CATERPILLAR®

Caterpillar Big Data Infrastructure

Big Data, Data Analytics, and Machine Learning

CATERPILLAR®

Caterpillar is the world’s leading manufacturer of construction and mining equipment, industrial diesel engines and gas turbines, and diesel-electric locomotives.

CATERPILLAR® Solutions

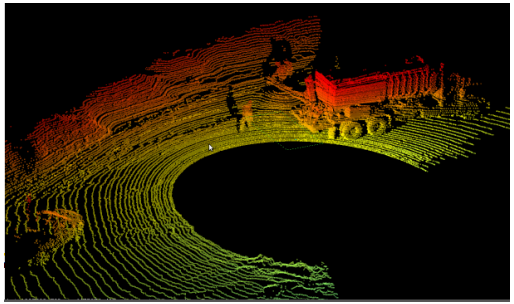
Autonomy and Operator Assistance

Autonomous Haul Trucks

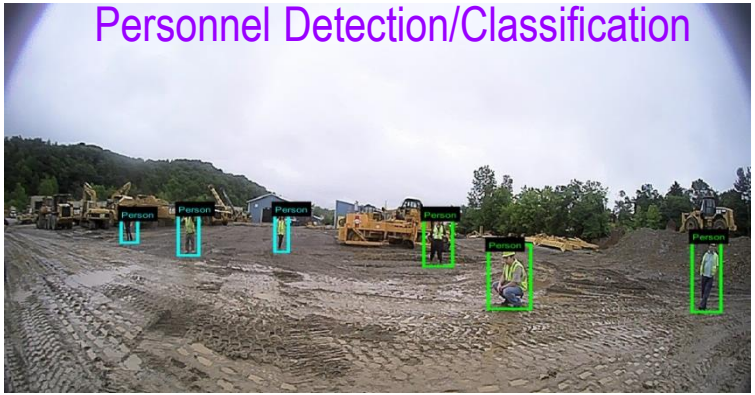
Non-Line of Sight
Remote Semi-Autonomy

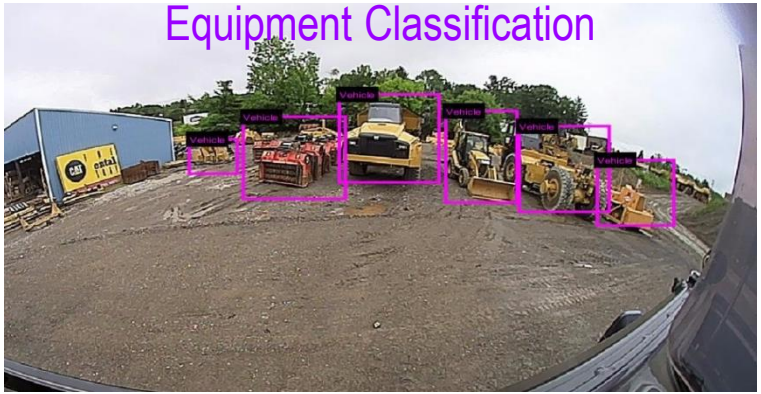
Operator Assistance

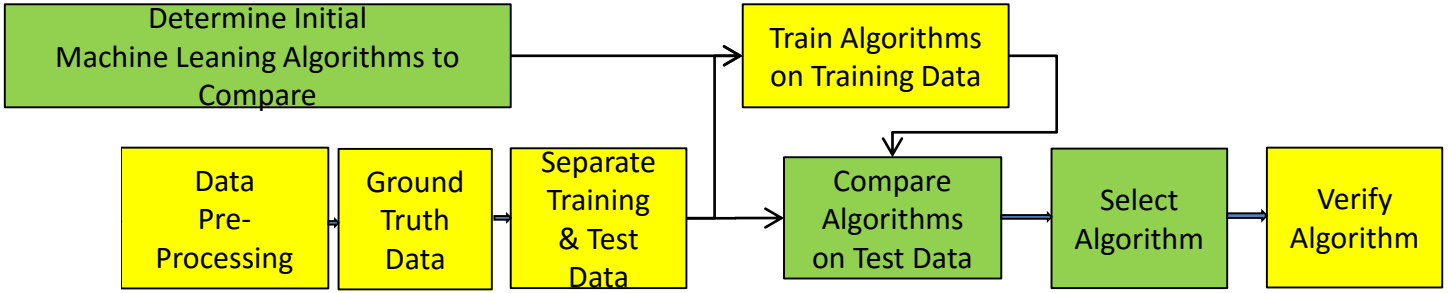
Machine Learning on Advanced Sensor Data



Why Do We Need a Big Data Infrastructure?

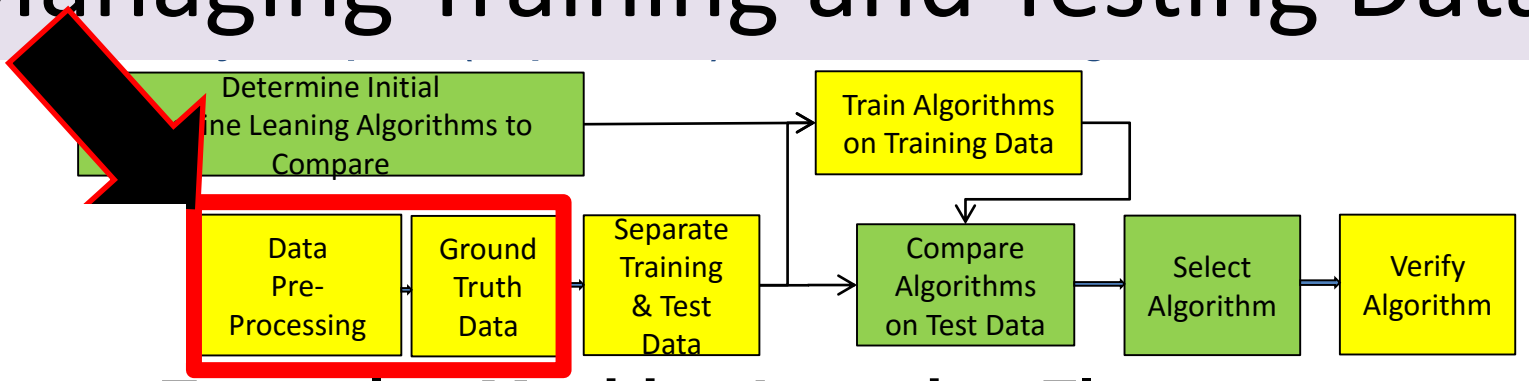






Example: Machine Learning Flow

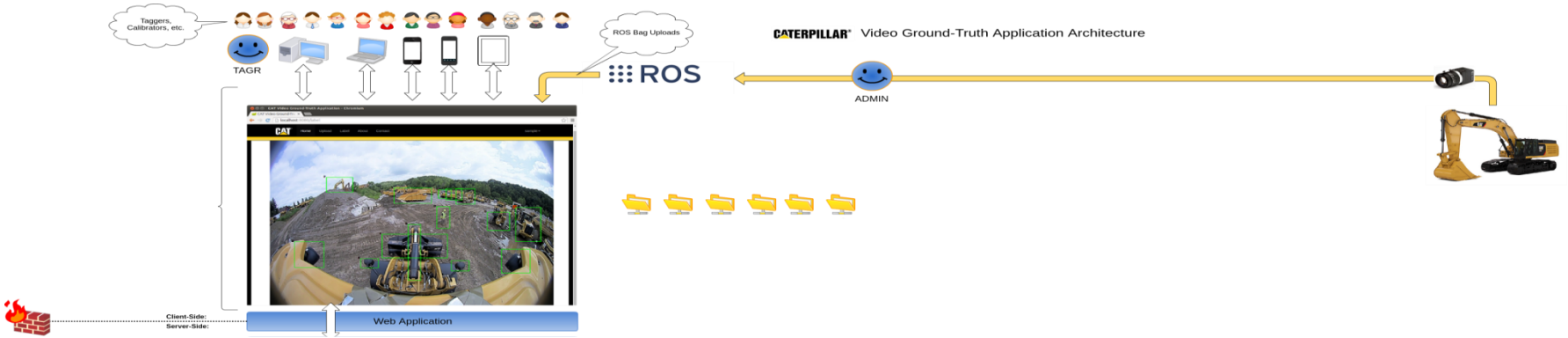
We Were Spending
Too Much Time
On Ground Truth
and Managing Training and Testing Data



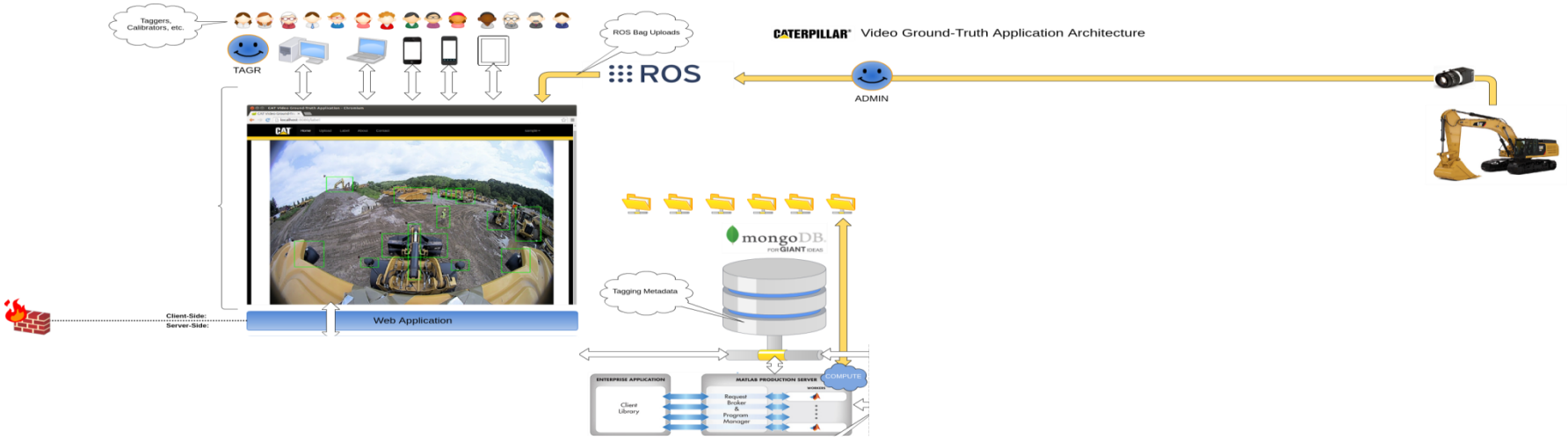
Example: Machine Learning Flow

CatBigDat – Field Data Collection

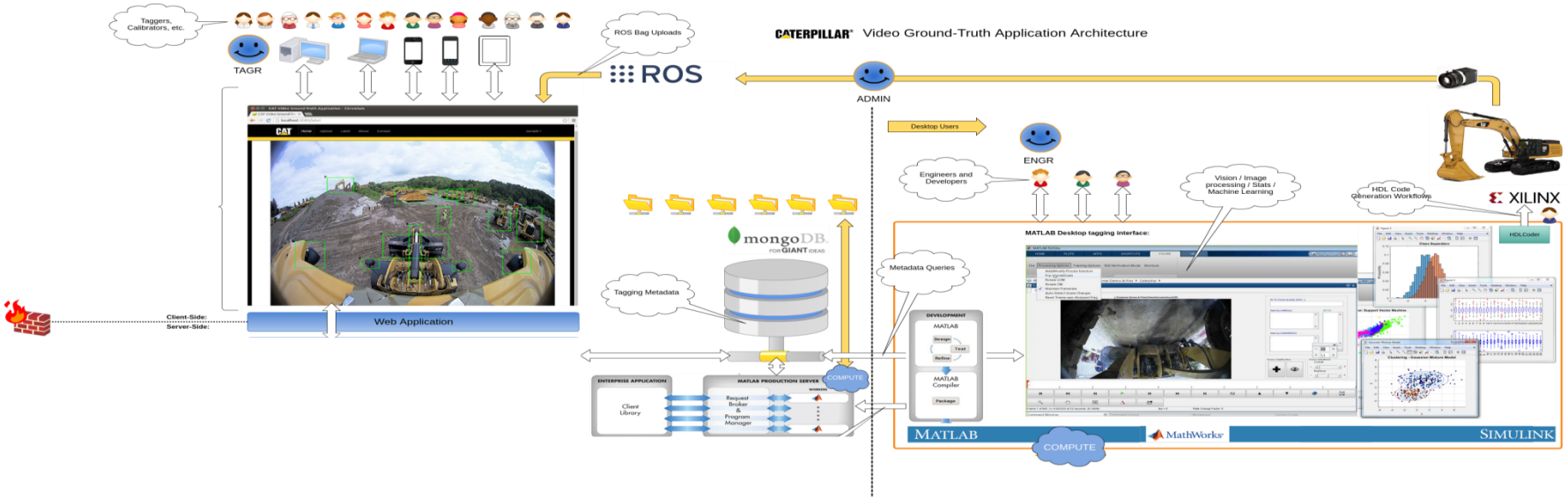
CatBigDat – Web Based Ground Truth Tagging



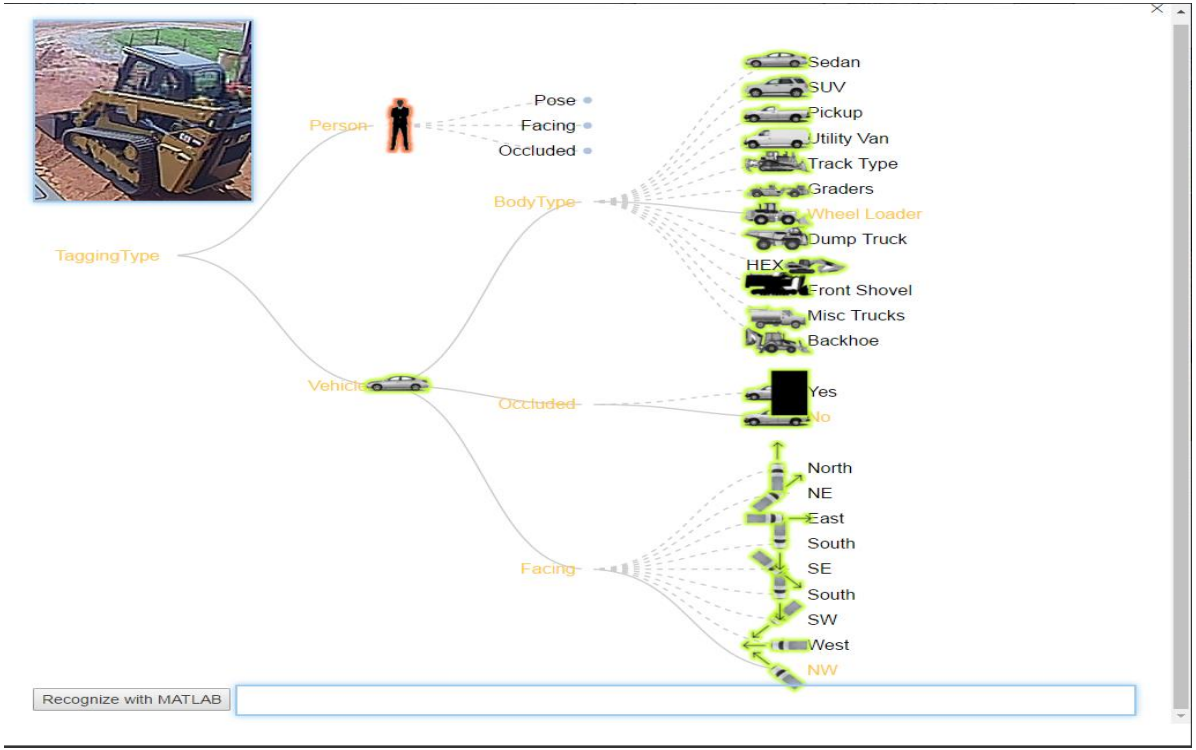
CatBigDat – Ground Truth Metadata Database



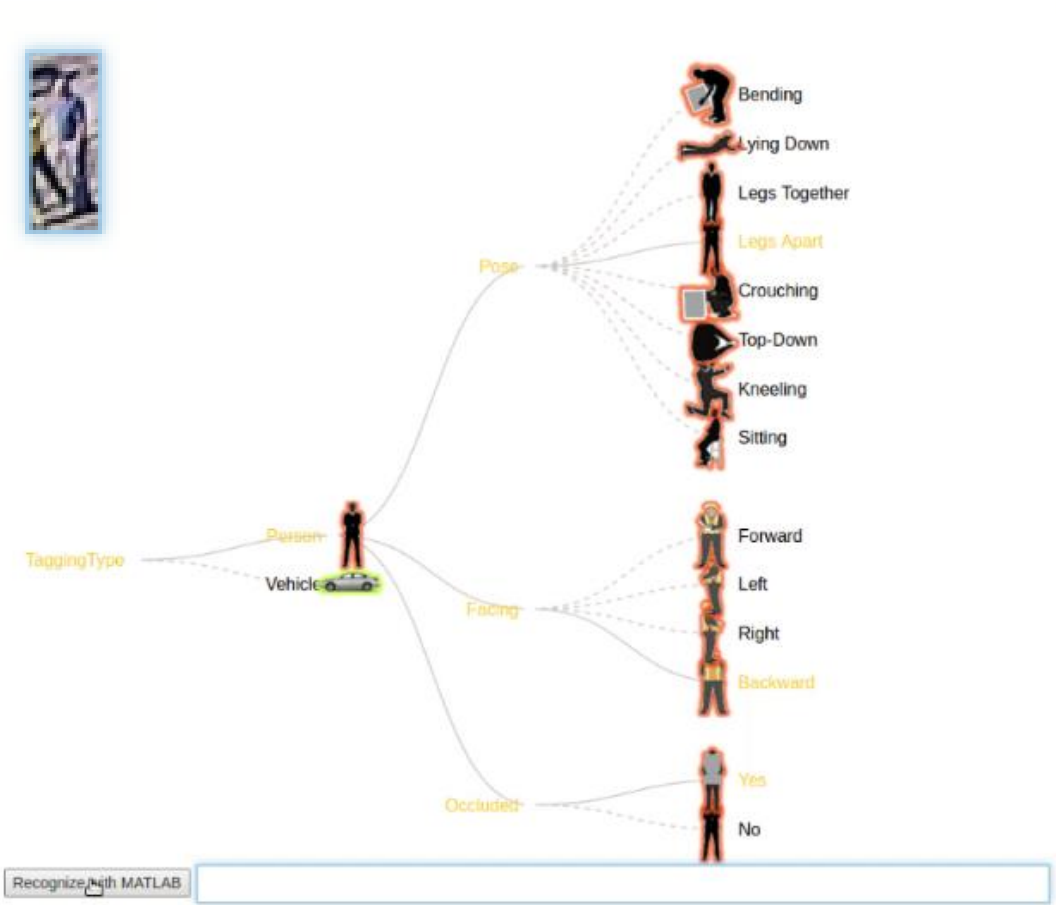
CatBigDat – Engineering Interface Leverages Power of MATLAB



Completely Flexible and Modifiable Ground Truth Label Hierarchy - Vehicle



Completely Flexible and Modifiable Ground Truth Label Hierarchy - Personnel



Annotation Controls

Icon visibility: ON

Label visibility: ON

ROI type: Box | Polyline | Segment

Saturation 0

Vibrance 0

Exposure 0

Hue 0

Sepia 0

Gamma 0

Noise 0

Clip 0

Sharpen 0

Blur 0

0 5 10 15 20

Independent control: OFF

General Additional Fields - Pick Lists

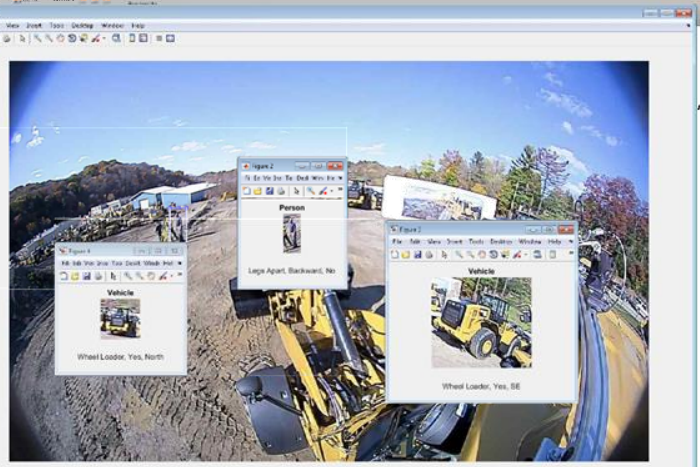
- Environmental Lighting
  - Sunny Day - Full day data, dawn to dusk on clear sunny day with mixed lighting (shadows and bright sunlight)
  - Cloudy Day -Full day data, dawn to dusk on cloudy day
  - Low Light
  - Night w/ Lights - Night data with vehicle lighting
  - Night w/ Lights and Incidental - Night data with vehicle and incidental lighting
- Background Environment (Construction Building, Construction Highway, Mine Surface, Commercial, Residential, Urban, Rural)
- Location (Indoor, Outdoor)
- Airborne obscurants (Dust, Fog, Smoke)
- Weather (Raining, Snowing)
- Ground Conditions (Mud/Dirt, Partial Snow, Majority Snow, On-Road, Off-Road, vegetation, gravel)
- Quality of Focus (Good, Poor, Lens Occlusion, Lens Damage)

Example Queries w/ Example Results

- Standing, un-occluded people
- Crouching, un-occluded people
- Close range, occluded people
- Negative Data (e.g. Non-People)
- Hydraulic Excavator, Side View
- Hydraulic Excavator, Rear View
- Wheel Loader, Bucket in Air

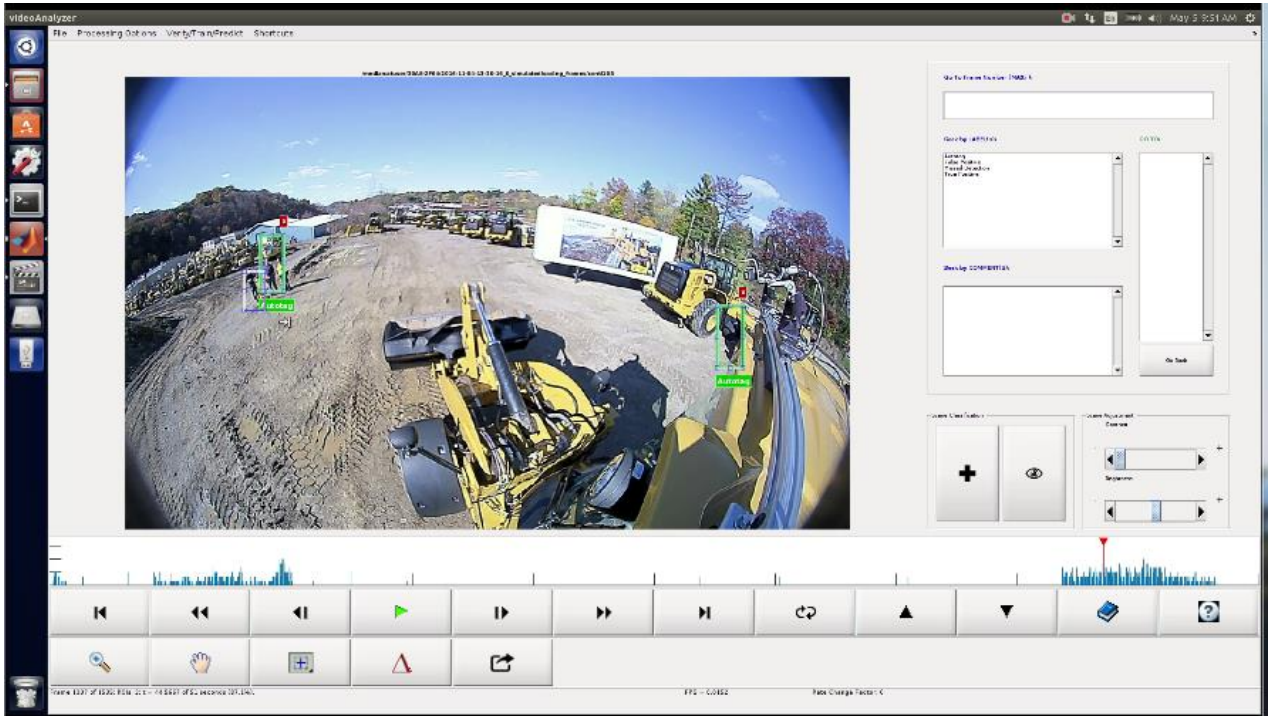
```
%%
c1=cat.annotation.find('QueryMAC1.json')
%%
c1.show
%%
c1.showChip
%%
c2=cat.annotation.find('QueryMAC2.json')
%%
c2.showChip
```

```
>>
c1 =

  annotation with properties:

           id: 'a12e8cac-da0e-43ff-9862-5daf5fbcb24c'
        image: [1×1 serializable]
       folder: '/srv/CAT/frames/2016-11-04-13-30-16_0_simulatedloading_frames/cont1108/'
       object: [1×1 serializable]
  description: []

>>
c2 =

  1×2 annotation array with properties:

    id

fx >>
```



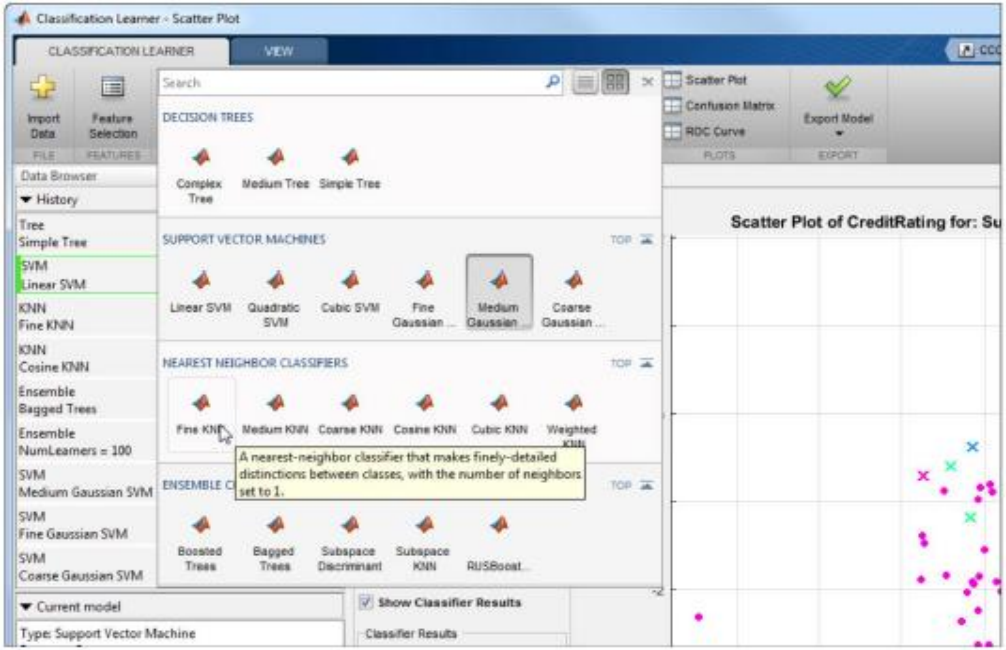

```
{$and:
    [
        {"object.hierarchy.children.name" : /vehicle/i},
        {$or:[{"object.hierarchy.children.children.children.name" : /north/i},
           {"object.hierarchy.children.children.children.name" : /se/i}]},
        {"object.hierarchy.children.children.children.name" : /Yes/i},
        {"object.hierarchy.children.children.children.name" : /Wheel Loader/i},
    ]
}
```

Automatic Labeling of Data



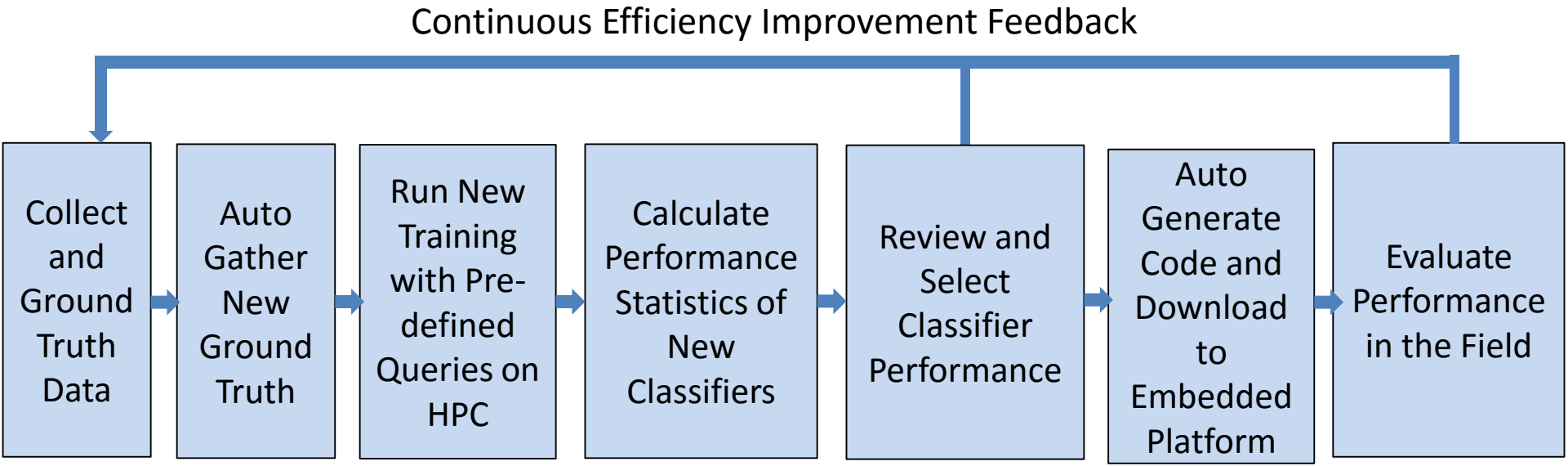
Tight integration with MATLAB Classification Learner App

- Simple queries into Caterpillar labeled data to import multi-class positive and negative data for training.
- Tight integration with MATLAB Machine Learning Backend (Classification Learner and Command Line)



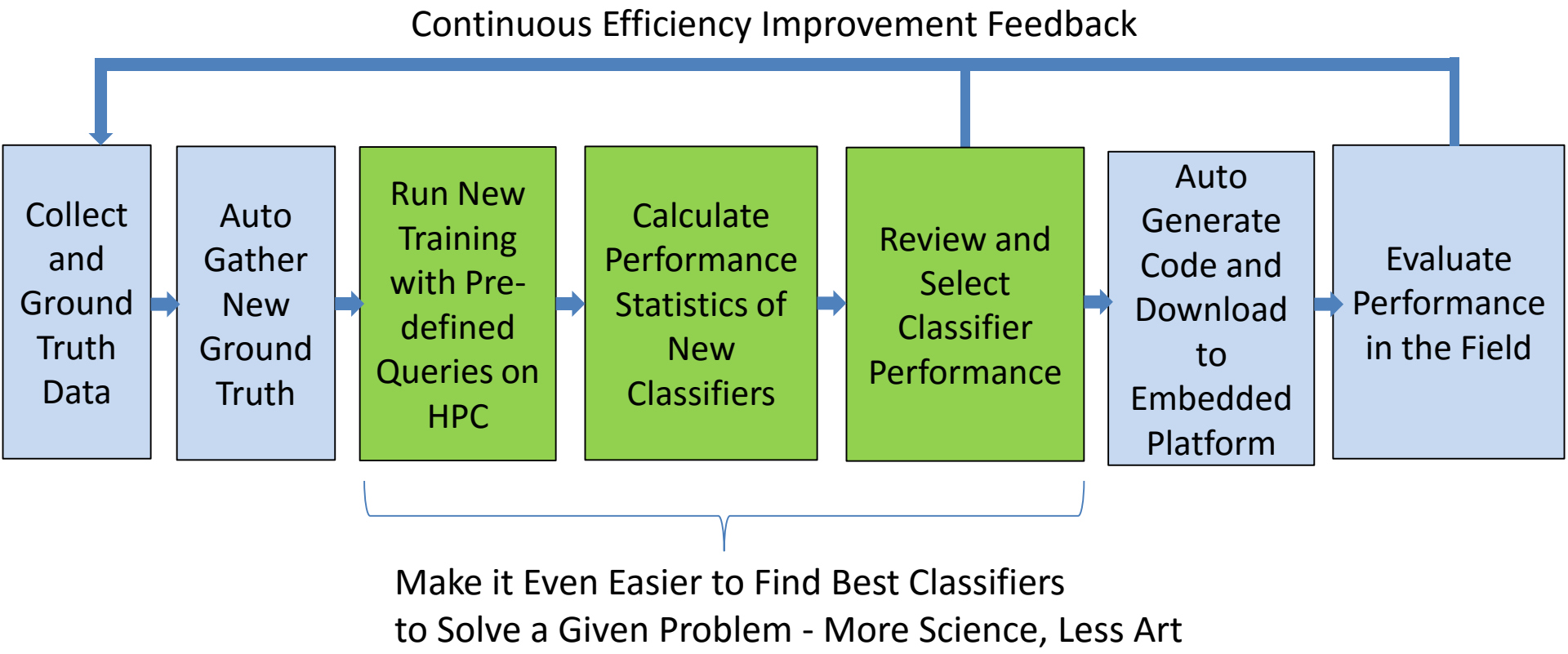
Integration with Auto-Coding Tools And 3rd Party Machine Learning

Using MATLAB for Continuous Improvement in our Big Data, Data Analytics, and Machine/Deep Learning Infrastructure



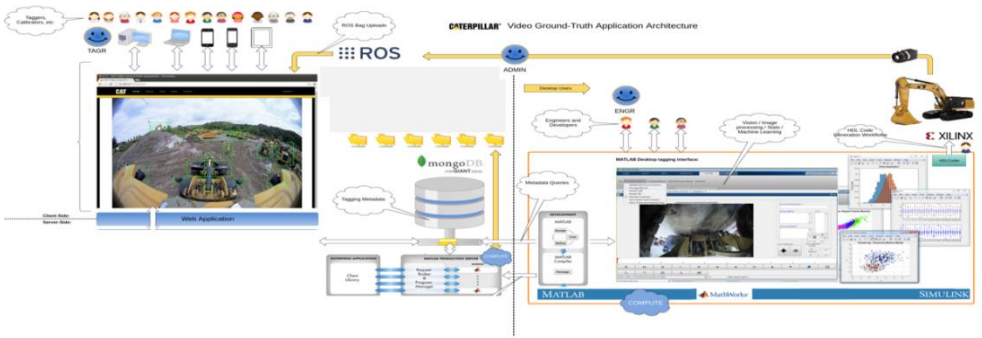
Because it is MATLAB, development time is short

Future Direction for the Infrastructure



Conclusions

- Developed big data and machine/deep learning infrastructure
- Web based ground truth interface
- Automatic ground-truth -- limits need for human supervision, reducing development time
- Database for storing and querying meta-data
- Engineering interface with tight integration with MATLAB products for learning, visualization, verification
- Code generation - direct to embedded real-time platforms
- Scalable in number of users, amount of data, and compute power



Thank You!

CAT

Lisa Crosier

Joe Forcash

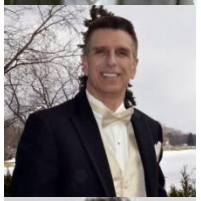
Larry Mianzo

Dan Troniak

MathWorks®

Amine El Helou

Gary Gunterman



Arvind Hosagrahara

Steve Kuznicki

Brett Shoelson