

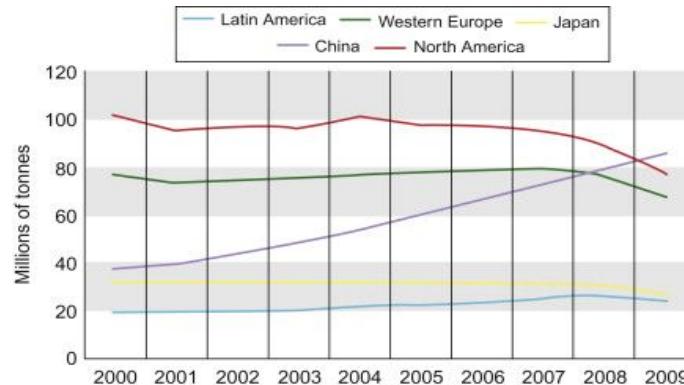
# **Realtime Wood Log Diameter Measurement System**

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(Group 17)

# Overview of the Pulp, Paper, and Timber Industry

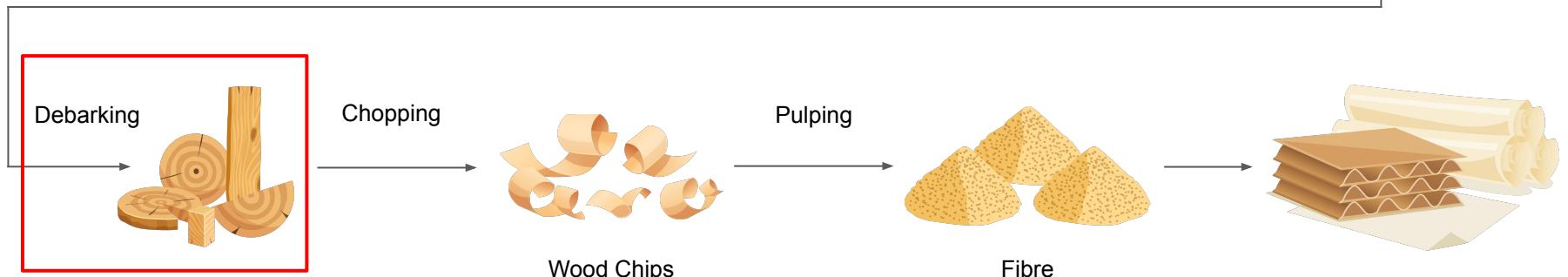
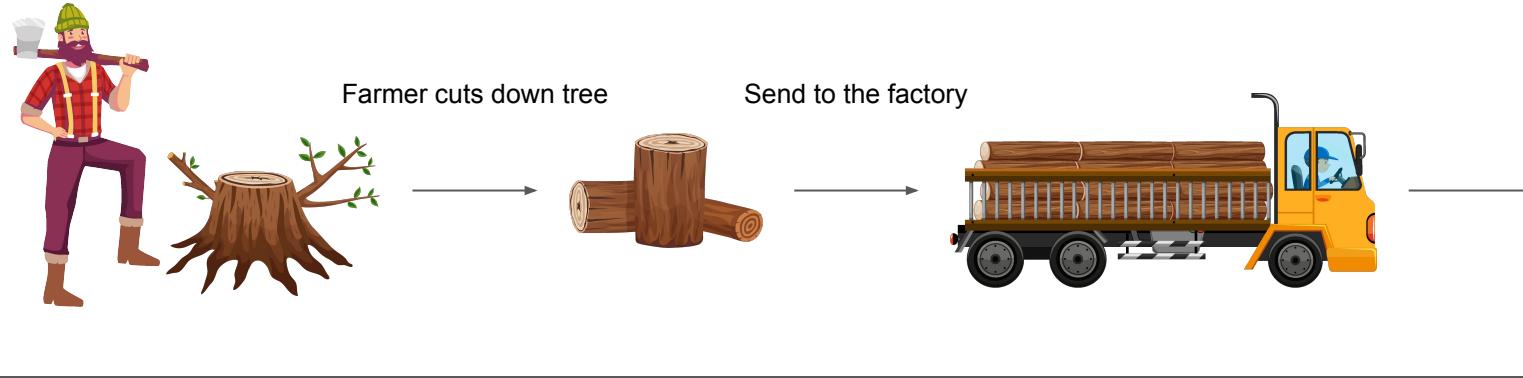
- The Pulp, Paper, and Timber industry are integral to the global economy, supplying raw materials for construction, packaging, and various applications.
- World production of paper and paperboard is around 390 million tonnes and is expected to reach 490 million tonnes by 2020. In 2009, total global consumption of paper was 371 million tonnes.



Source: Recycling and Deinking of Recovered Paper, Pratima Bajpai, 2014

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# Simplify Paper Production Process



\* Image taken from [Freepik](#)

# Business Problems

- Debarker breaks down due to too large or too small wood logs
- Visual inspection at the back of the truck doesn't reveal the quality of the wood logs inside the truck
- Human inspection at the debarker is costly and dangerous



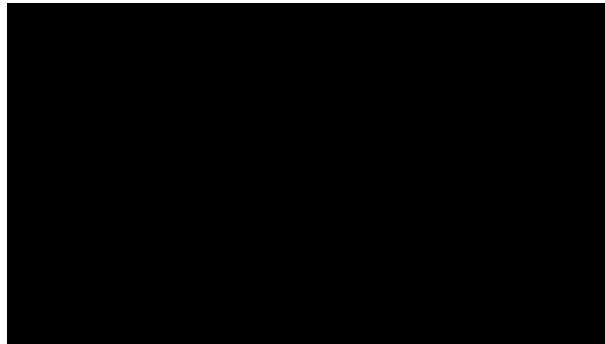
\* Click here to see the video

# Technical Requirements

- The system should be able to process the video feed in realtime
- The system should be able to run 24/7
- All hardware must be weatherproof, i.e., able to operate outdoor
- There should be minimal change to the current work process

# Dataset

IP Camera footage (8MP 10FPS) in front of the debarker

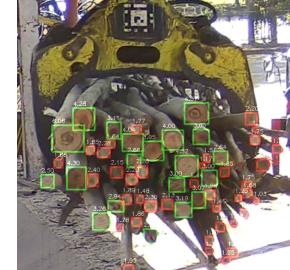


\* Click here to see the video



# Problem Formulation

1. Grabber Detection
2. Grab Cycle Segmentation
3. Wood Log Size Detection
  - a. Detect the wood log
  - b. Determine the size in realworld unit (cm / inch)



# Methodology: Grabber Detection

- We prepare a dataset of 300 images
- We train a 1-class YOLOv4-tiny object detector at multiple input resolutions
- Image augmentation techniques are used to adjust hue, exposure, and saturation and to flip the input image



Input Resolution	Detection Rate (%)	Runtime (sec)*
240x240	91.20	0.01686
416x416	94.72	0.01723

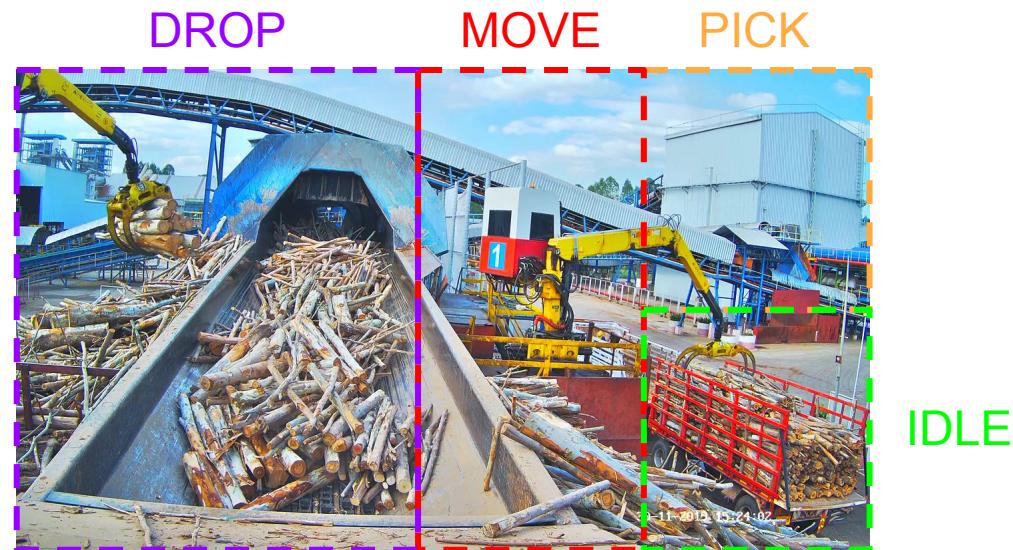
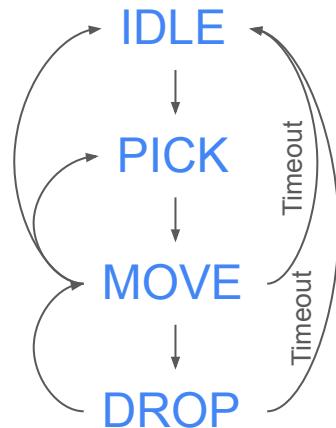
\* All runtimes are measured on Apple MacBook Air M2 w/ 16GB RAM

# Realtime Grabber Detection Results



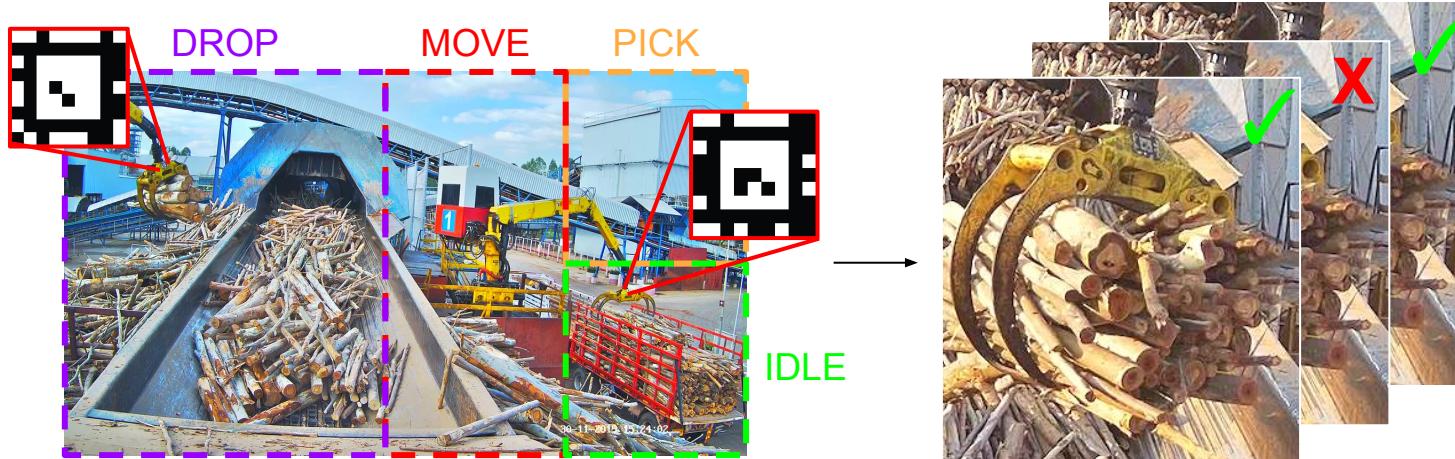
# Methodology: Grab Cycle Segmentation

We partition the frame into three zones: pick, move and drop and determine the cycle using the following rules



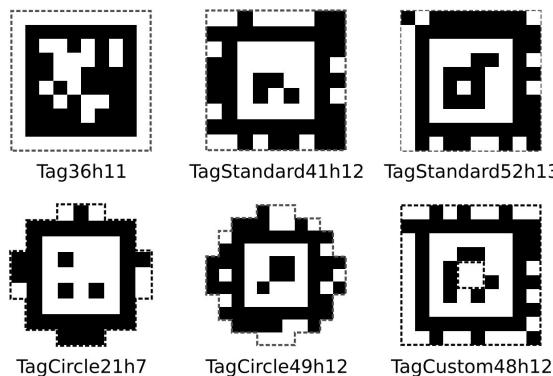
# Methodology: Grab Cycle Segmentation

For each grab cycle, we get a set of images to send to the next step (wood log size detection). However, there could be some images from the other side that need to be rejected



# AprilTag

- AprilTag is a visual fiducial system developed by the APRIL Robotics Laboratory at the University of Michigan
- It is adopted due to its robustness to partial occlusion, lighting conditions, and viewing angles



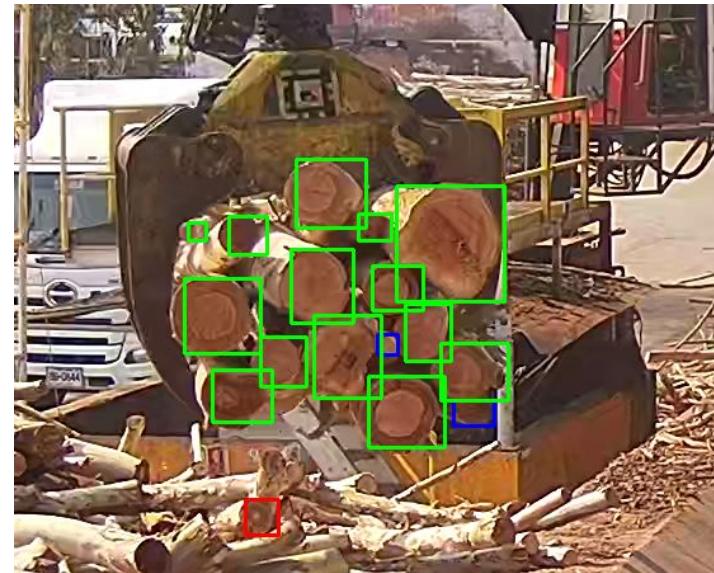
# Methodology: Wood Log Size Detection

1. Detect the wood log
  - We prepare a dataset of 230 images
  - We apply image augmentation by randomly cropping, flipping, and adjusting the color of the images. Then, we train several object detectors to detect the wood log
2. Determine the size in realworld unit (cm / inch)
  - We compare the size of the bounding box with the AprilTag, which has a known size of 14x14 cm
  - Some calibration is needed since the wood is closer to the camera than the tag

# Wood Log Detection Model Comparison

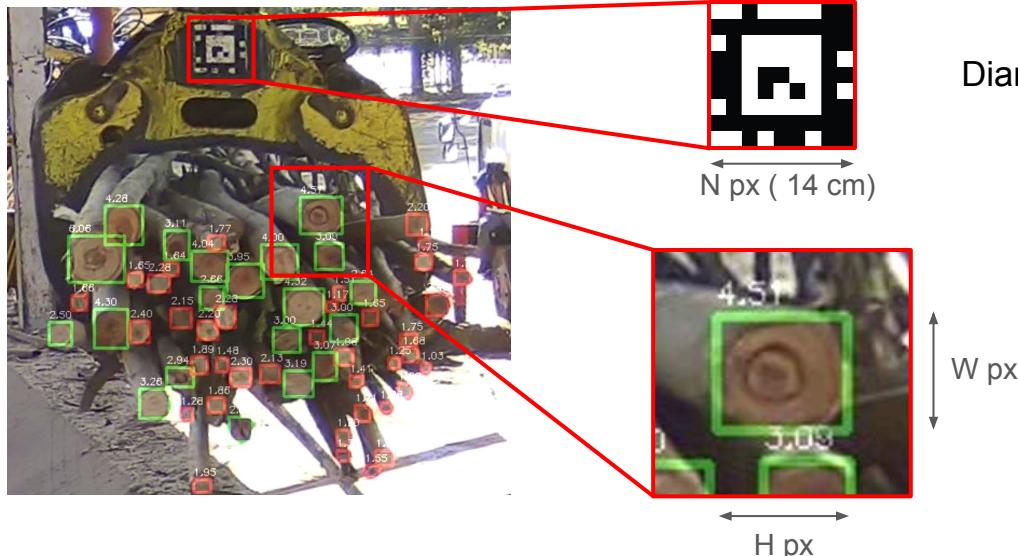
We train several models and compare using the following metrics

1. Percent of **correct** boxes
2. Percent of **incorrect** boxes
3. Percent of **missing** boxes
4. Average size error
5. Average runtime



# Log Size Computation

To calculate the diameter of the wood in inches, we compare the size of the detected bounding box to the size of the AprilTag



$$\text{Diameter (cm)} = 14 \times \text{MAX}(W, H) / N$$

# Wood Log Detection Model Comparison

Model	% Correct	% Incorrect	% Missing	Avg. Size Error	Runtime (sec)*
Faster R-CNN (Inception V2)	58.68	5.16	41.31	-0.787±16.38	0.425
Faster R-CNN with Inception Resnet v2, Atrous	60.56	2.5	39.43	1.317±15.24	3.48
Faster R-CNN with Inception Resnet v2, Atrous (4 patches)	82.16	23.47	17.84	1.356±17.19	15.14

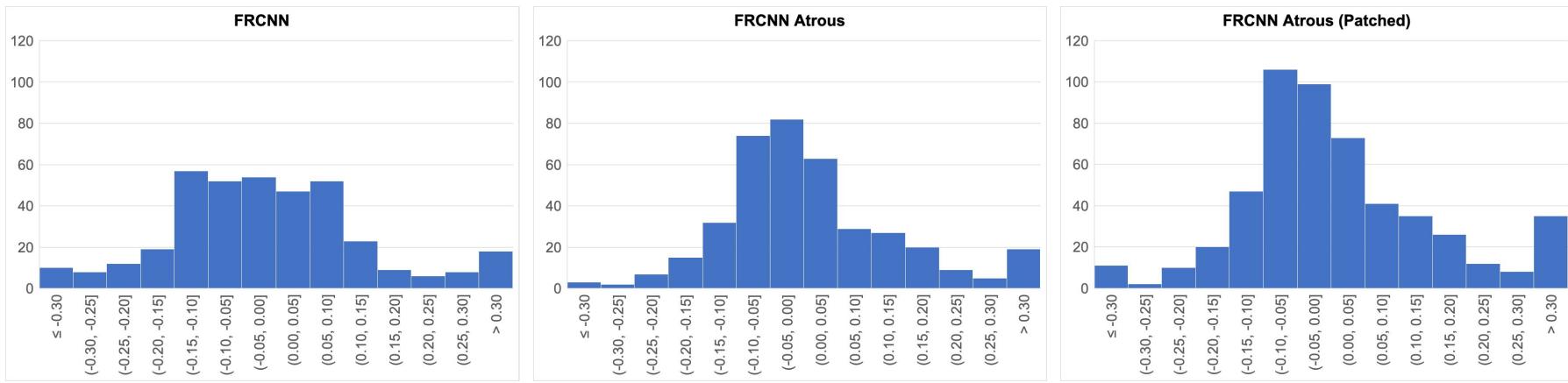
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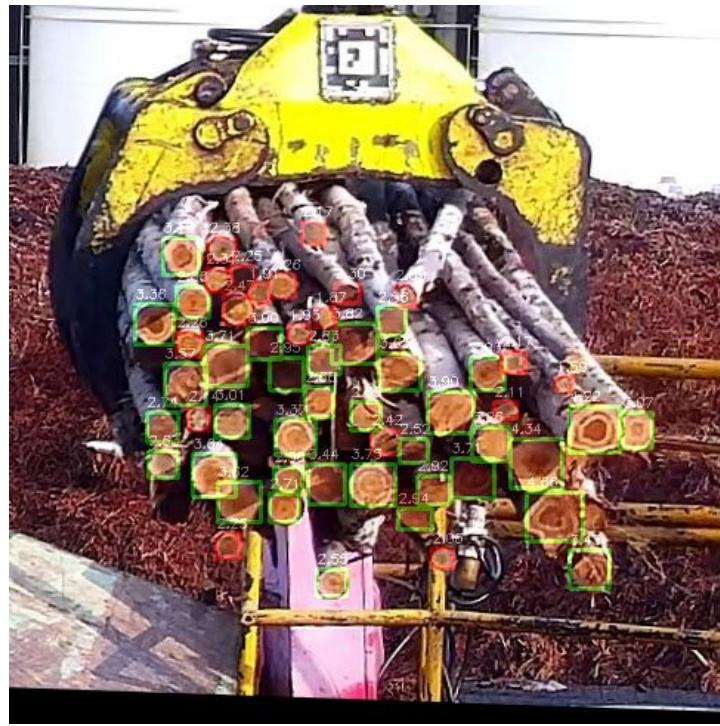
# Wood Log Detection Result



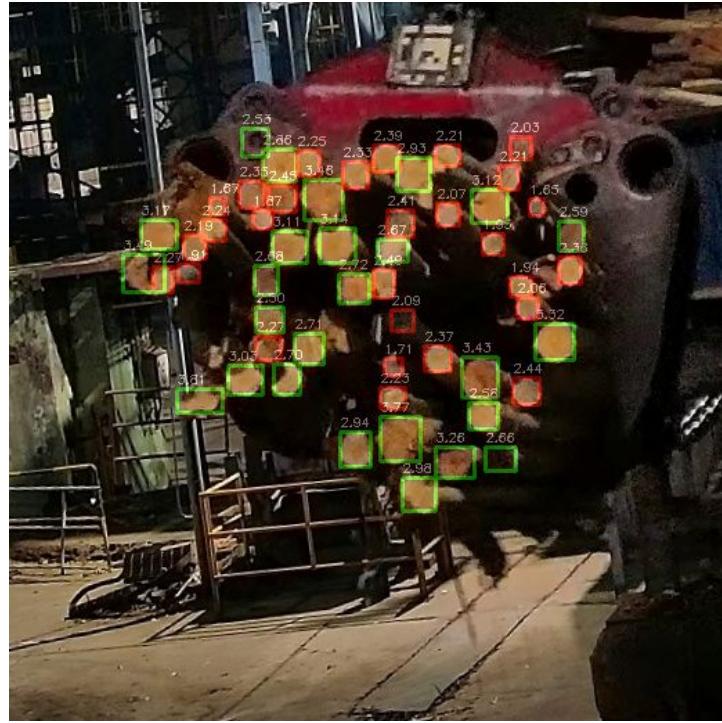
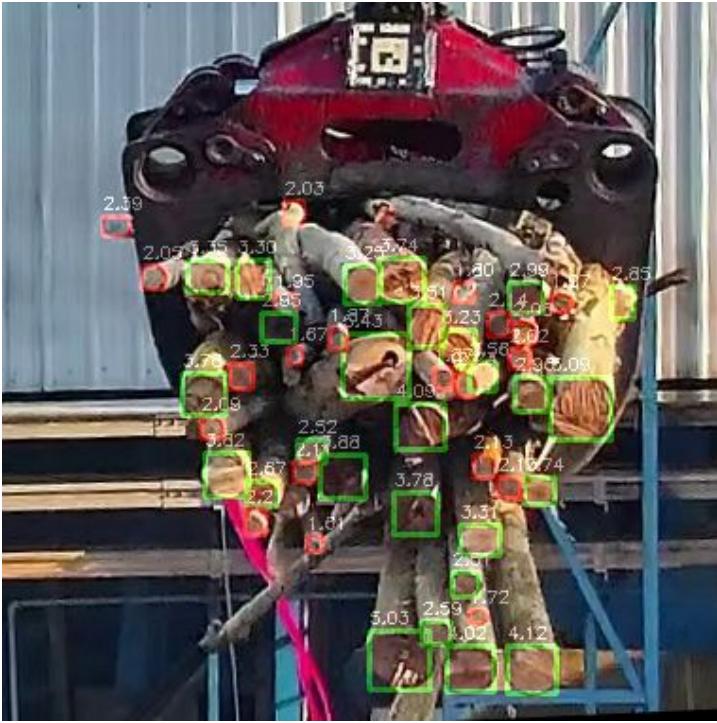
# Wood Log Detection Model Comparison



# Wood Log Detection Result

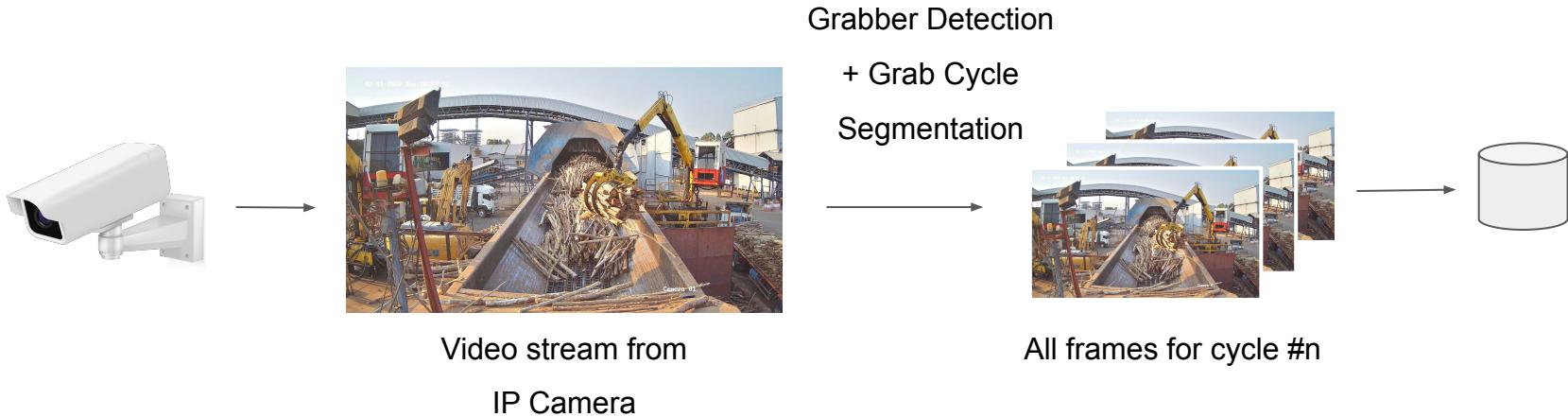


# Wood Log Detection Result



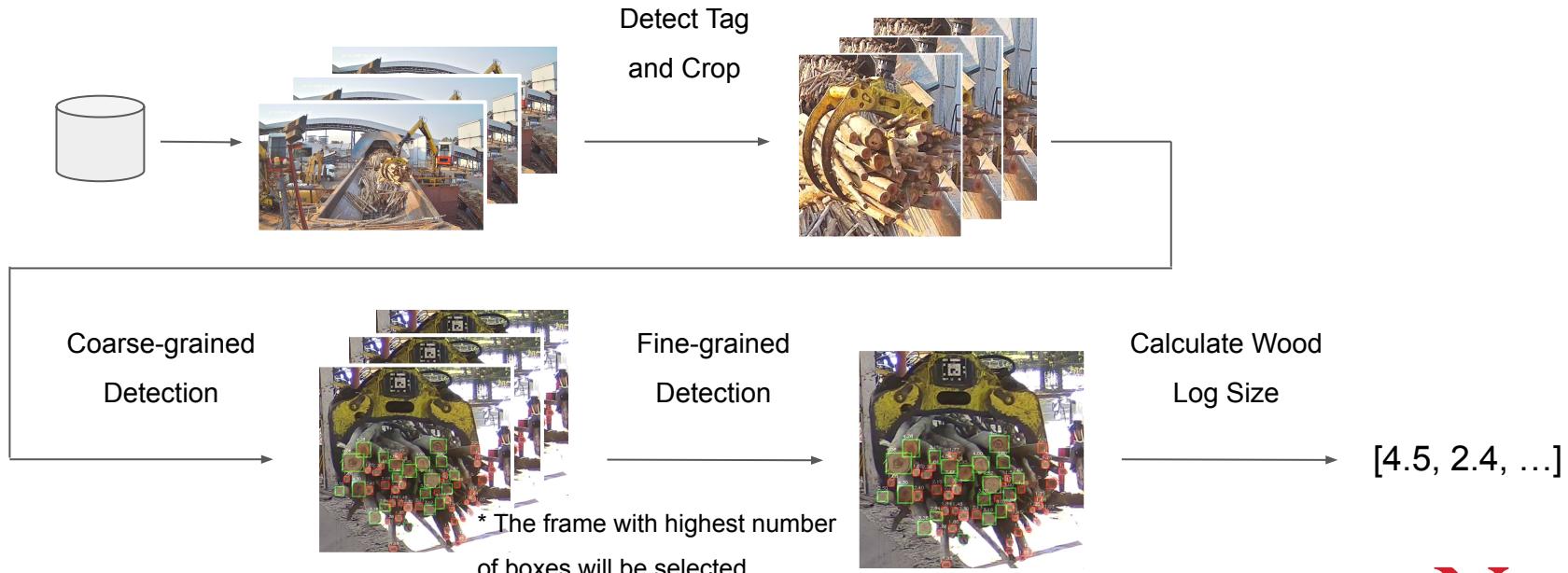
# Overall System Architecture

## 1) Realtime Phase



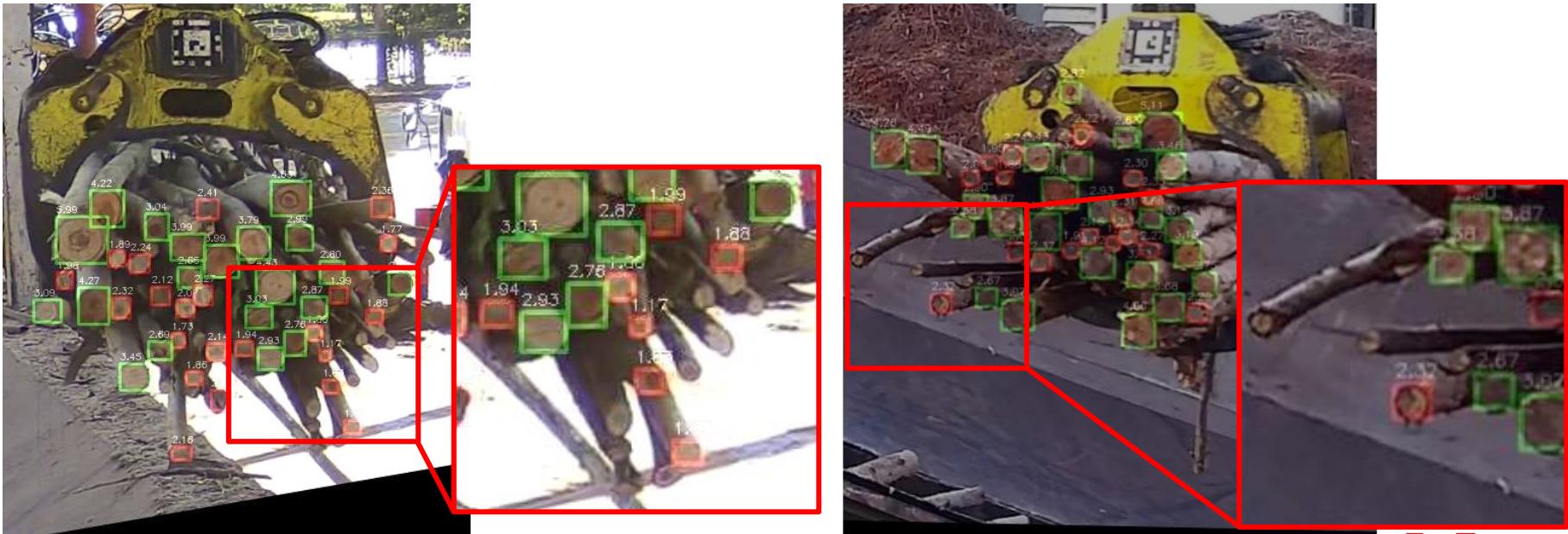
# Overall System Architecture

## 2) Near-realtime (Offline) Phase



# Challenge: Detection Rate On Small Wood Log

Some wood logs occupy a very small area and aren't detected in some scenarios

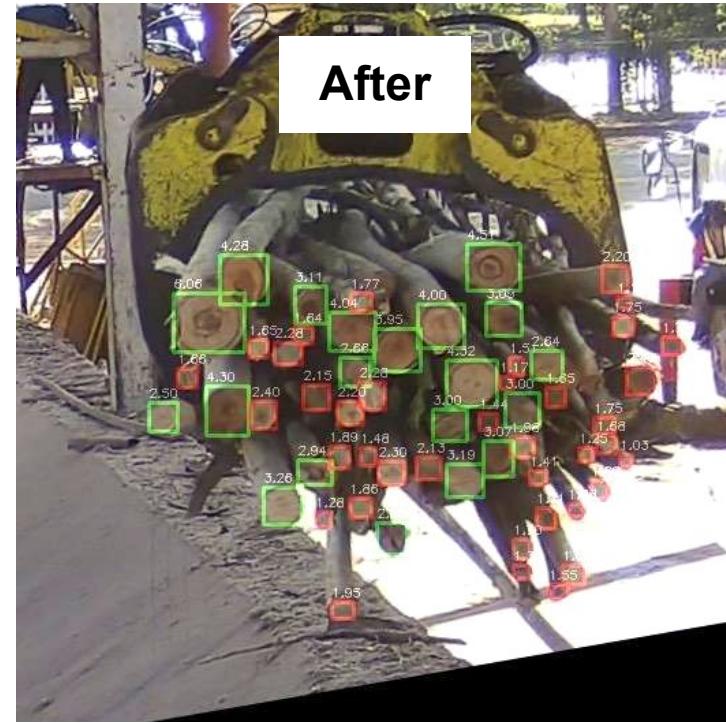
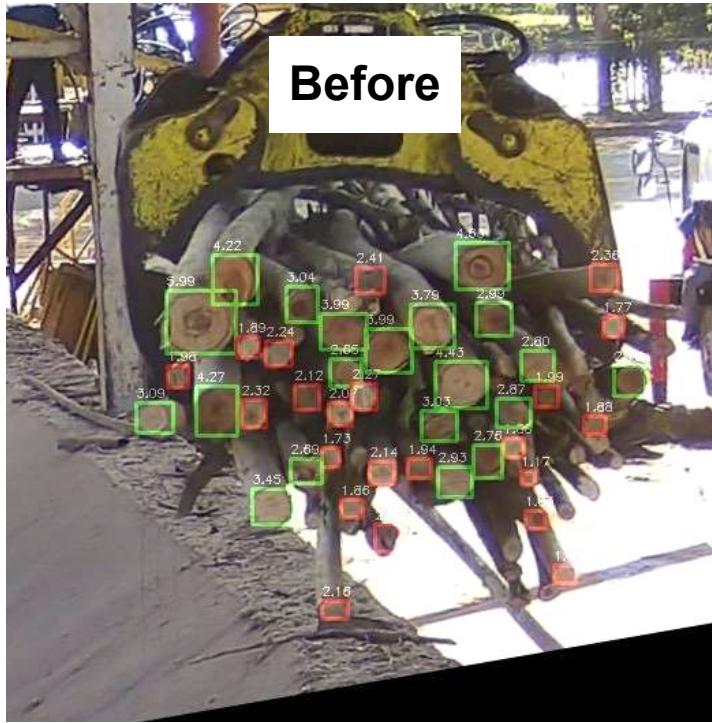


# Patch-based Detection

We address this problem by splitting an image into four overlap patches and combining all the boxes with the non-maximum suppression (NMS) algorithm



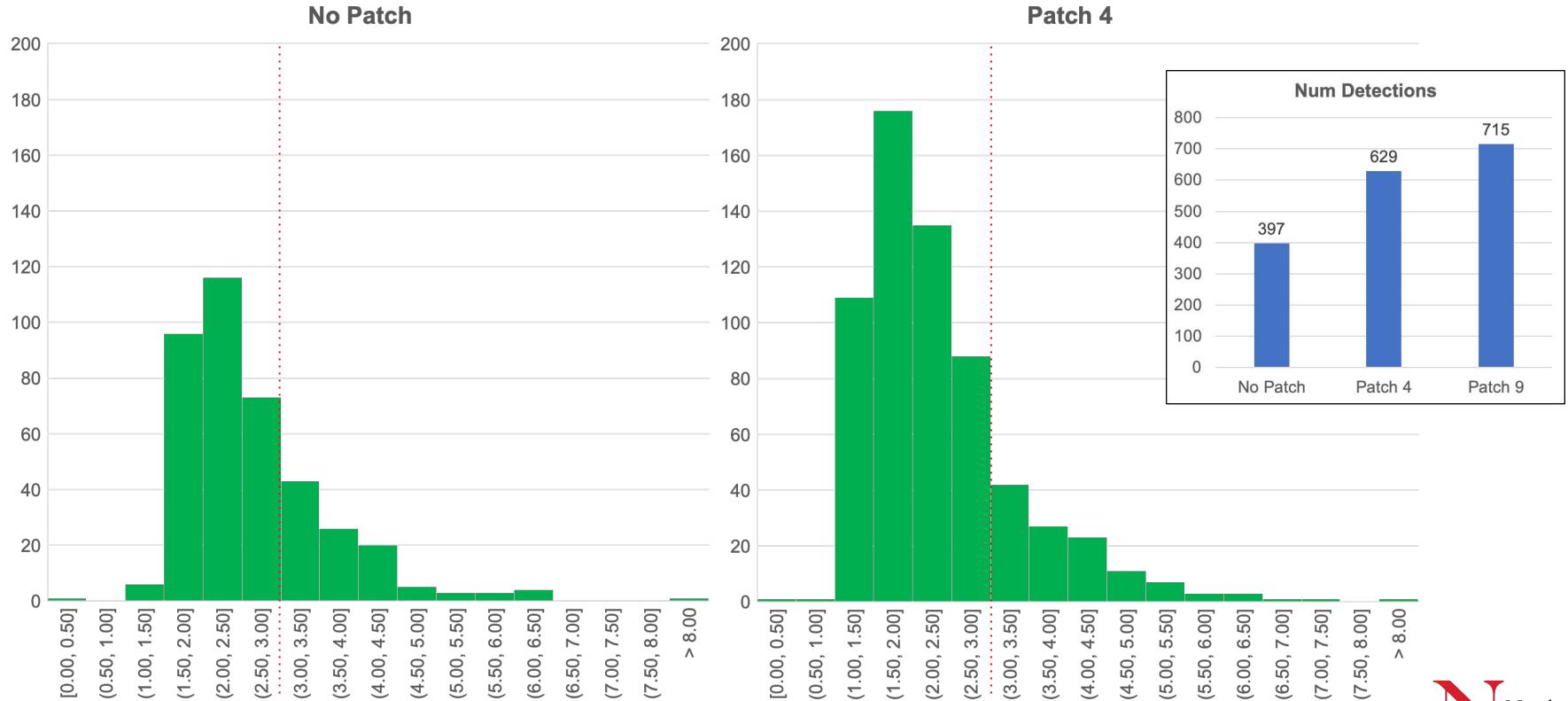
## Patch-based Detection: Sample Result Images



# Patch-based Detection: Sample Result Images



# Patch-based Detection: Wood Size Distribution



# Challenge: Grabber Angle

The grabber may not face the camera directly in some cases, rendering the wood undetectable



# Challenge: Tag Occlusion

The AprilTag must be cleaned on a regular basis because it may be exposed to dirt from the environment and oil from the machine



# Challenge: Poor Lighting Condition

Poor lighting conditions might lower detection rates, especially at night



# Challenge: Bad Image Quality

- The grabber moves too quickly at night when the shutter speed is slow.
- The image became blurred due to camera vibration.



# Related Works

- Dahl, A.B., Guo, M., Madsen, K.H.: Scale-space and watershed segmentation for detection of wood logs. In: Vision Day, Informatics and Mathematical Modelling (2006)
- Boykov, Y., Jolly, M.P.: Interactive graph cuts for optimal boundary region segmentation of object in n-d images. In: Int. C. Comput. Vision, pp. 105–112 (2001)
- M. Carlos, Woodech Forestry 4.0, Expocorma 2020, Santiago, Chile, Mar. 2020.
- <https://timbeter.com/> - Digital supply chain management for timber
- <https://www.mdpi.com/1999-4907/14/2/285> - A Novel Wood Log Measurement Combined Mask R-CNN and Stereo Vision Camera
- Fiducial Markers for Pose Estimation- <https://link.springer.com/article/10.1007/s10846-020-01307-9>

# Thank You