DRAGNET VISION MODEL

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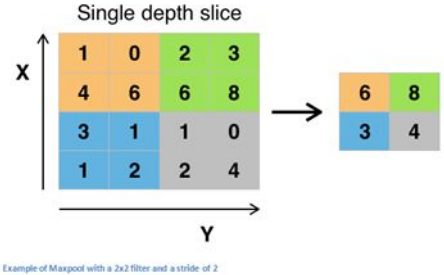
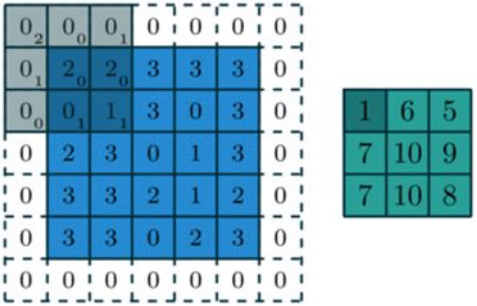
METHODOLOGY

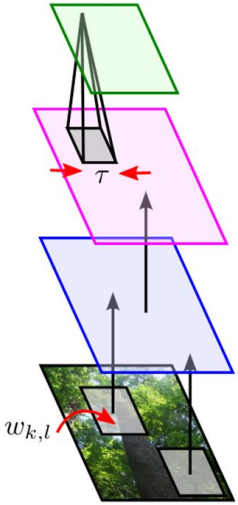
DragNet Vision Model

Convolutional Neural Network Theory

How Do CNNs work?







$$x_{i,j} = \max_{|k|<\tau,|l|<\tau} y_{i-k,j-l}$$

mean or subsample also used — pooling stage

$$y_{i,j} = f(a_{i,j})$$

e.g. $f(a) = [a]_+$

$f(a) = \text{sigmoid}(a)$ — non-linear stage

$$a_{i,j} = \sum_{k,l} w_{k,l} z_{i-k,j-l}$$

only parameters — convolutional stage

$z_{i,j}$ — input image

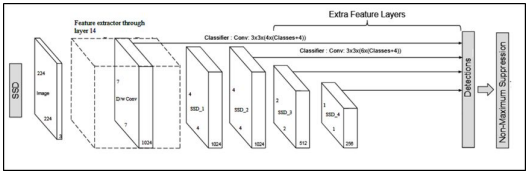
METHODOLOGY

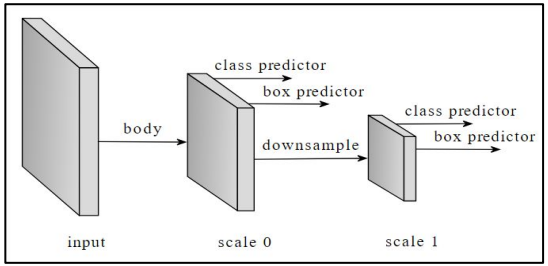
DragNet Vision Model

Model Architecture

Depth	Layer Type	Stride	Filter Shape	Input Size	Parameters
1	Convolution	2	3 x 3 x 32	224 x 224 x 3	864
2	D/w Convolution	1	3 x 3 x 32	112 x 112 x 32	2336
3	D/w Convolution	2	3 x 3 x 64	112 x 112 x 64	8768
4	D/w Convolution	1	3 x 3 x 128	56 x 56 x 128	17536
5	D/w Convolution	2	3 x 3 x 128	56 x 56 x 128	33920
6	D/w Convolution	1	3 x 3 x 256	28 x 28 x 256	67840
7	D/w Convolution	2	3 x 3 x 256	28 x 28 x 256	133376
8	D/w Convolution	1	3 x 3 x 512	14 x 14 x 512	266752
9	D/w Convolution	1	3 x 3 x 512	14 x 14 x 512	266752
10	D/w Convolution	1	3 x 3 x 512	14 x 14 x 512	266752
11	D/w Convolution	1	3 x 3 x 512	14 x 14 x 512	266752
12	D/w Convolution	1	3 x 3 x 512	14 x 14 x 512	266752
13	D/w Convolution	2	3 x 3 x 512	14 x 14 x 512	528896
14	D/w Convolution	2	3 x 3 x 1024	7 x 7 x 1024	1057792
15	Avg Pooling	1	Pool 7 x 7	7 x 7 x 1024	-
16	Fully-Connected	1	1024 x 18	1 x 1 x 1024	-
17	Softmax	1	Classifier	1 x 1 x 18	-
					3185088

Feature Extraction (Howard et al., 2017)





Single Shot Detection (Liu et al. 2016)

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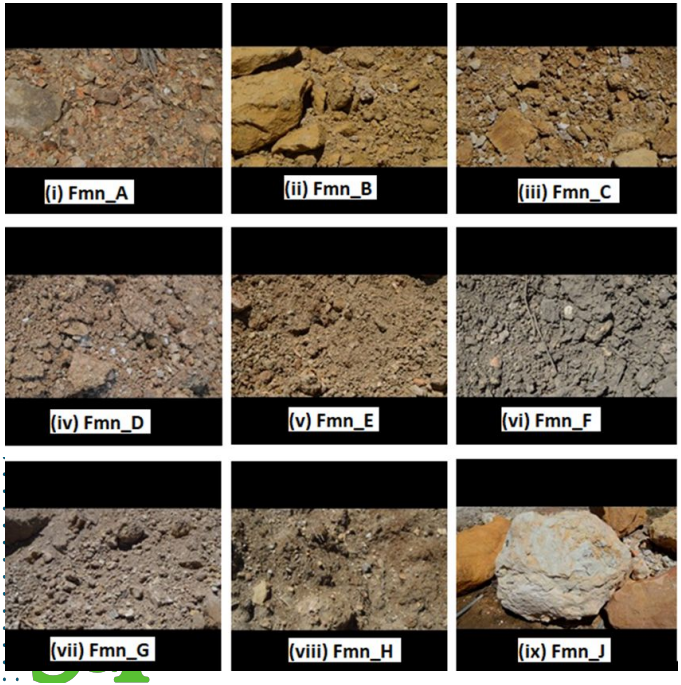
Model Input Data



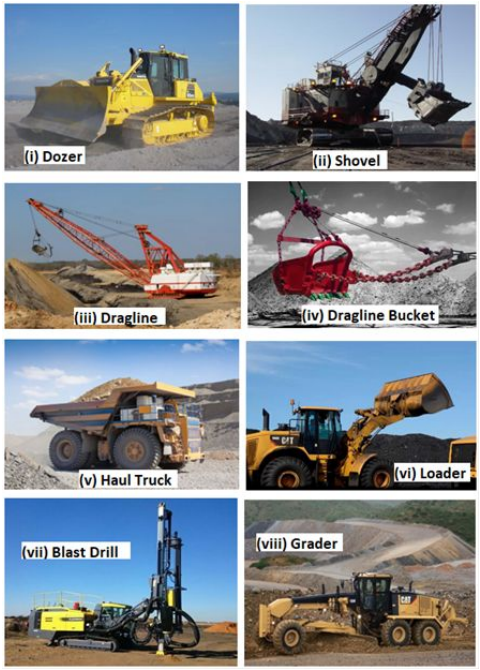


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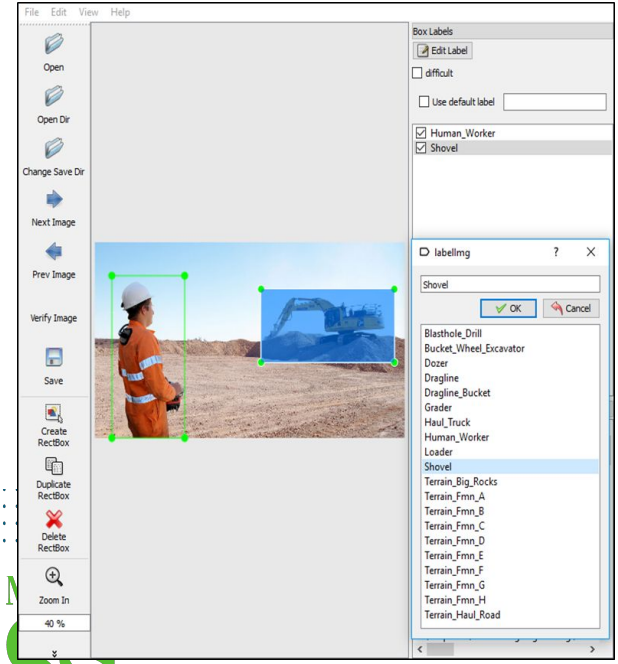
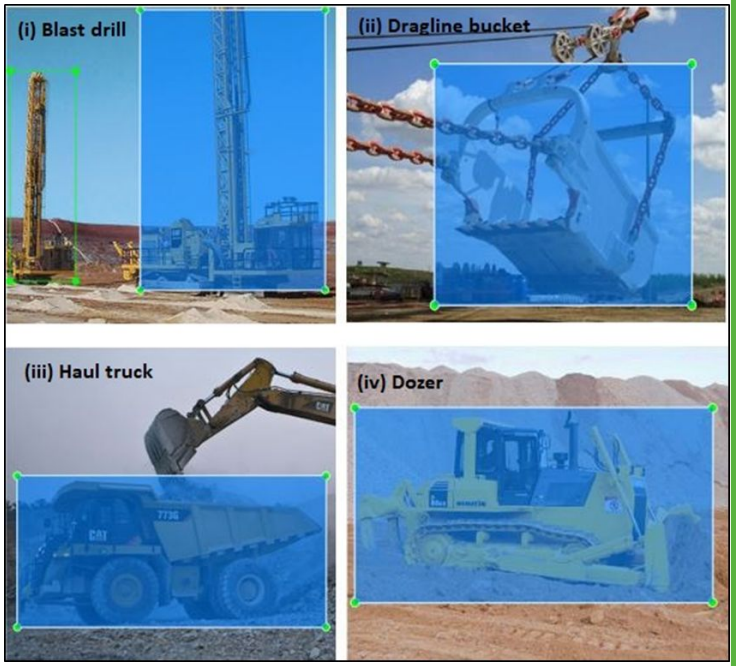
Image Annotation using LabelImg



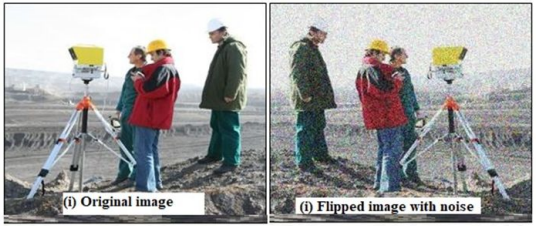


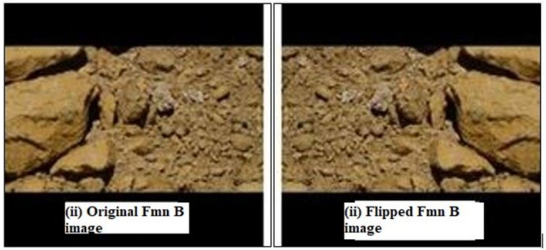
Tzutalin (2017)

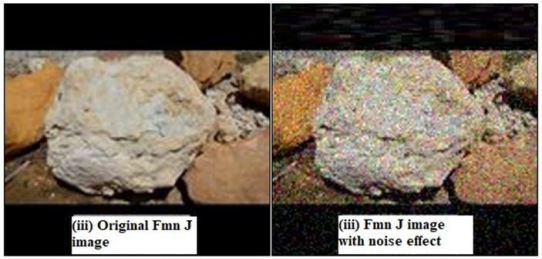
METHODOLOGY

DragNet Vision Model

Data Augmentation







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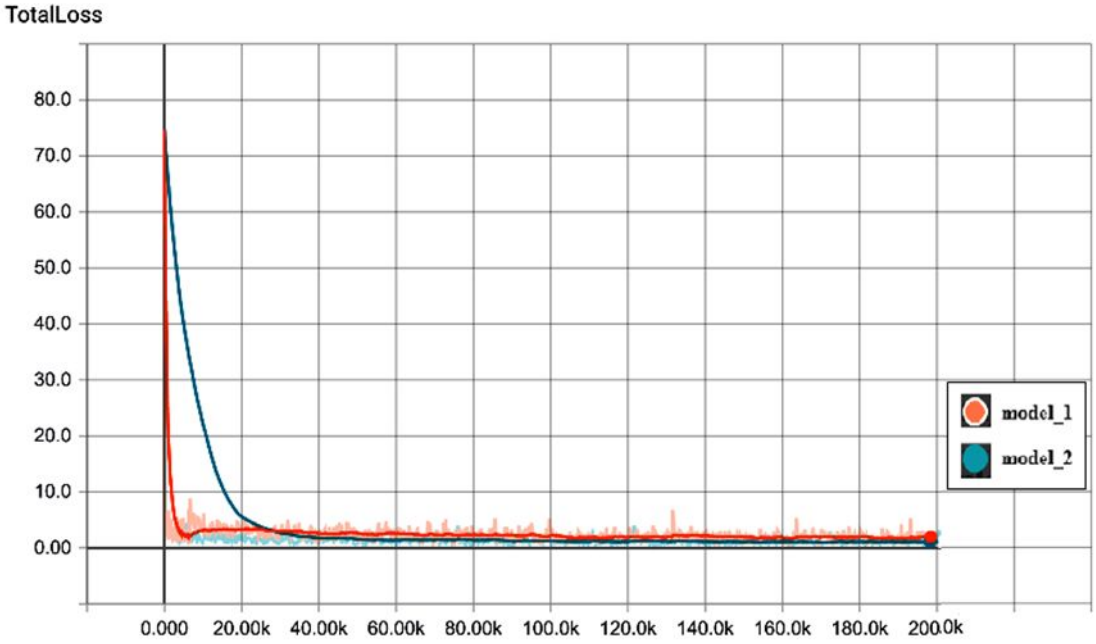
Model Verification



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Model Validation

GROUND TRUTH	MODEL PREDICTIONS: Blast Drill	Dozer	Dragline	Dragline Bucket	Fmn_A	Fmn_B	Fmn_C	Fmn_D	Fmn_E	Fmn_F	Fmn_G	Fmn_H	Fmn_J	Grader	Haul Truck	Human	Loader	Shovel	Undetected	Model Accuracy (%)
Shovel	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	22	2	88.0
Loader	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	13	1	1	86.7
Human	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	-	-	1	80.0
Haul Truck	-	-	-	-	-	-	-	-	-	-	-	-	-	1	8	-	-	-	2	72.7
Grader	-	-	-	-	-	-	-	-	-	-	-	-	-	13	-	-	-	-	2	86.7
Fmn_J	-	-	-	-	-	-	-	-	-	-	-	-	10	-	-	-	-	-	3	76.9
Fmn_H	-	-	-	-	-	-	-	-	-	-	1	11	3	-	-	-	-	-	4	57.9
Fmn_G	-	-	-	-	-	-	-	-	-	-	20	-	-	-	-	-	-	-	-	100.0
Fmn_F	-	-	-	-	-	-	-	-	-	19		-	-	-	-	-	-	1	-	95.0
Fmn_E	-	-	-	-	-	-	-	-	10	-	5	-	-	-	-	-	-	1	-	62.5
Fmn_D	-	-	-	-	-	-	-	12	-	-	-	-	2	-	-	-	-	-	2	75.0
Fmn_C	-	-	-	-	-	-	19	1	-	-	-	-	-	-	-	-	-	-	2	86.4
Fmn_B	-	-	-	-	-	8	-	-	-	-	-	-	-	-	-	-	-	1	2	72.7
Fmn_A	-	-	-	-	23	-	-	-	-	-	-	-	4	-	-	-	-	-	-	85.2
Dragline Bucket	-	-	-	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	88.9
Dragline	-	-	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	72.7
Dozer	-	17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	100.0
Blast Drill	16	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	100.0
																		Average:		82.6

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RESULTS & DISCUSSION

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Results & Discussions

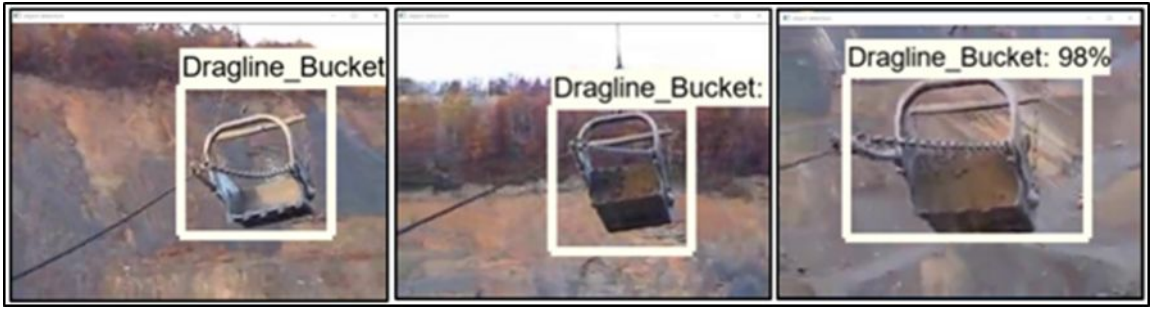
DragNet Application: Bucket Pose Estimation

Some loading phase detection results.

Some hoisting phase detection results.

Results & Discussions

DragNet Application: Bucket Pose Estimation

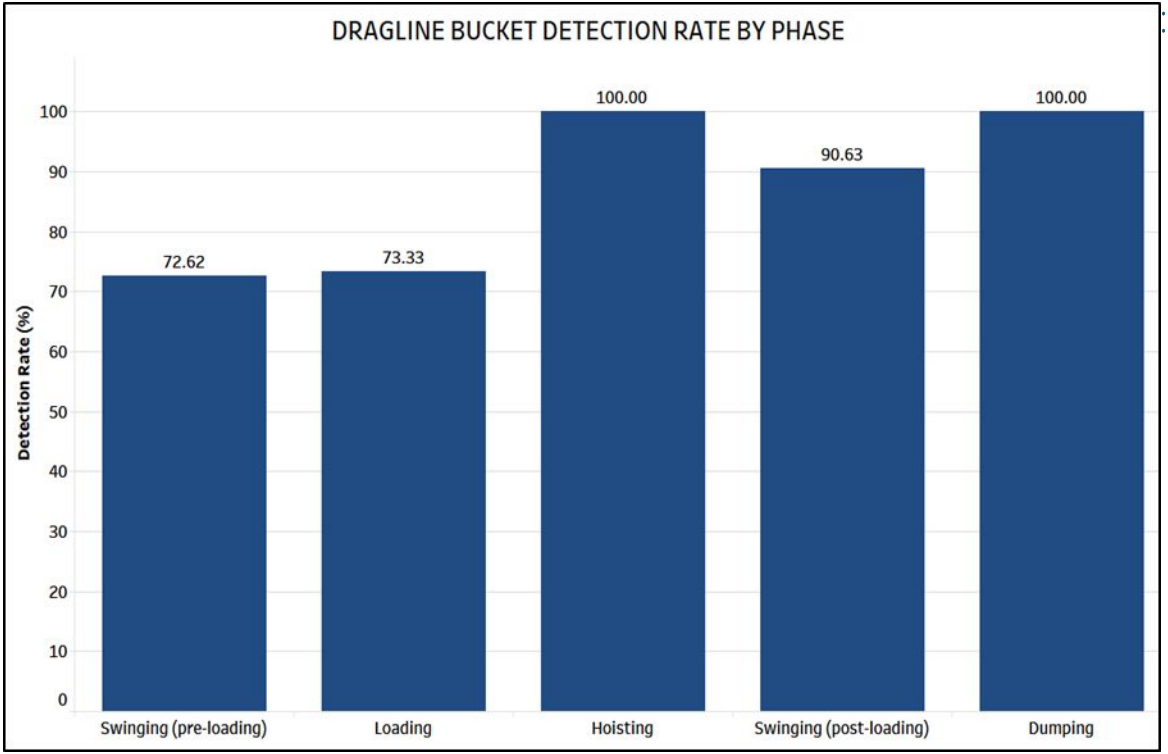


Some swinging phase detection results.

Some dumping phase detection results.

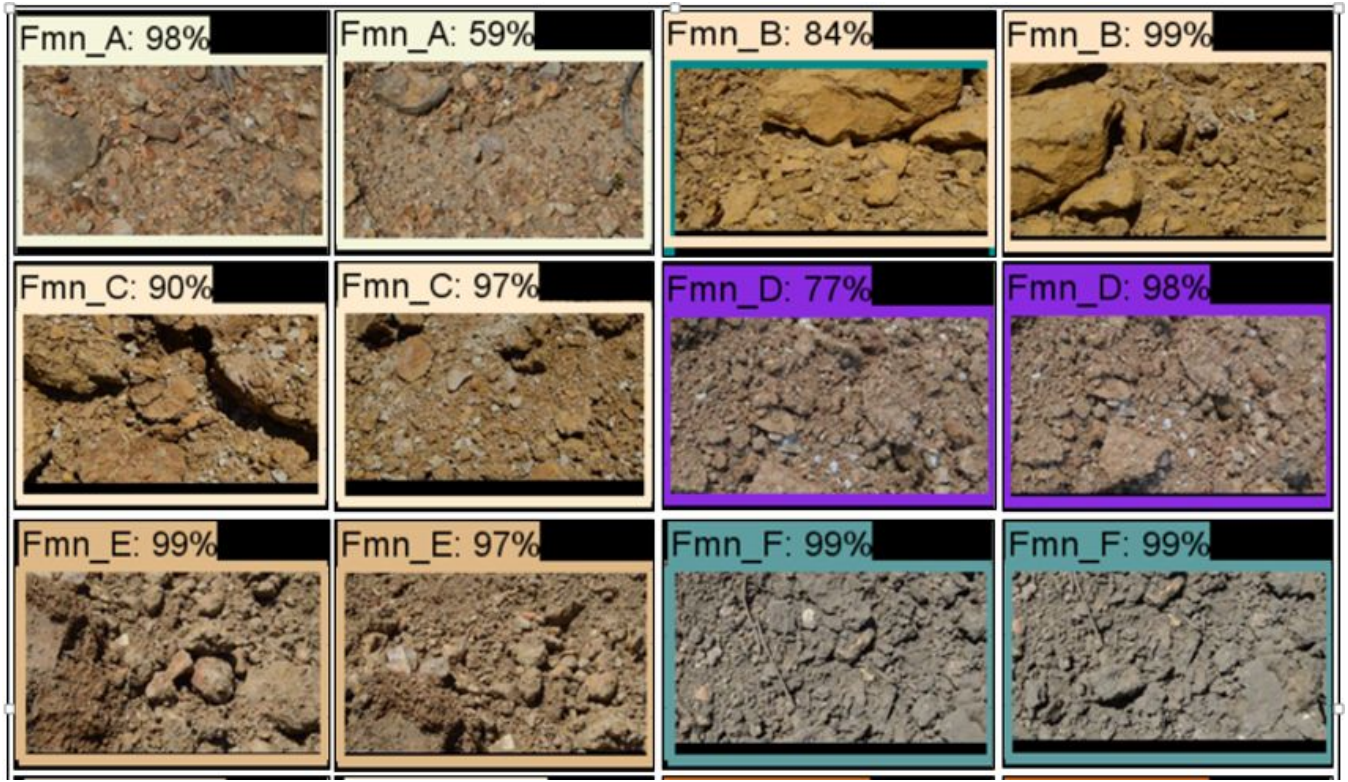
Results & Discussions

DragNet Application: Bucket Pose Estimation



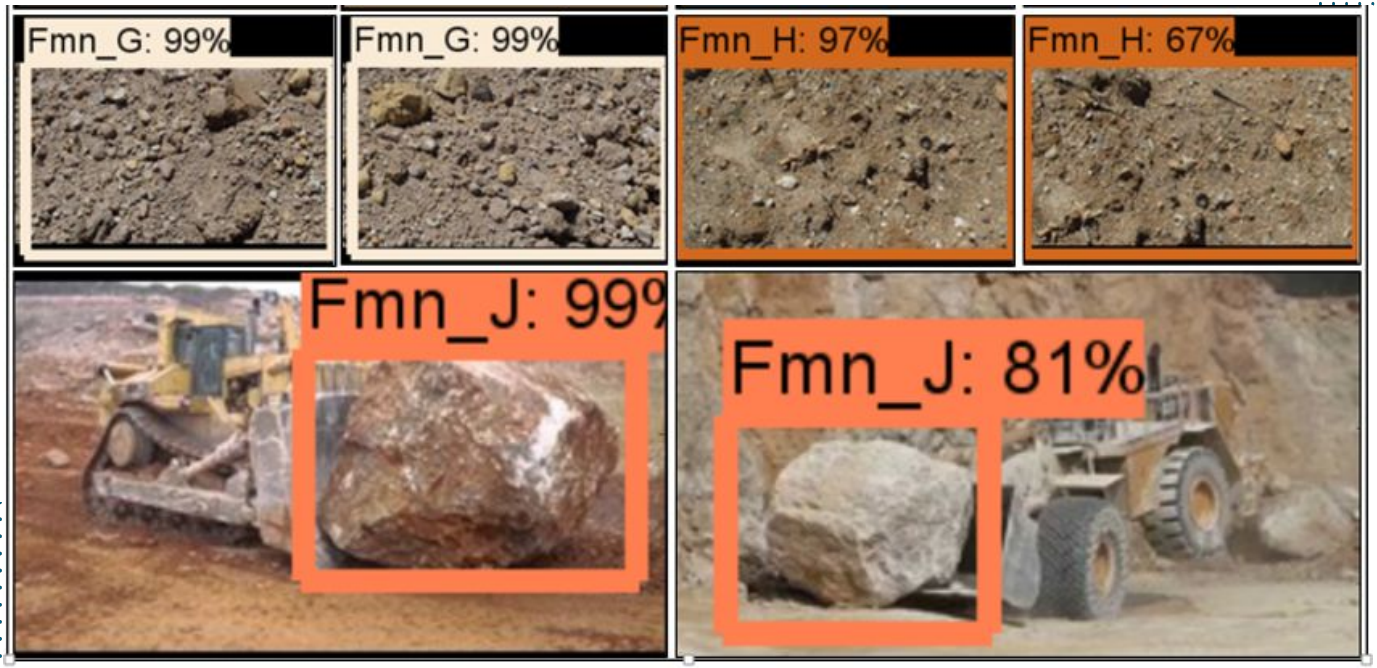
Results & Discussions

DragNet Application: Terrain Recognition



Results & Discussions

DragNet Application: Terrain Recognition



Results & Discussions

DragNet Application: Terrain Recognition

Conclusions – Dragline Vision

1. The DragNet model is able to achieve an 87.32% average detection rate across all operation phases on bucket pose estimation tasks.

2. The DragNet model is able to achieve 80.9% precision and 91.3% recall performance on terrain recognition tasks.

3. While the DragNet model performs considerably well, future improvements will be required to meet minimum performance thresholds for safe operation.

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