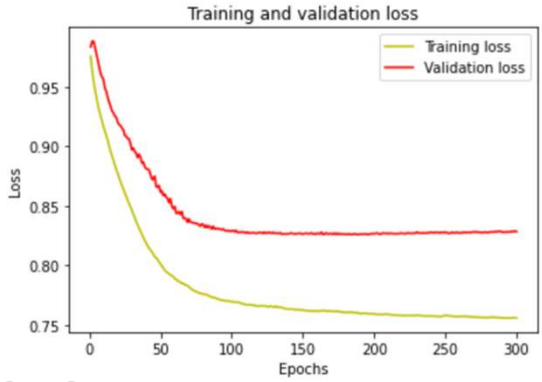
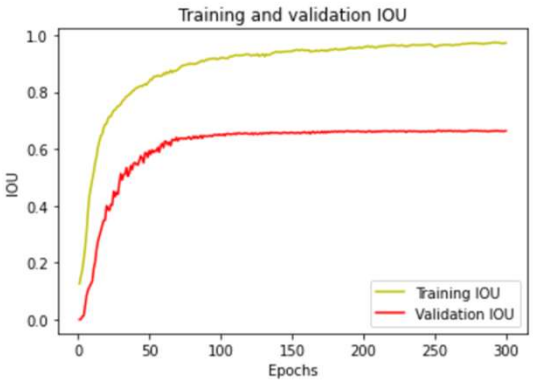
Dull Grade Measurement – Evaluation





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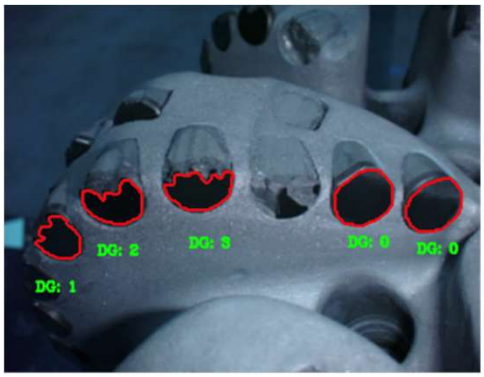
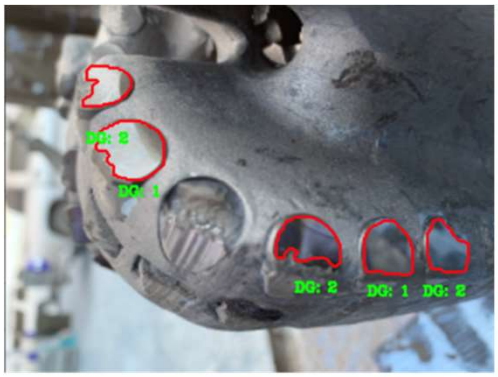
Dull Grade Measurement – Area/Contour

Grading	0	1	2	3	4	5	6	7	8
Good Cutter Area %	100 – 93.75 %	93.74 – 81.25 %	81.24 – 68.75 %	68.75 – 56.25 %	56.24 – 43.75 %	43.74 – 31.25 %	31.24 – 18.75 %	18.74 – 6.25 %	6.24 – 0.00 %

(Ashok et al., 2020)





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Conclusion and Future Work

- These two models, we can provide valuable information and insights in the search for automating the drill bits analysis with high accuracy.
- For YOLO model, find more ways to tackle the class imbalance.
- For U-Net model, have a standard size set of images, expand the training set and tackle overfitting.
- For OpenCV measurement, improve the Dull grade assignment or explore other options.
- Possibility of combining the two models into a single one.

References

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