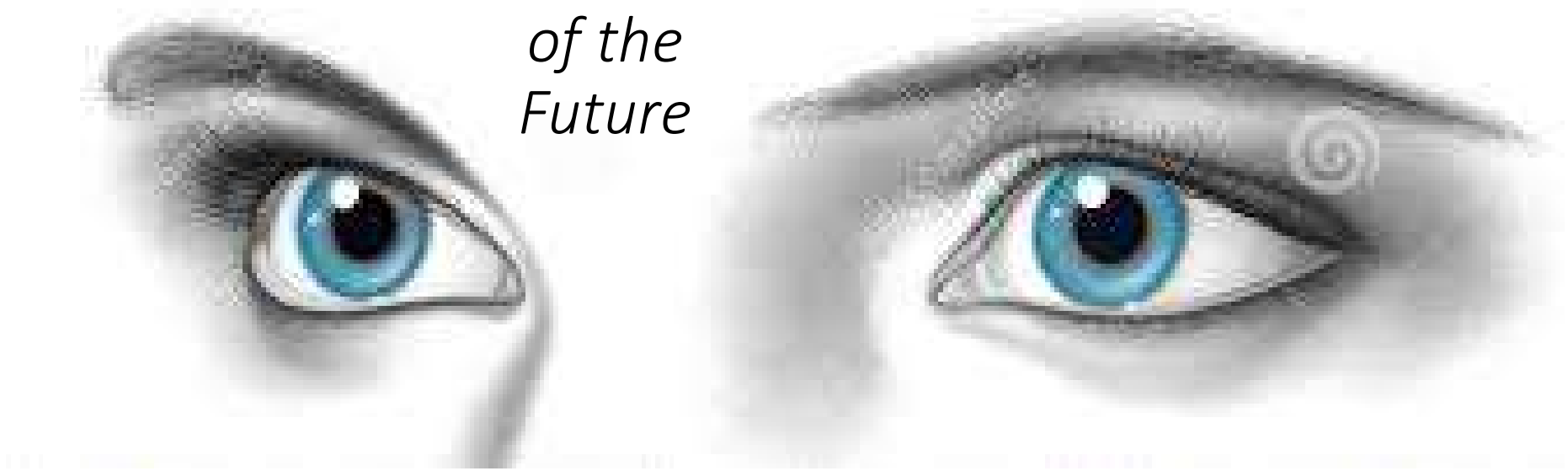
Car-Eyes: Extending Vision for

Drivers of the Future



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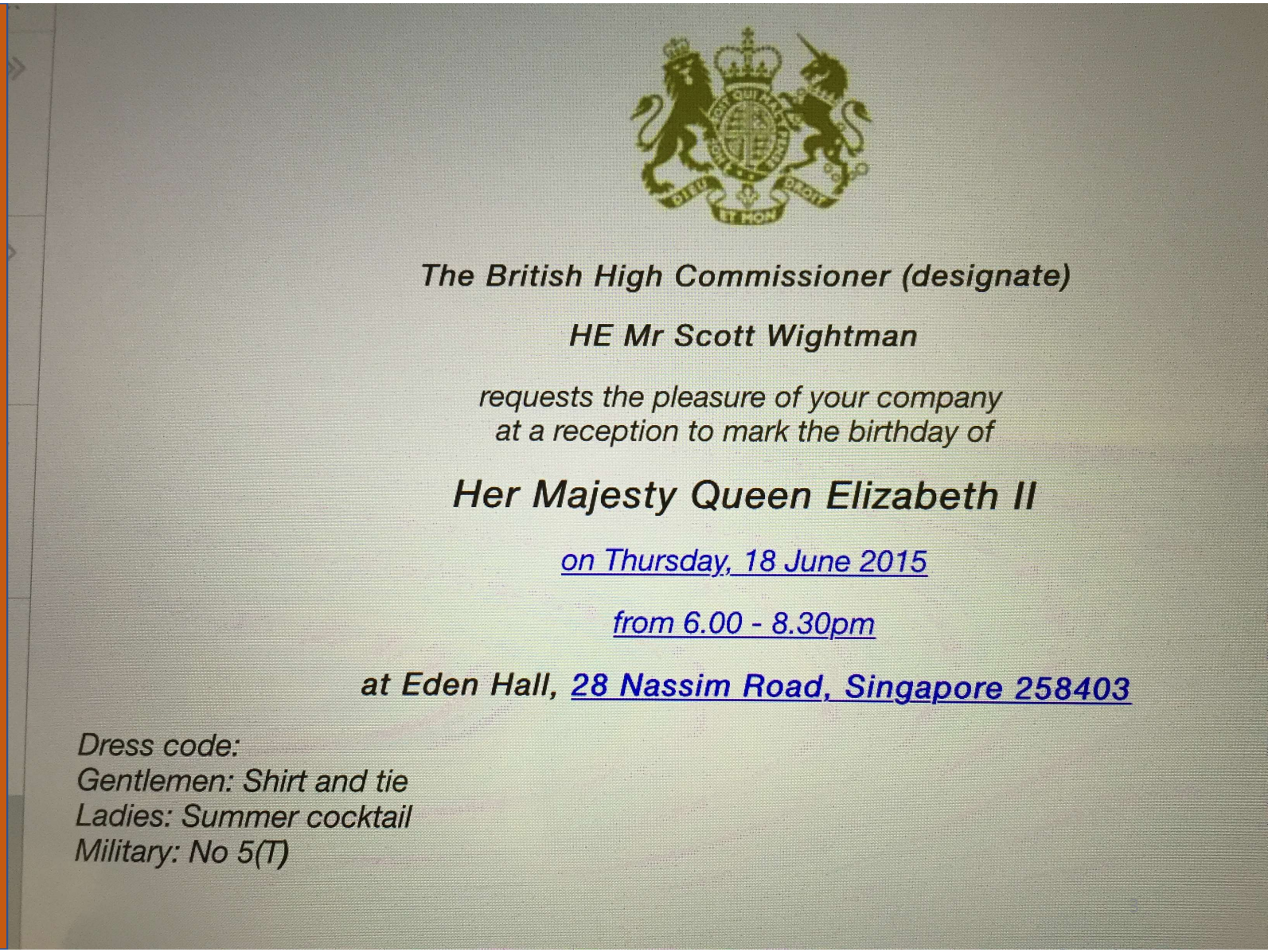
INTRO:

Me in Tainan, 2009

My first electric motorbike

Me in Singapore

Spent time in industries as VP & CTO



Purpose of My Talk

TODAY, our research is to extend the “seeing” capabilities of cars!!

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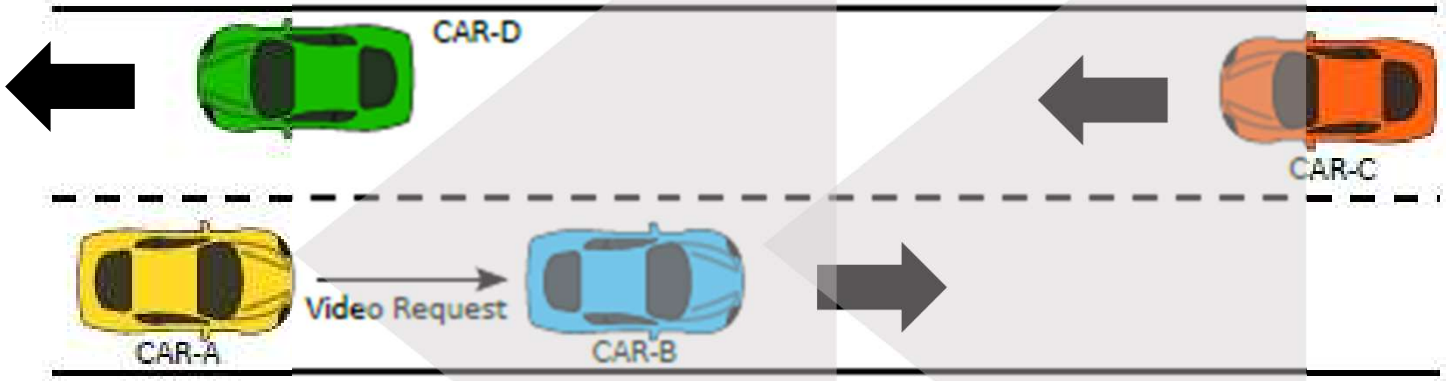
PROBLEM: Our Views Today are LIMITED

ISSUES: The Dangers of Overtaking

Approach: Extending vision to drivers (1)

- Give “EYES” to cars!! Help drivers see beyond what is ahead
- Driver asks for Video prior to overtake – asynchronous operation



(b) The client *requests* video from the server.

Fig. 1: Functional overview of EYES - *Step one*.

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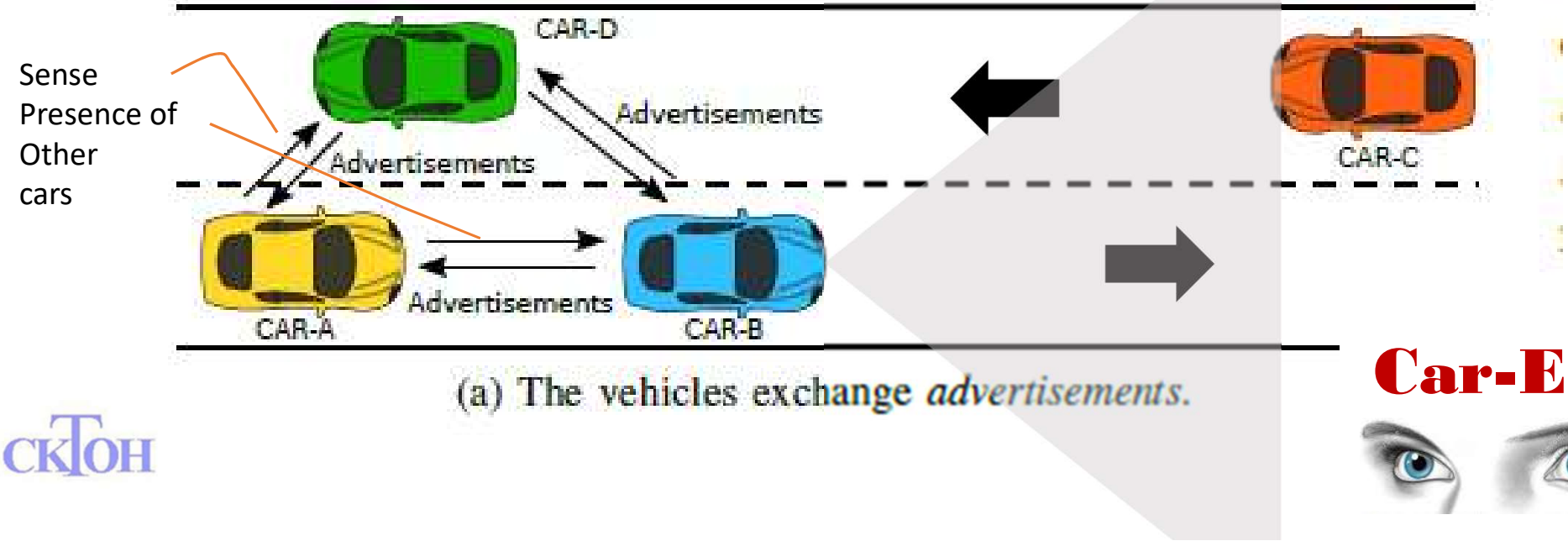
Our Approach: (2)

- V2V comms + Video and image capture + wireless Video transport
- Taking into account direction of travel, surrounding cars, etc.



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Our Approach: (3)

- CAR-B sends Extended Video View back to CAR-A wirelessly (backwards)

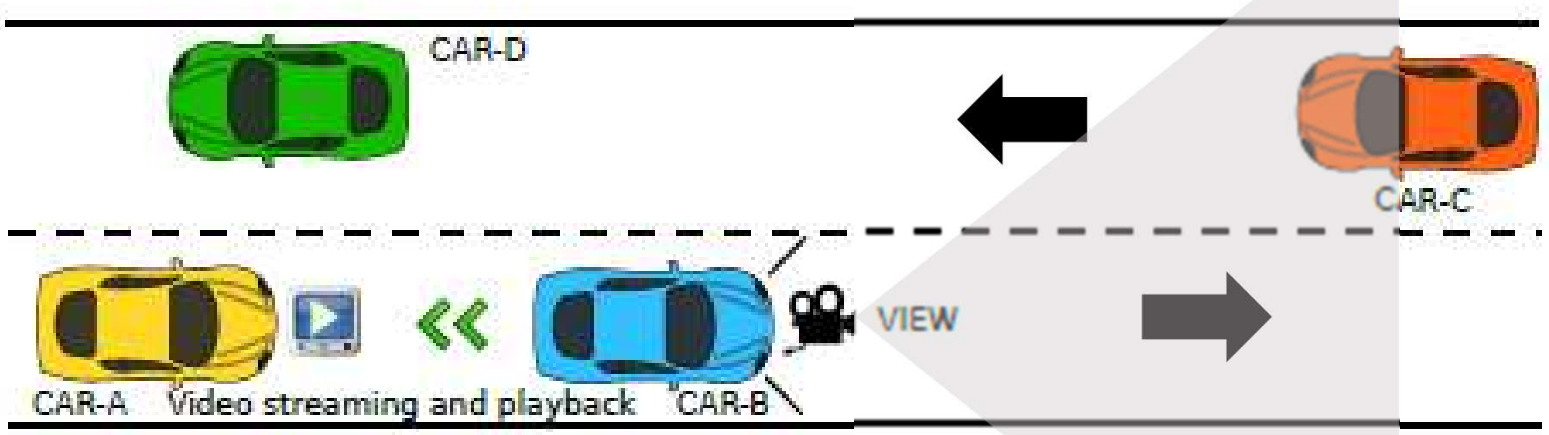

Fig. 2: Functional overview of EYES - *Step two*.

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Our Approach: (4)

- CAR-A then knows CAR-C is still far away, and safe to overtake
- CAR-A can now safely overtakes CAR-B

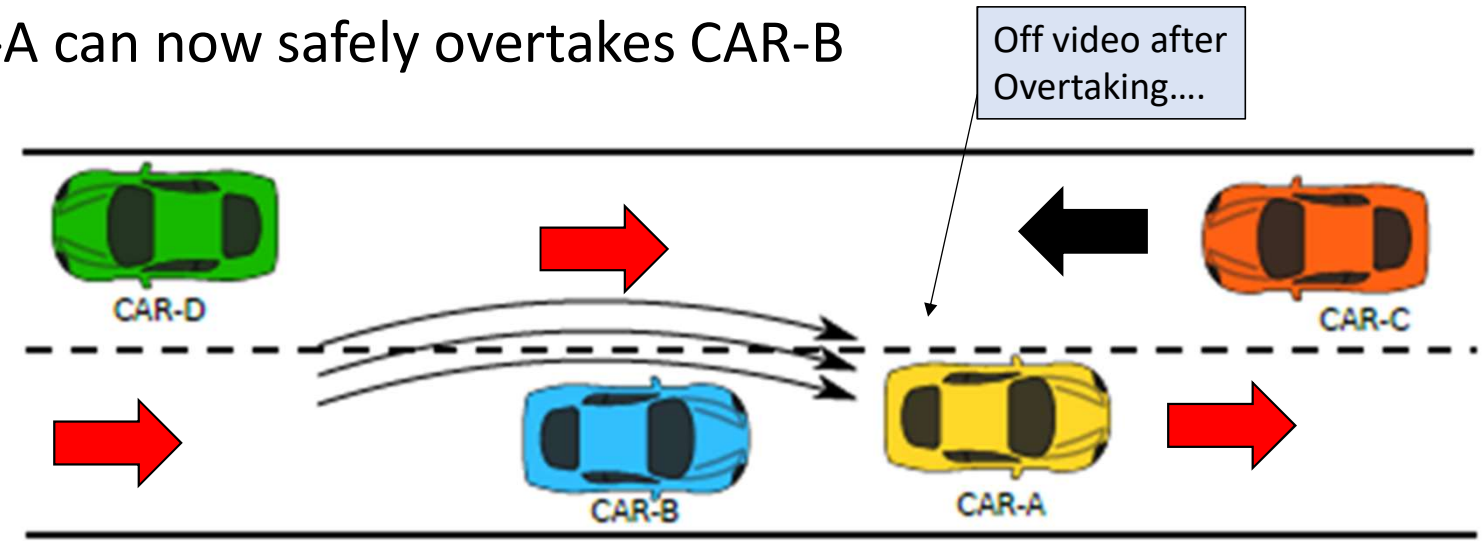

Fig. 3: Functional overview of EYES - *Step three.*

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Technical Challenges: 5+

- C1: Detecting if cars on same lane or opposite lane
- C2: Detecting if car is safe to overtake
- C3: Errors in estimating oncoming car distance
- C4: Is video quality good enough?
- C5: Is video transmission and reception fast enough?

C1: Detecting Same Direction

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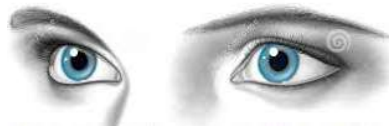
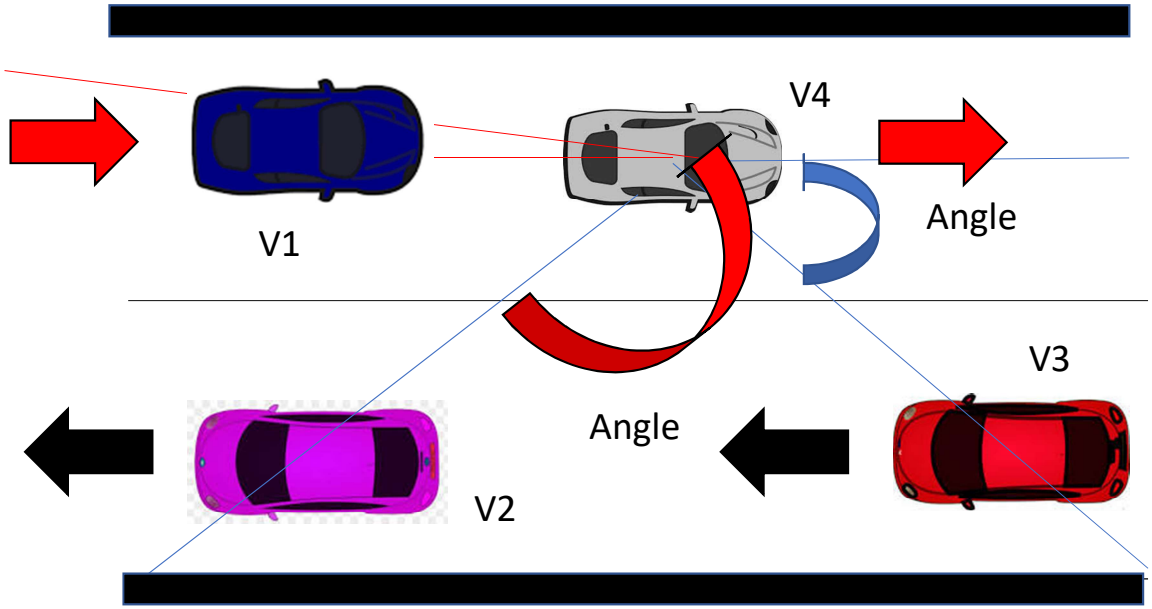


- GPS location info, and cars Advertisements (beacons)
- Compute which cars are travelling in same direction or opposite
- If they are moving in same direction, angle between them should be less than α degrees.
- Also, look at GPS trajectory



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C1: Detecting Same Lane

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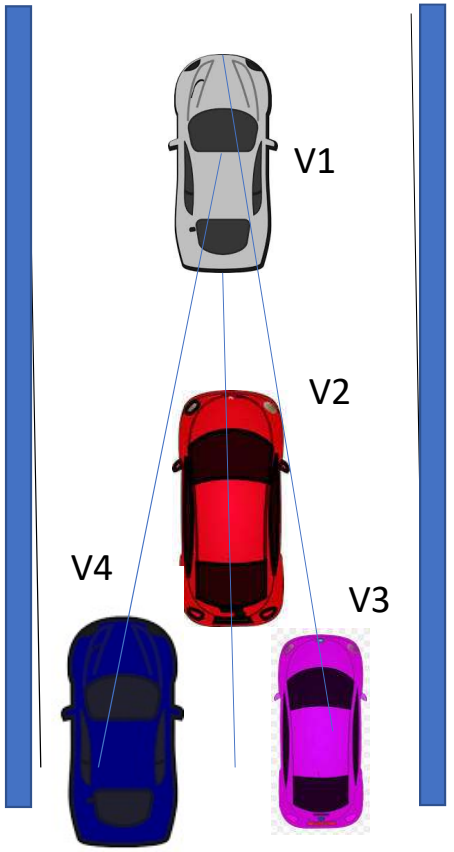
- Compute which cars are travelling in same lane or not
- If they are moving in same lane, angle θ between them should be less than β degrees.
- If they are back-to-back in the same lane and axis, then θ is = 0
- You don't want to receive videos from cars in opposite lanes



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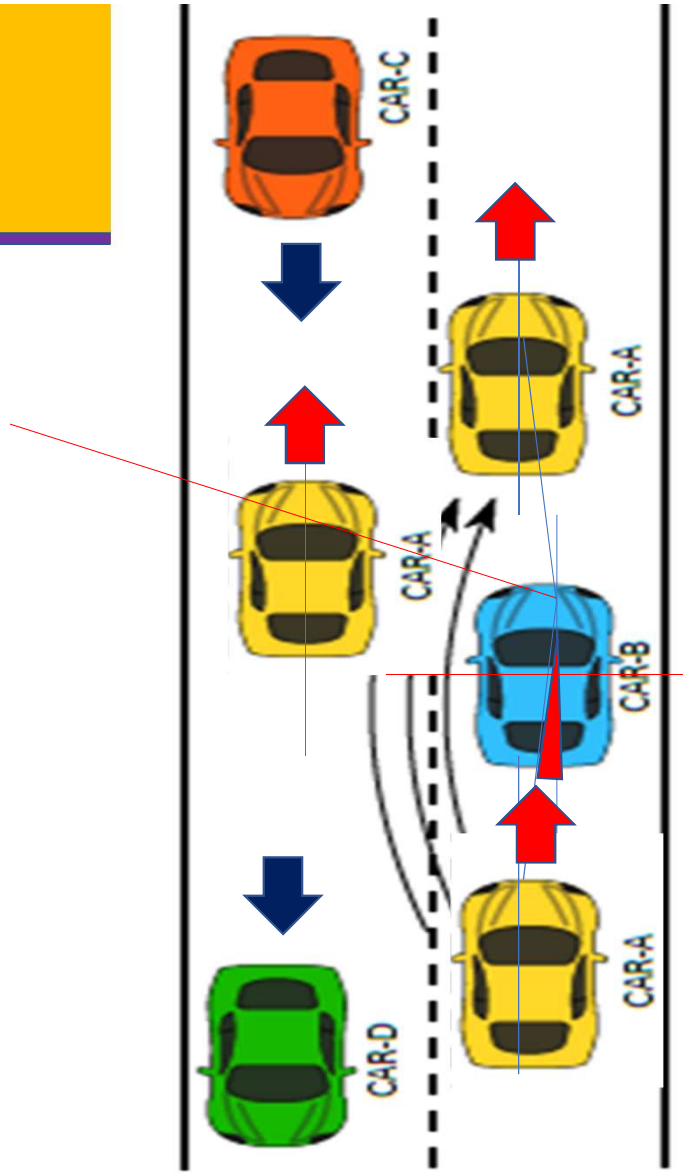
C2: Overtake angle

- To automatically stop the video streaming when finish overtaking

- The cancellation must be done by the overtaking car automatically

- When angle between overtaking car and front car increases above 270 degrees



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C3: Position Error & Video Delays

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- Explain

Fig. 8: Error due to delay.

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CarEyes System Implementation

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- Today, no wide V2V deployment yet.
- V2V comms box in car
- iPad – GRC1 – GRC2 – iPad
- Video Server – client video player
- Enables
  video from iPad
  or phone cameras
  to other cars.

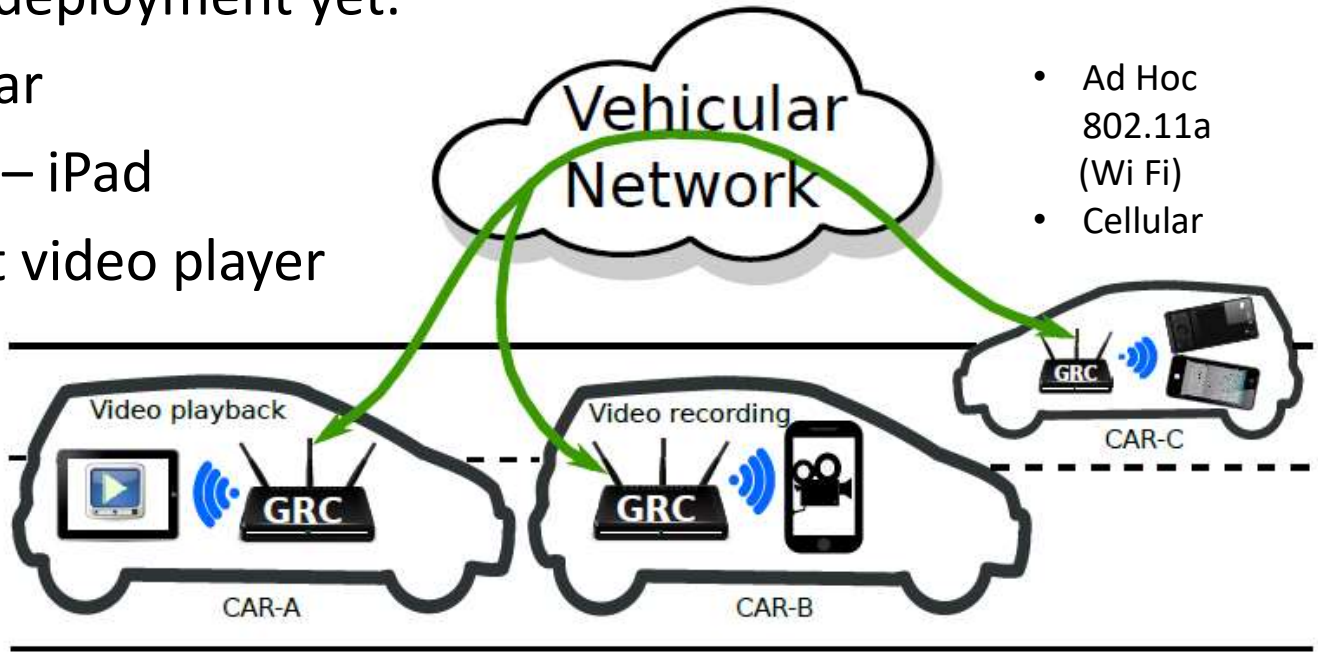

Fig. 7: Our application working together with GRCBox.

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Cars in the opposite direction

Car ahead transmitting video using EYES

System Setup and Outdoor Road Tests

The video from the car ahead being played

GRCBox used to create the vehicular network

Android devices: Nexus 7 (1.2GHz processor, 1GB RAM, 1.2MP camera)
Samsung Note 10 (1.9GHz quad core, 3G RAM, 8MP primary camera, 2MP secondary camera)

Video Server & Clients state diagram design

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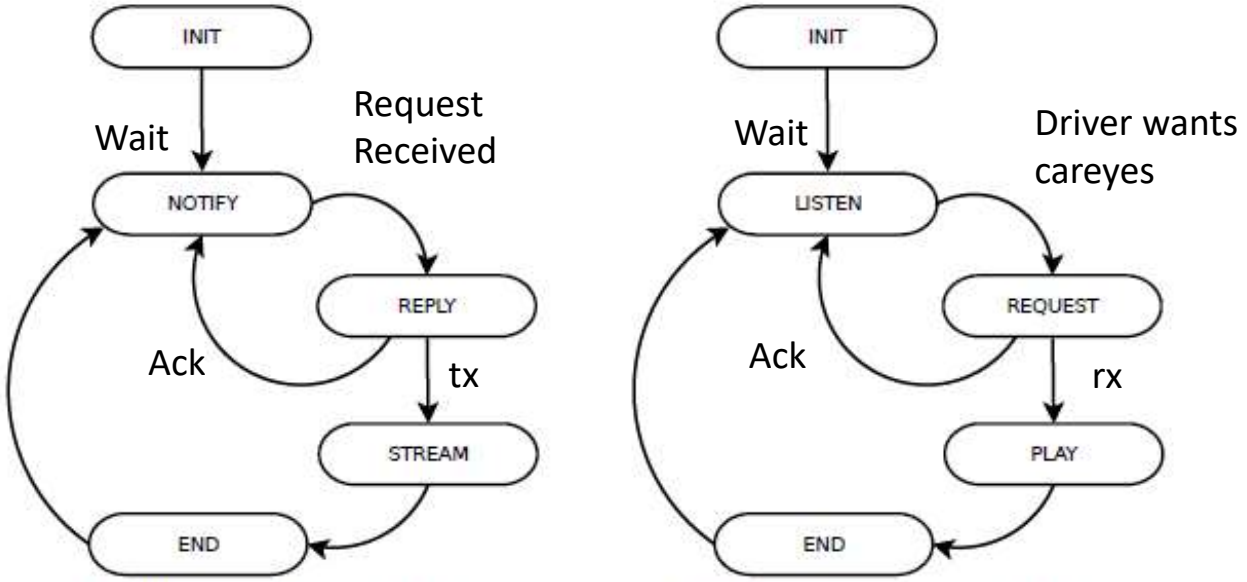
- Asynchronous request / pull
- Tx / Rx control message
- Tx / Rx Image
- Tx / Rx Video stream
- Each car is both a server and client



(a) Different Server States. (b) Different Client States.

Fig. 4: State diagram of the Server and Client.

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V2V Message Exchange (Server/Client)

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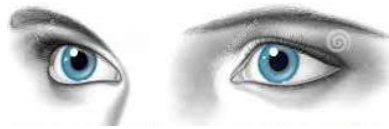

- Server and clients are iPads while the communications are relayed via our V2V GRCbox
- Transmit both CONTROL DATA (Loc, Dir, Speed, etc) and VIDEO

Message Type	From → To	Client State	Server State	Message Contents
Hello	S → C	Listen	Notify	Location and Direction
Request	C → S	Request	Notify	Location and Direction
Ready	S → C	Request	Reply	Video sender port
Reject	S → C	Request	Reply	-
Data	S → C	Play	Stream	Location, Direction and Speed
Data-Ack	C → S	Play	Stream	-
End	C → S	Play	Stream	-

TABLE I: Messages exchanged between the Server and Client.

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Indoor & Outdoor Tests & Experiments

- **INDOOR**
  - Compare DELAY for H.264 and MPEG capture, transmission, and playback
- **OUTDOOR**
  - Test video streaming applications on the road
- **Will show video clip later**

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Evaluation & Results

- Video Quality
- Video Delay
- Position Error
- License Plate Detection instead of angle estimation

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C5: Video Quality: JPEG & MPEG

FINDINGS:

- JPEG is lossy compression
- Quality above 80% is not necessary
- Tested over UDP & TCP
- No further visible difference
- Also, **10 frames / sec is good enough**
- Data rate requirements increases with video quality

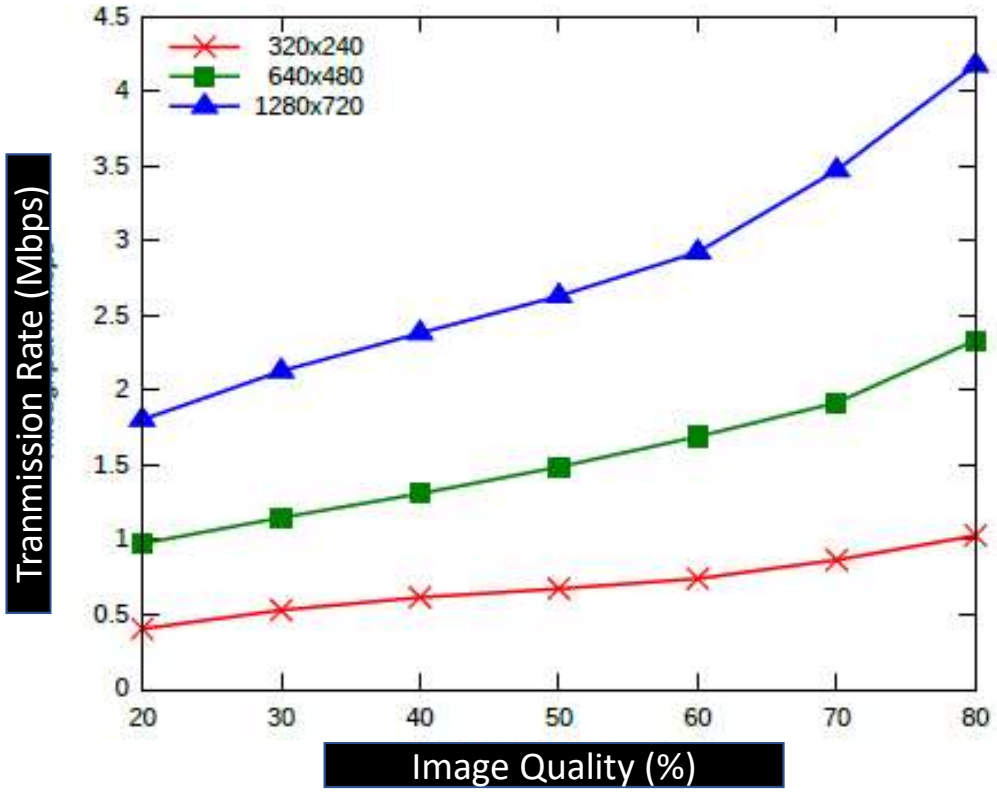

Fig. 9: Variation of throughput with JPEG quality for a 10fps MJPEG video.

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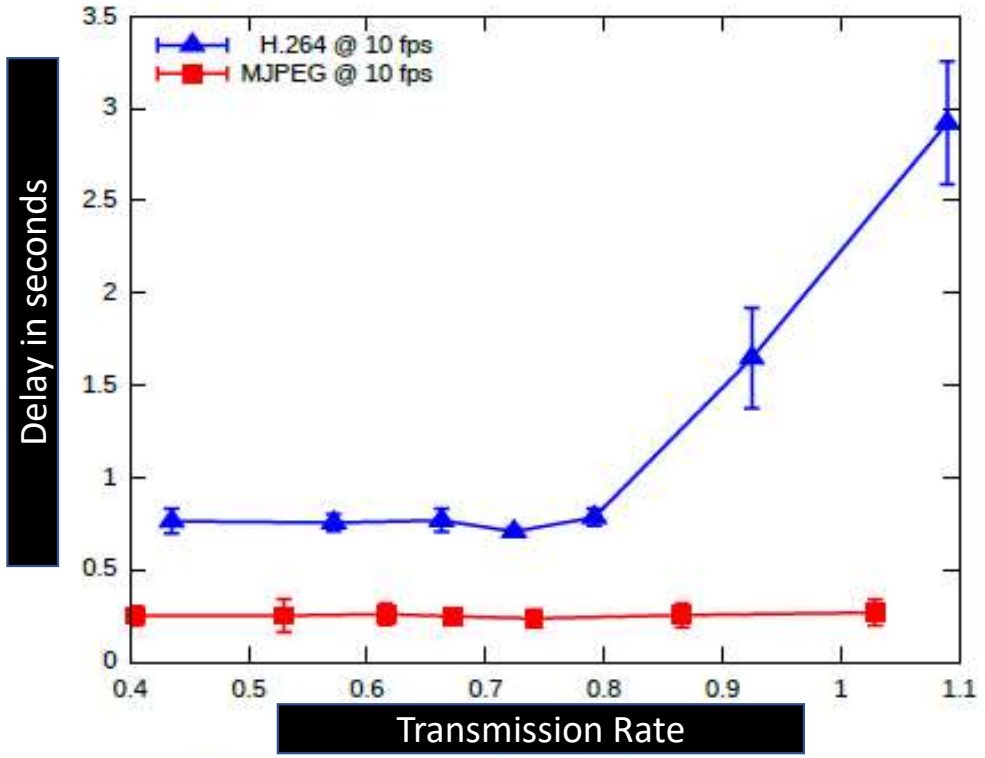
C4: Video Delay: 320x240 resolution

FINDINGS:

- Delay = Diff b/w Video Capture and Video Playback
- 320x240 video stream
- **H264 has a higher delay over time**
- **MPEG delay is pretty consistent at 0.3 seconds**



(a) The delay comparisons for 320x240 video stream.

C4: Video Delay: 640x480 resolution

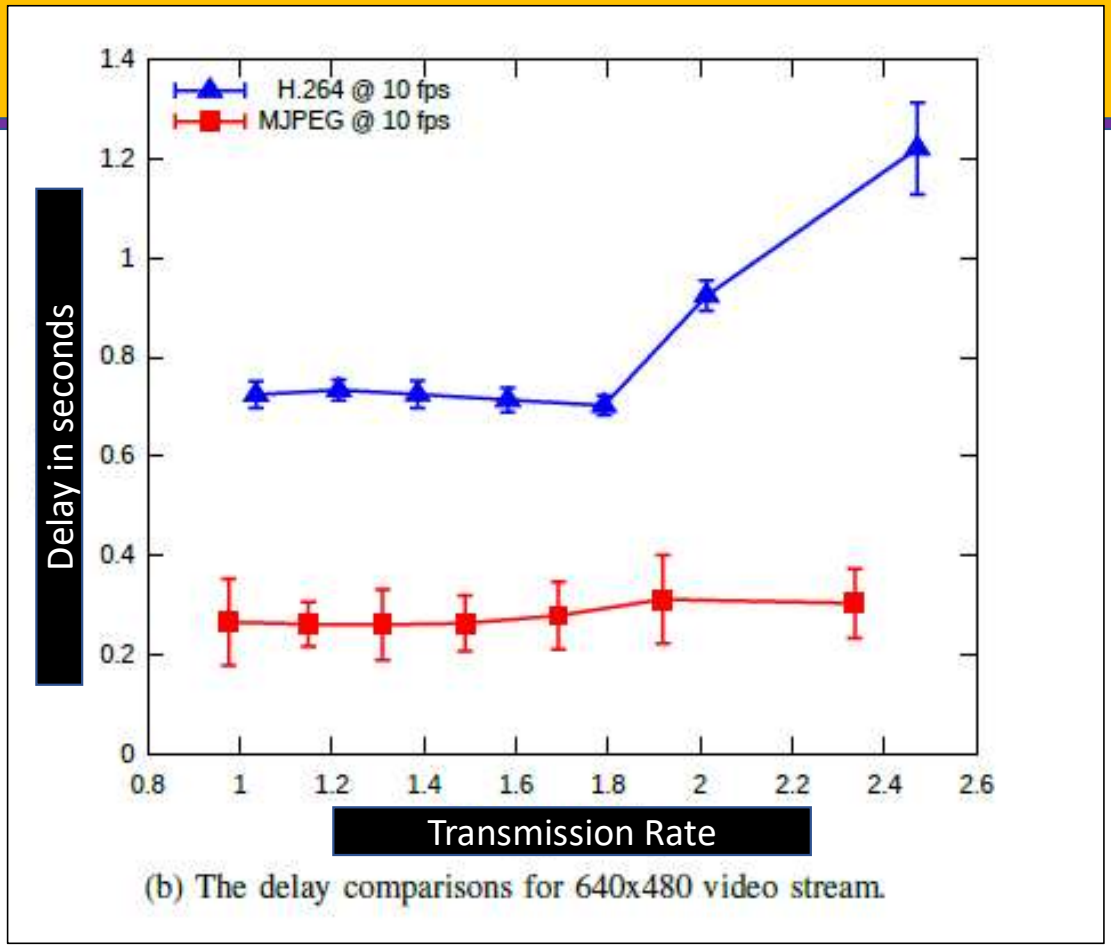
- 640x480 video stream
- 10 frames / sec
- Again, delay for MPEG

Pretty constant

- But delay for H264

went up as data rate

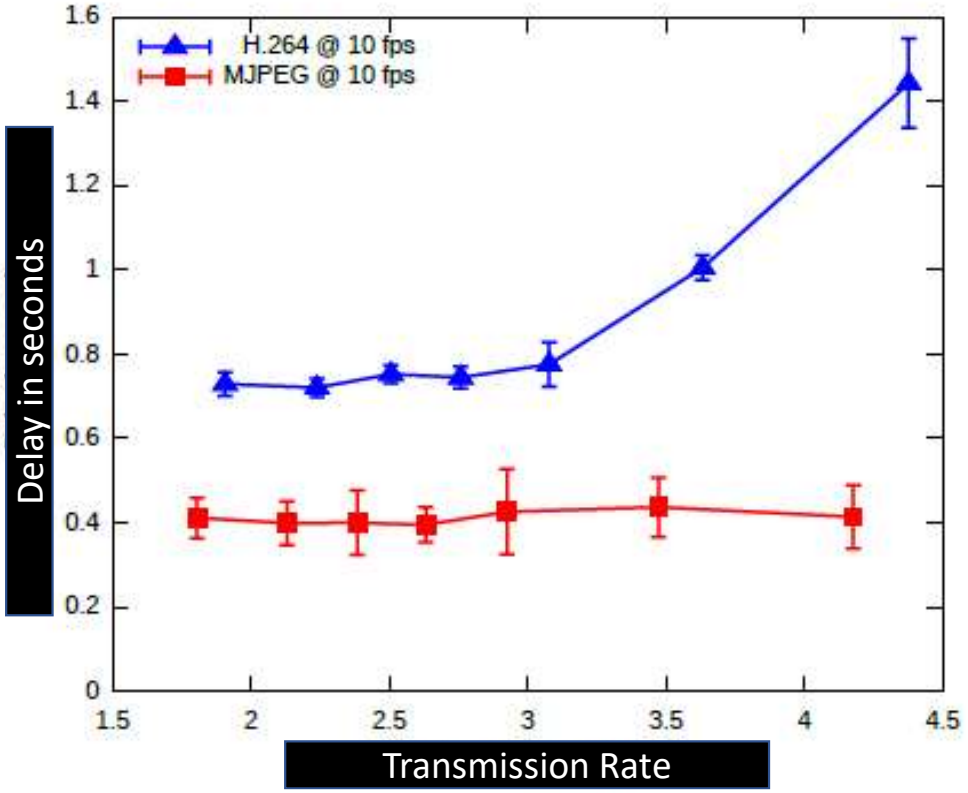
Increases



(b) The delay comparisons for 640x480 video stream.

C4: Video Delay: 1280x720 resolution

- Higher resolution of 1280x720 video stream
- Frame rate=10 frames / second
- H264 is unable to cope
- MPEG still manages well
- This implies we chose MPEG video for Careyes!!



(c) The delay comparisons for 1280x720 video stream.

Fig. 10: The comparison of MJPEG and H.264.

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Outdoor Evaluation: Angle for same direction

- Angular Density Plot for same direction test
- Most θ lies within 20 degrees (this is governed by width of car and width of Lane)

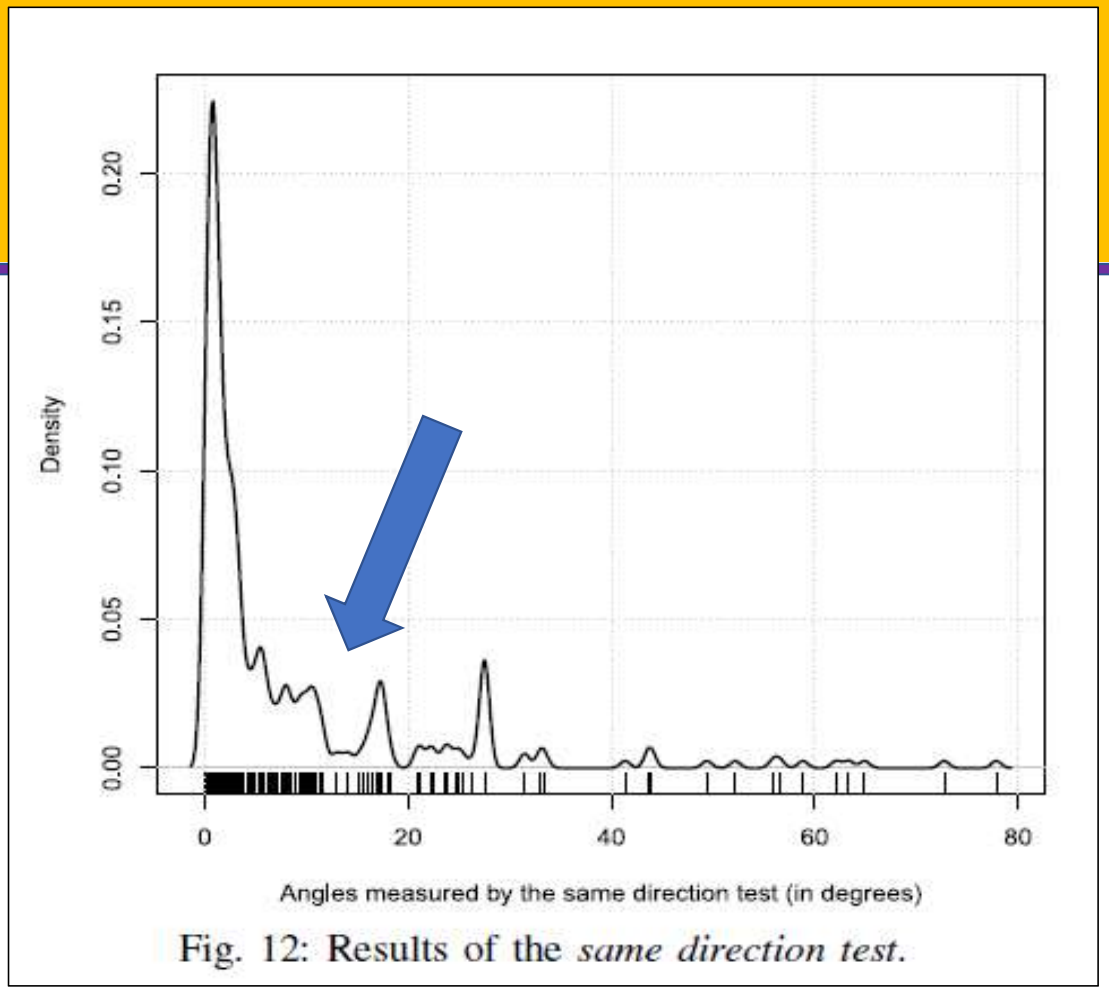

Fig. 12: Results of the *same direction test.*

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Outdoor Evaluation:
Angle for same lane

- Angular Density for same lane test (a road can have Multiple lanes going in same Direction)
- Most θ lies within 30 degrees

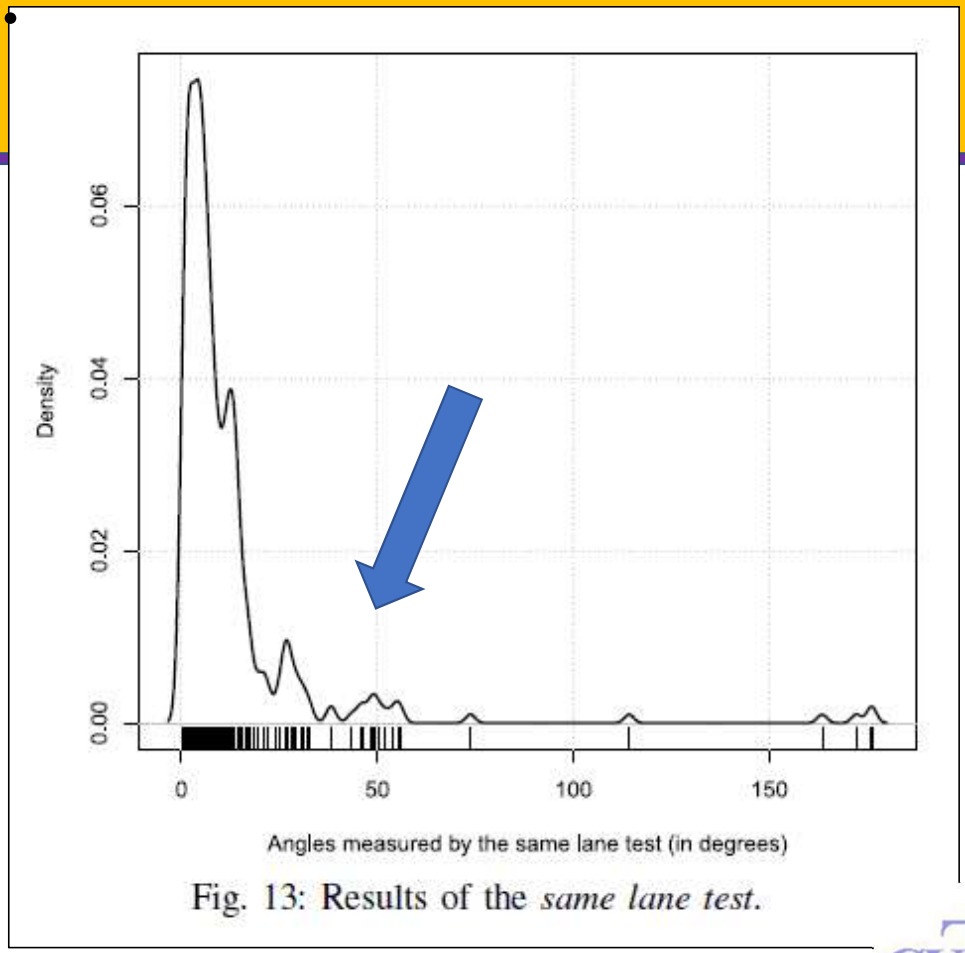

Fig. 13: Results of the *same lane test*.

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Other Evaluation: Using License Plate detection instead of computing angles

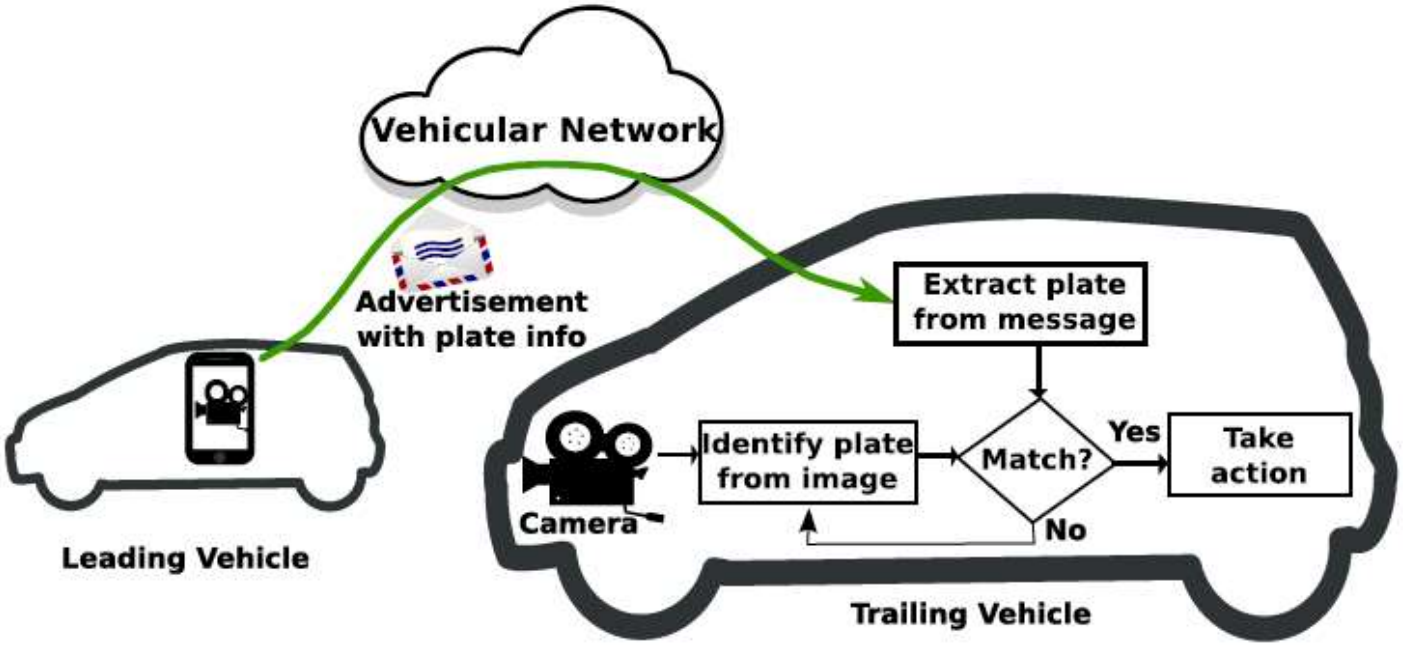

Figure 3: Use of image processing in relative positioning.

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Use to identify video
Is coming from front vehicle

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License Plate Detection

- Detection accuracy improves with VGA and HD
- HD is not necessary

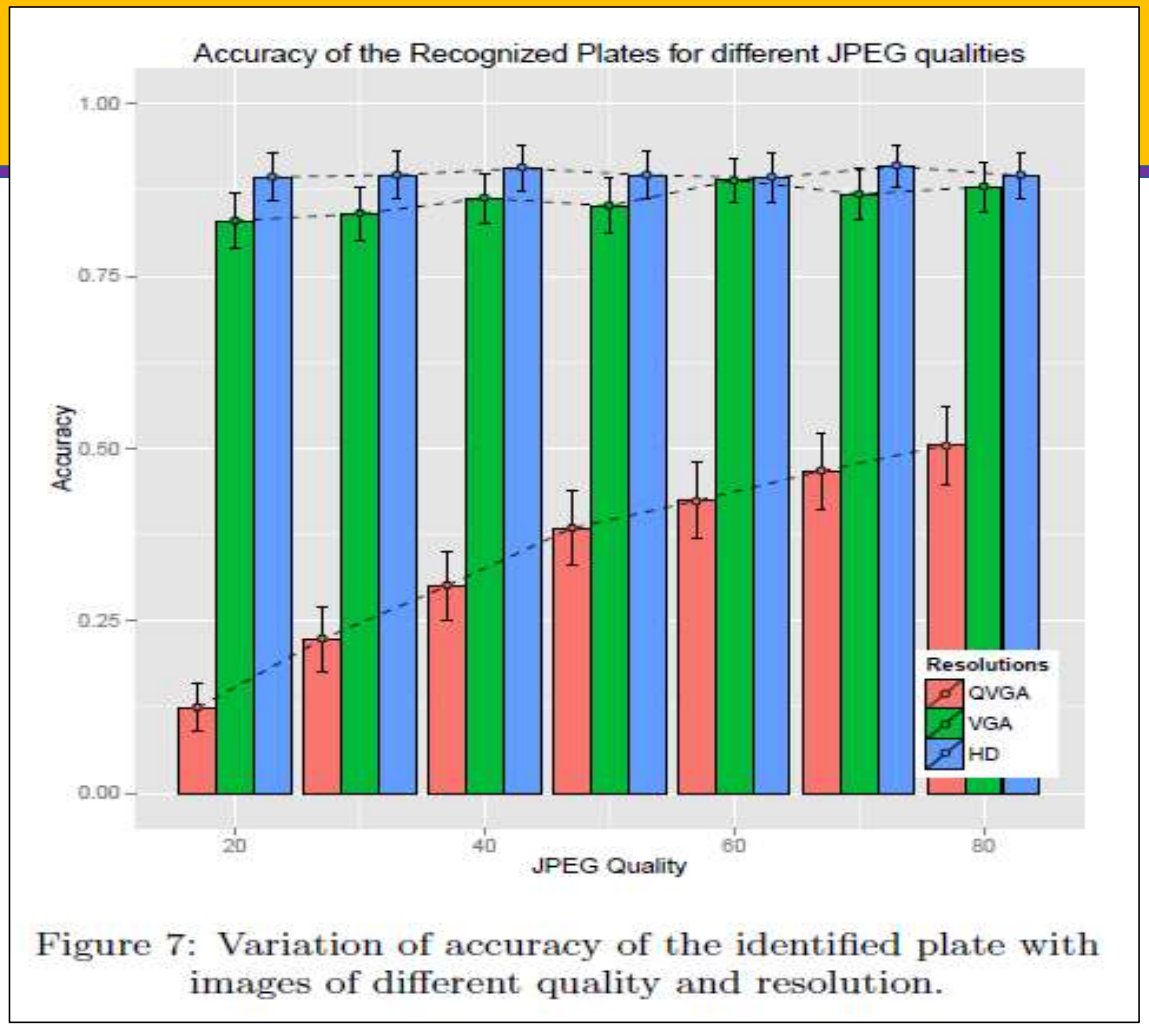

Figure 7: Variation of accuracy of the identified plate with images of different quality and resolution.

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Image Processing Time for QVGA/VGA/HD

- Android phones (Samsung, Moto, & Nexus) , we compared image processing time for QVGA, VGA and HD resolutions
- HD incurs the most processing time, followed by VGA and QVGA
- So, transmitting VGA is most appropriate choice given time, Quality, and image detection accuracy

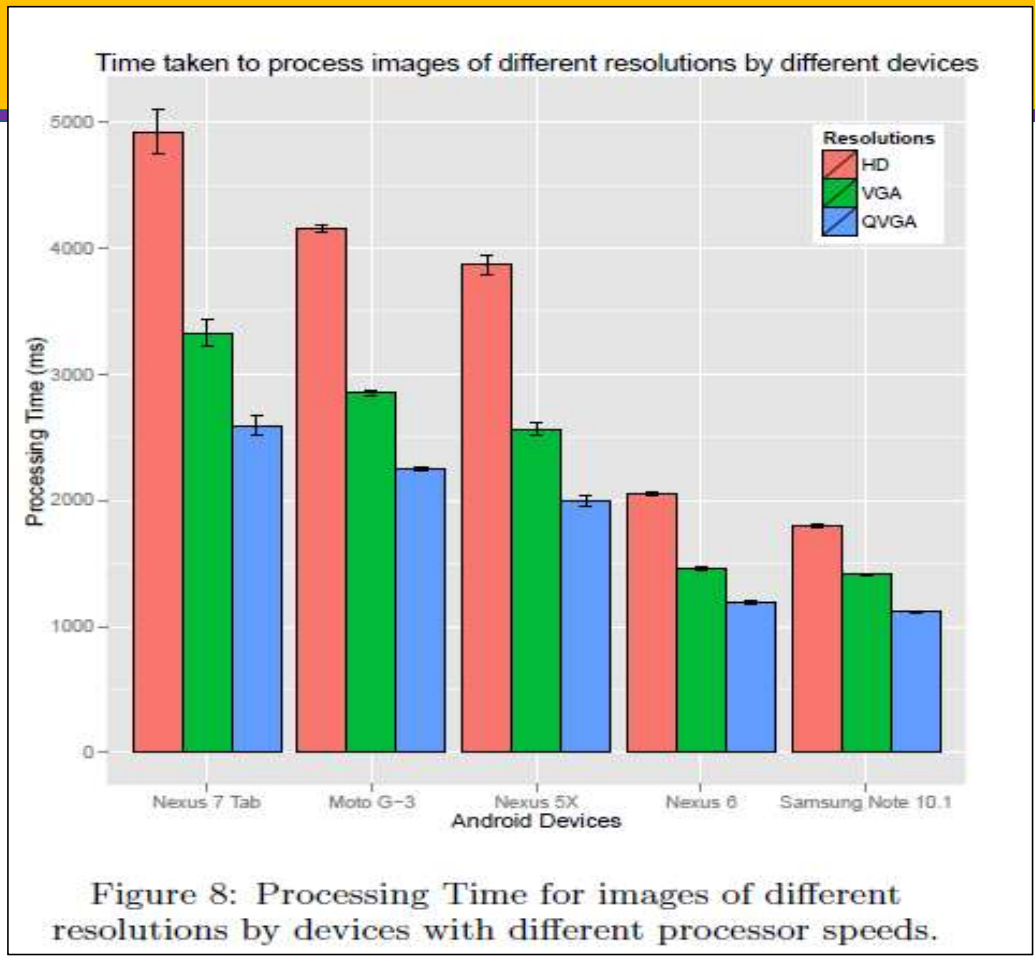

Figure 8: Processing Time for images of different resolutions by devices with different processor speeds.

Conclusion

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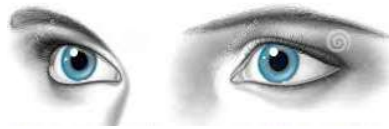

- **CarEyes** have successfully provided extended vision for cars
- Car ahead can stream video image to car behind upon request
- MPEG video at 10 fps is sufficient
- VGA resolution for license plate recognition is sufficient
- Our setup uses V2V and multimedia streaming
- It enhances car overtaking safety not possible before
- Future work: security, etc.
- Thank you.

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YouTube Video

Car-Eyes

- https://www.youtube.com/watch?v=eUQfalxPK0o

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