



AUTOMATED VERIFICATION OF AUTOMOTIVE INFOTAINMENT

BMW GROUP



Alexandra Tran

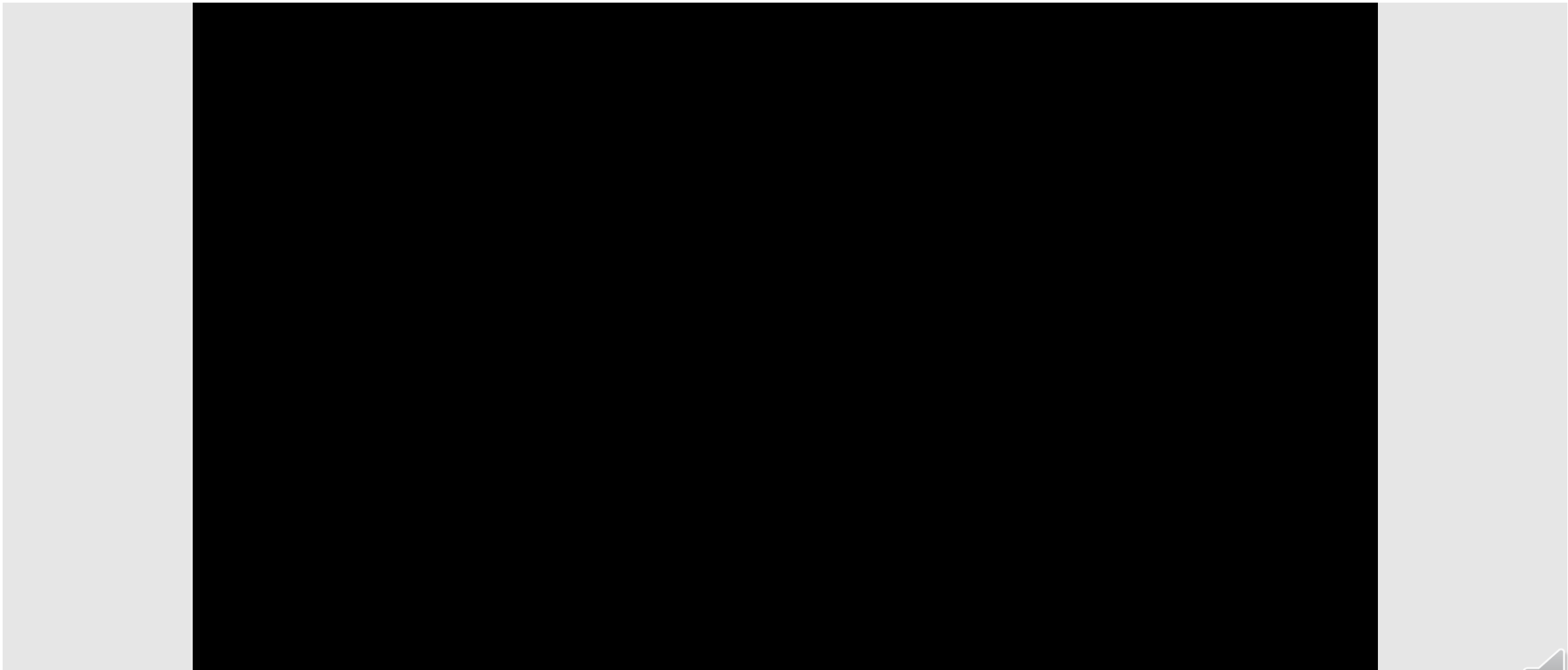


AGENDA



1. BMW Autonomous Driving
2. Assisted Driving View (ADV)
3. Conventional Testing
4. Lab Verification Methods
5. Future Strategy
6. MATLAB Demonstration
7. Questions & Answers

AUTONOMOUS DRIVING



ASSISTED DRIVING VIEW



Visualise Real-Time Traffic

Secure Driver Trust

VISUAL VERIFICATION

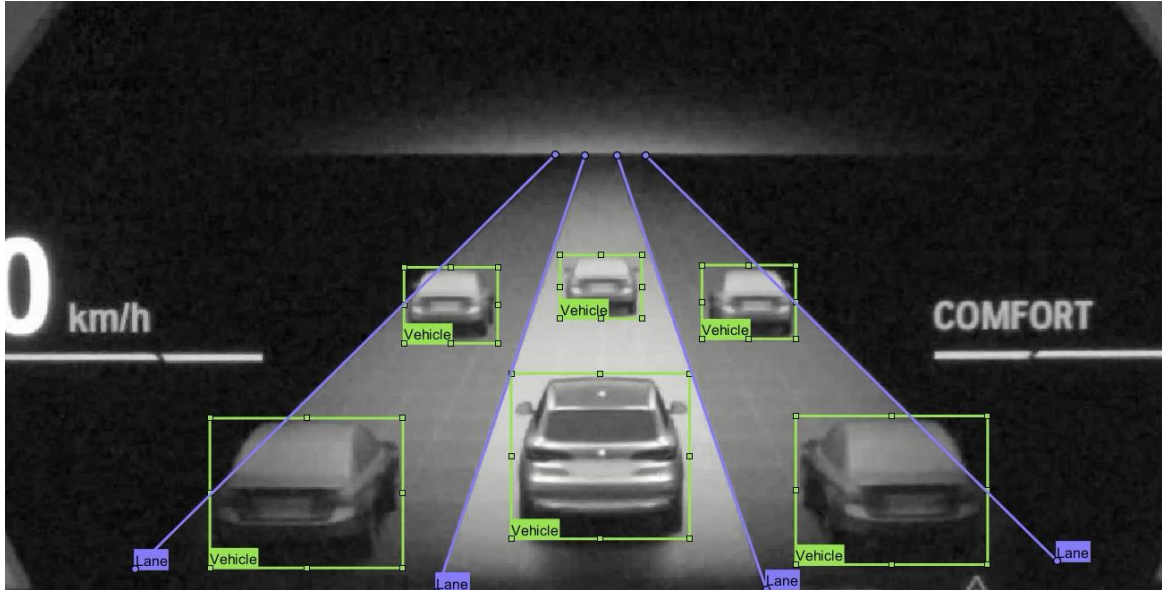


Original Method

Drive & Report

SIMULATION VERIFICATION

Test Rack 1: Ground Truth Data



Test Rack 2: Experimental Data



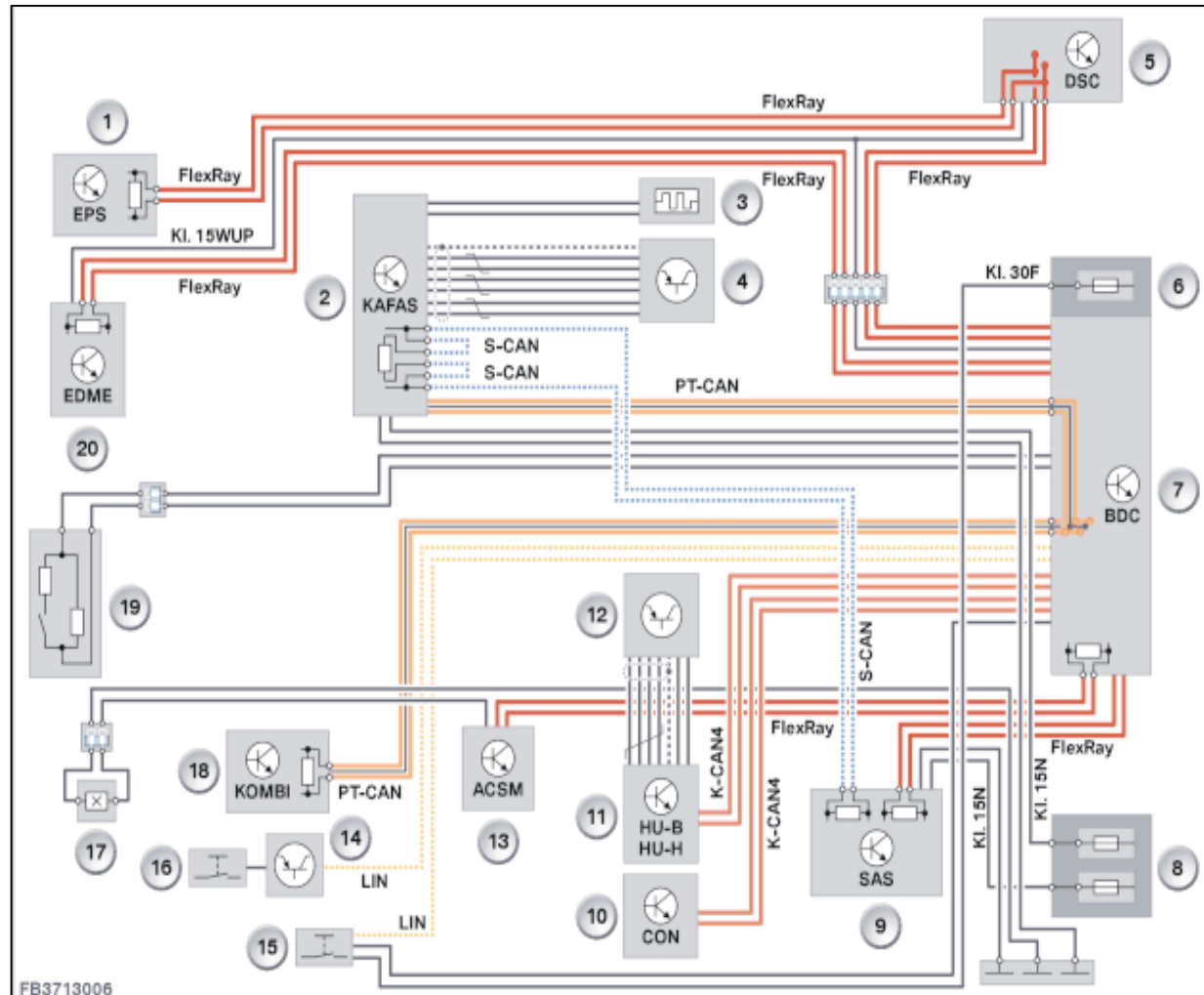
End to End

Code Ground Truth

Create Animated Scenario

Compare Instrument Clusters

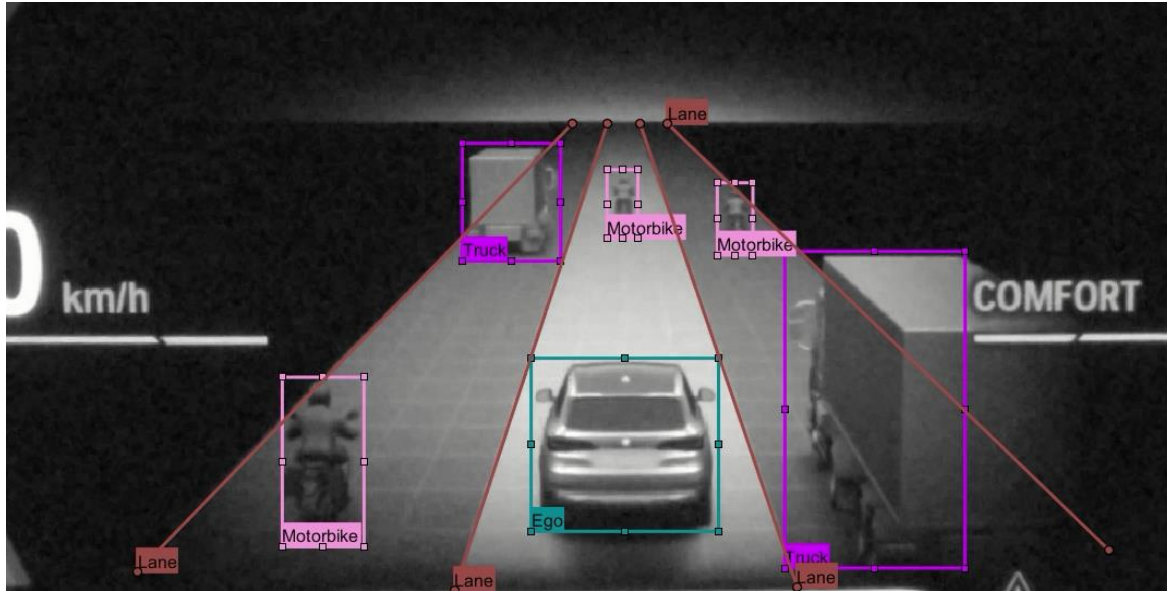
HARDWARE IN THE LOOP



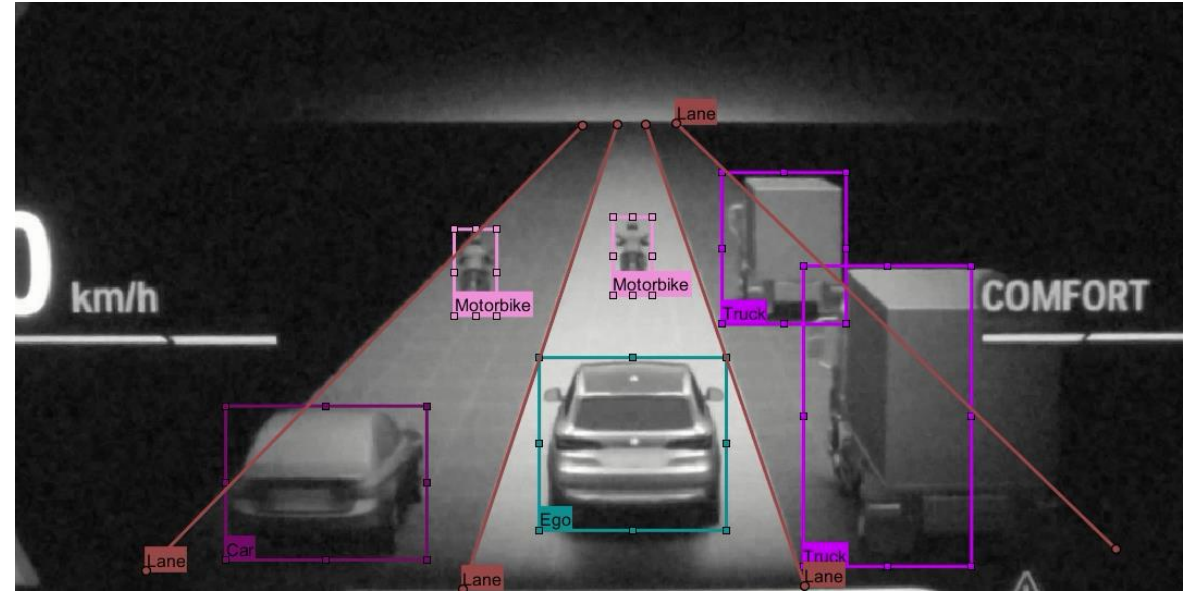
1. Camera based driver support systems (KAFAS)
2. Radar and Ultrasound Sensors
3. Body Domain Controller (BDC)
4. Optional Equipment System (SAS)
5. Head Unit (HU)
6. Instrument Cluster (KOMBİ)

VERSION VERIFICATION

Version 1: Verified Scene



Version 2: Hypothetical Scene



Version to Version

Test new software version

Play same vehicle signals

Detect differences

FUTURE VERIFICATION



Real Traffic vs Assisted Driving View

Deep Learning Implementation

MATLAB DEMONSTRATION

Object Detection

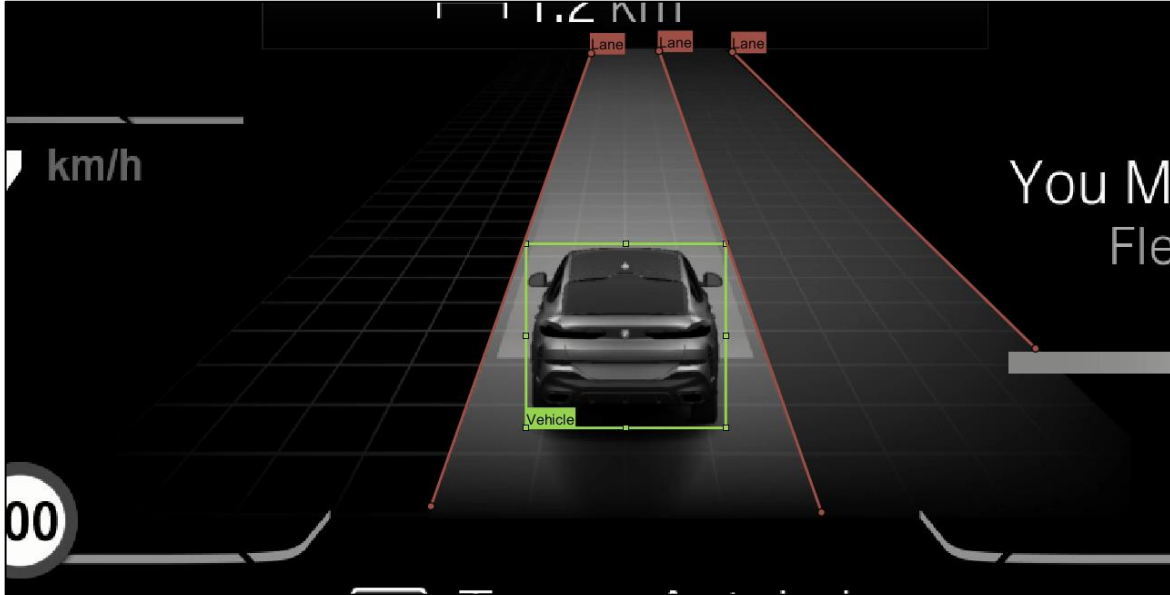
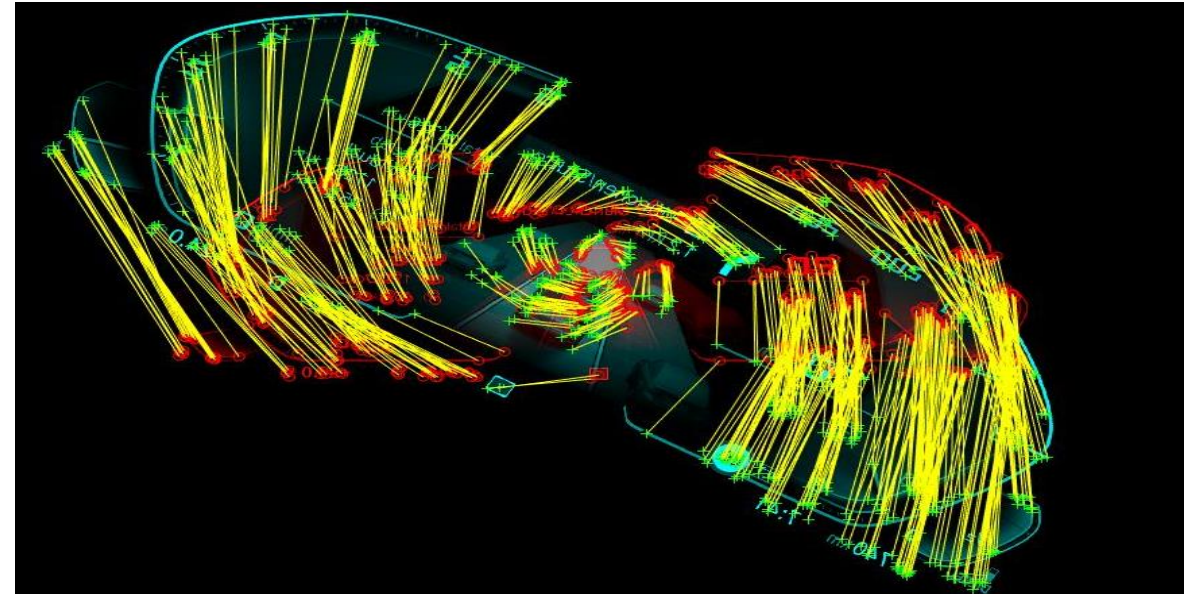


Image Registration



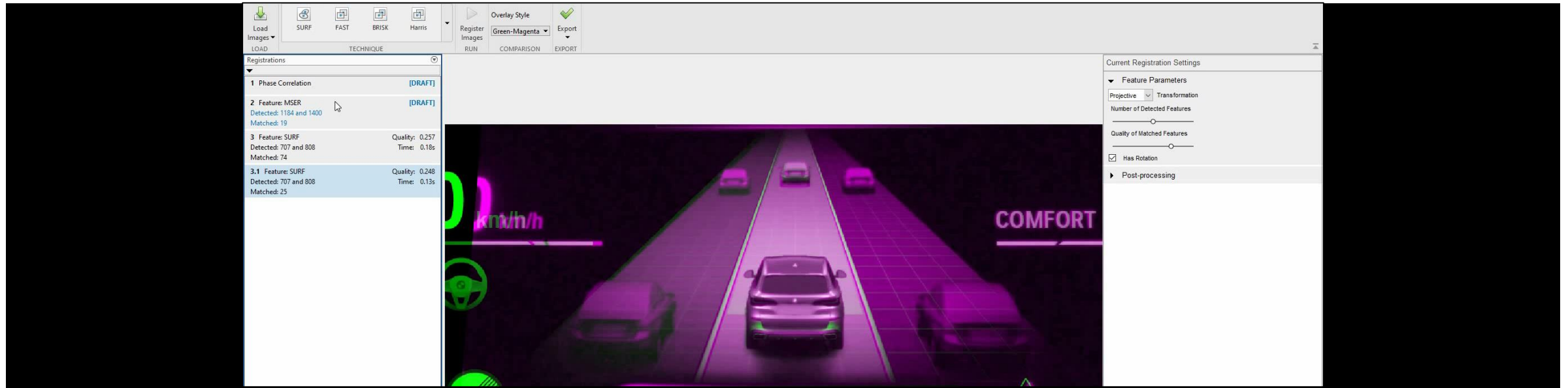
Simplified Machine Learning Workflow

Register Images

Label Objects

Train, Deploy & Evaluate Detector

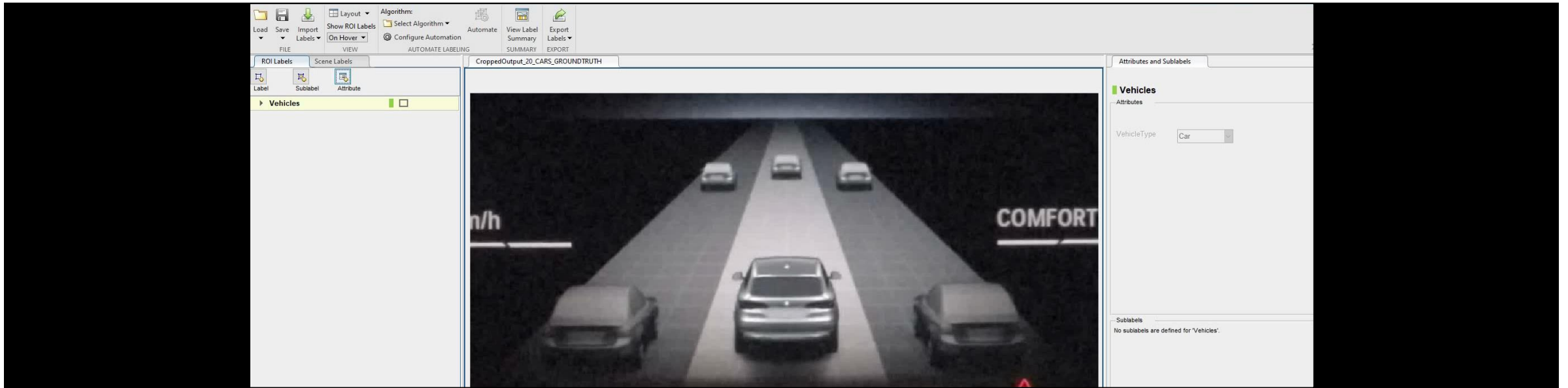
STEP 1: PRE-PROCESS IMAGES



Apply exported transformation to entire image set:

```
tform = registerImages(moving, fixed).Transformation;  
imwarp(moving, tform);
```

STEP 2: LABEL GROUND TRUTH TO TRAIN DETECTOR



Train detector from exported labels:

```
trainingData = objectDetectorTrainingData(gTruth);  
detector = trainACFObjectDetector(trainingData);
```

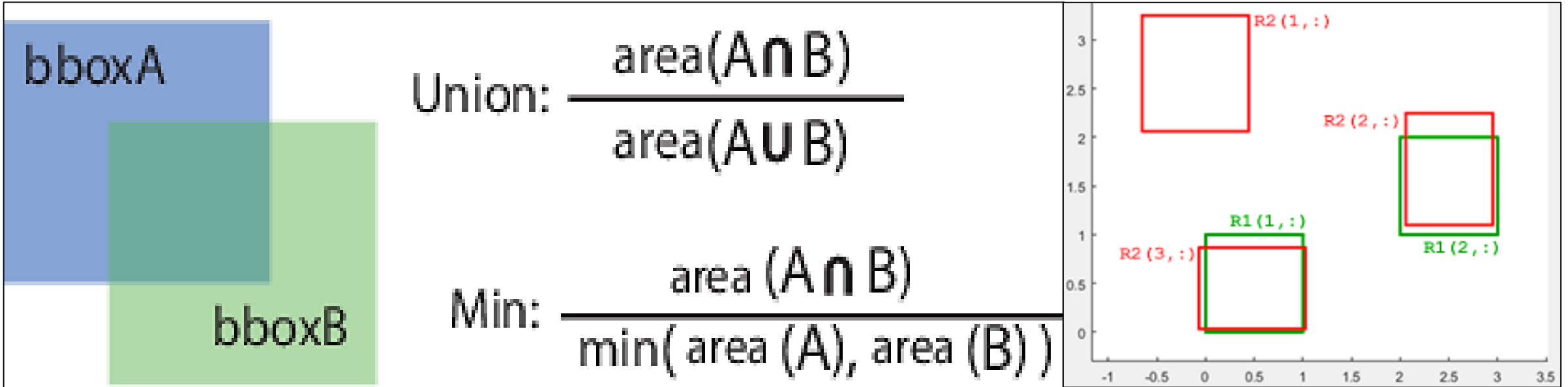
STEP 3: DEPLOY AND EVALUATE DETECTOR



Deploy detector on independent image set:

```
[bboxes, scores] = detect(detector);  
evaluateDetectionPrecision(detectionResults, gTruthData);
```

STEP 4: UNIT TESTING



Computer bounding box overlap ratio:

```
overlapRatio = bboxOverlapRatio(bboxA, bboxB, ratioType)
```

Class Based Unit Testing:

```
matlab.unittest.qualifications.Verifiable class
```

STEP 5: MOBILE INTEGRATION

BMW Vehicle Verification
Icon Recognition with Position and Timestamp

Test Cases
Vehicle / Test Rack

- Test Case 1**
Perform Input
Validate Output
- Test Case 2**
Perform Input
Validate Output
- Test Case 3**
Perform Input
Validate Output

Recording In Progress
Perform Input

Finished Cancel Restart

Accuracy
Compare Result

Test Result

Ground Truth

Evaluation
All Icons

- Car 1**
Position: x,y pixels
Confidence: 90%
Timestamp: 00:11:12
Match: **CORRECT**
- Truck 1**
Position: x,y pixels
Confidence: 70%
Timestamp: 00:11:15
Match: **WRONG POSITION**
- Bike 1**
Position: N/A
Confidence: 0%
Timestamp: 0
Match: **MISSING**

Report
Automatic Generation of Error Report

Test Case 1

DATE: 12/02/2020
TIME: 13:00 - 13:05
VEHICLE / VIN: X7
TEST: Autonomous Lane Change
ERRORS: Bike Missing, Truck Position
EVIDENCE: Images Attached
RECORD: Emailed to User

Hardware Package Support

Simulink → Android Mobile

SUMMARY



1. **Computer Vision** offers improved speed, accuracy and reliability.
2. **Lab Simulations** facilitate controlled, reproducible data collection.
3. **Machine Learning Workflow:**
 - a. Collecting, Preprocessing & Labelling **Data**
 - b. Training, Deploying, & Evaluating **Model**

Q&A

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Onboard Platform

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