GPU Computing in Tomorrow's Automobiles

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NVISION 08

San Jose, CA

automotive apps need compute

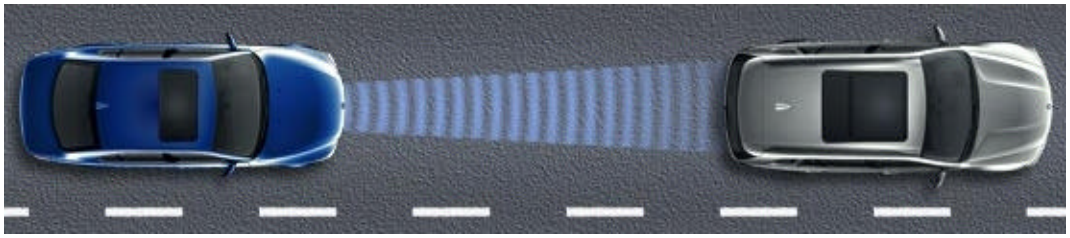
- Today's cars provide many features with compute requirements.
  - e.g. BMW 7 Series have over a hundred digital systems

- Future apps will require even more compute!

today we have…

Some of the current advanced tech:

– active cruise control



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- lane departure warning system

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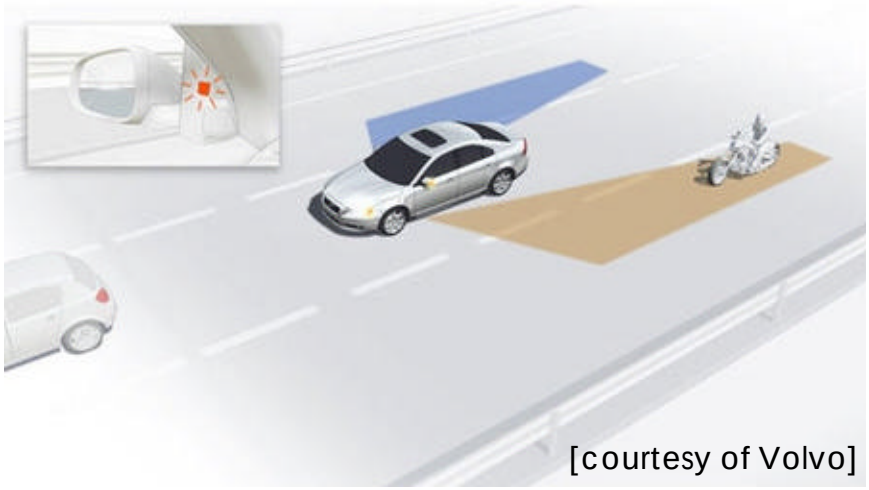
- adaptive headlights
- lane departure warning system
- blind spot information system



[courtesy of Volvo]

today we have...

Some of the current advanced tech:

- active cruise control
- adaptive headlights
- lane departure warning system
- blind spot information system
- night vision

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- lane departure warning system
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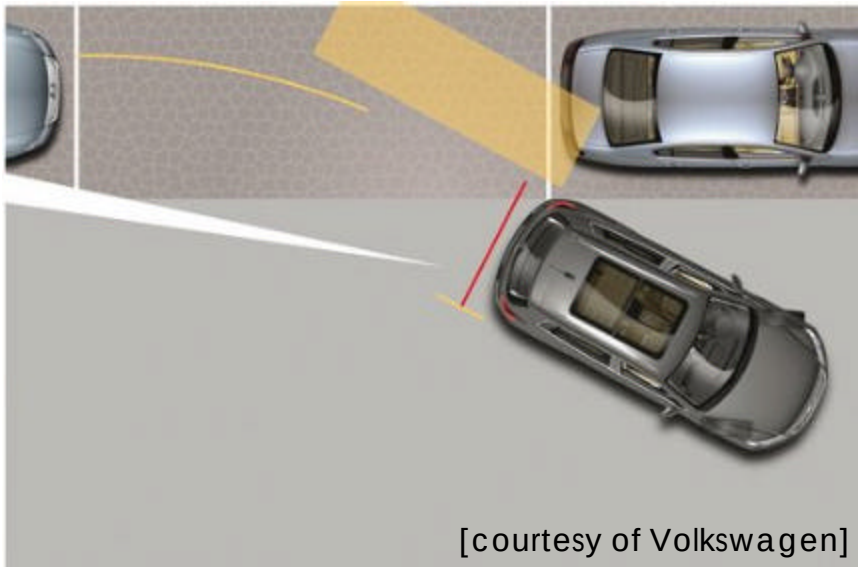
- parallel park assistance



[courtesy of Volkswagen]

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- night vision
- parallel park assistance
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[courtesy of Audi – from Jean-François Mainguet's site]

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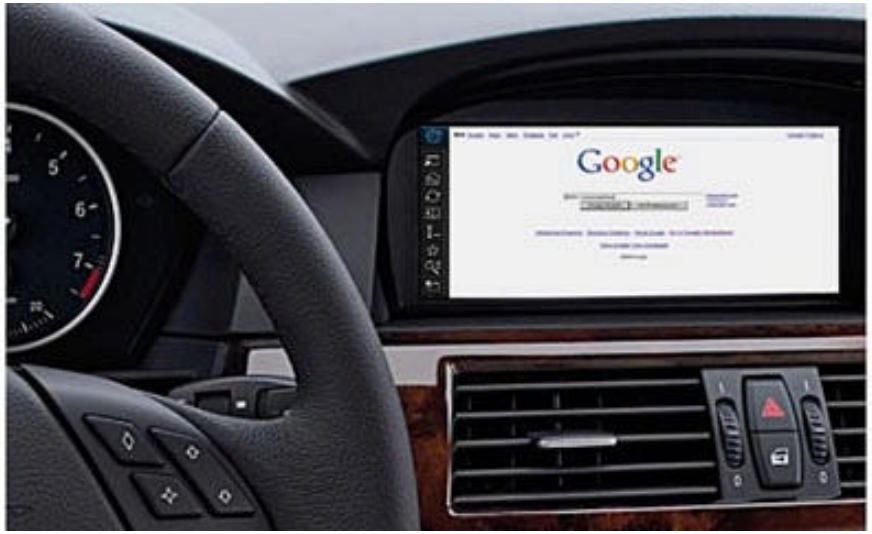
- infotainment & telematic apps

tomorrow we will have…

Some of the upcoming tech:

- Internet connection



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[courtesy of Mercedes-Benz]

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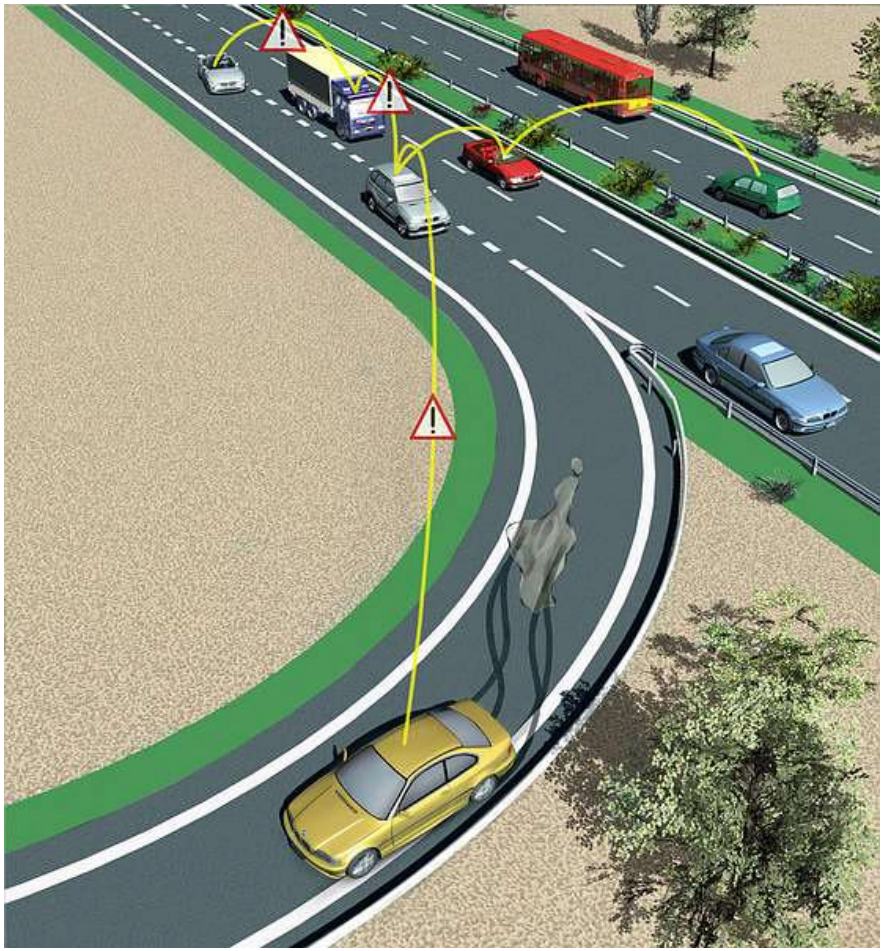
- e-mailing with speech recognition/synthesis
- driver fatigue recognition
- car-to-car communication



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In the long run:

- active pedestrian avoidance

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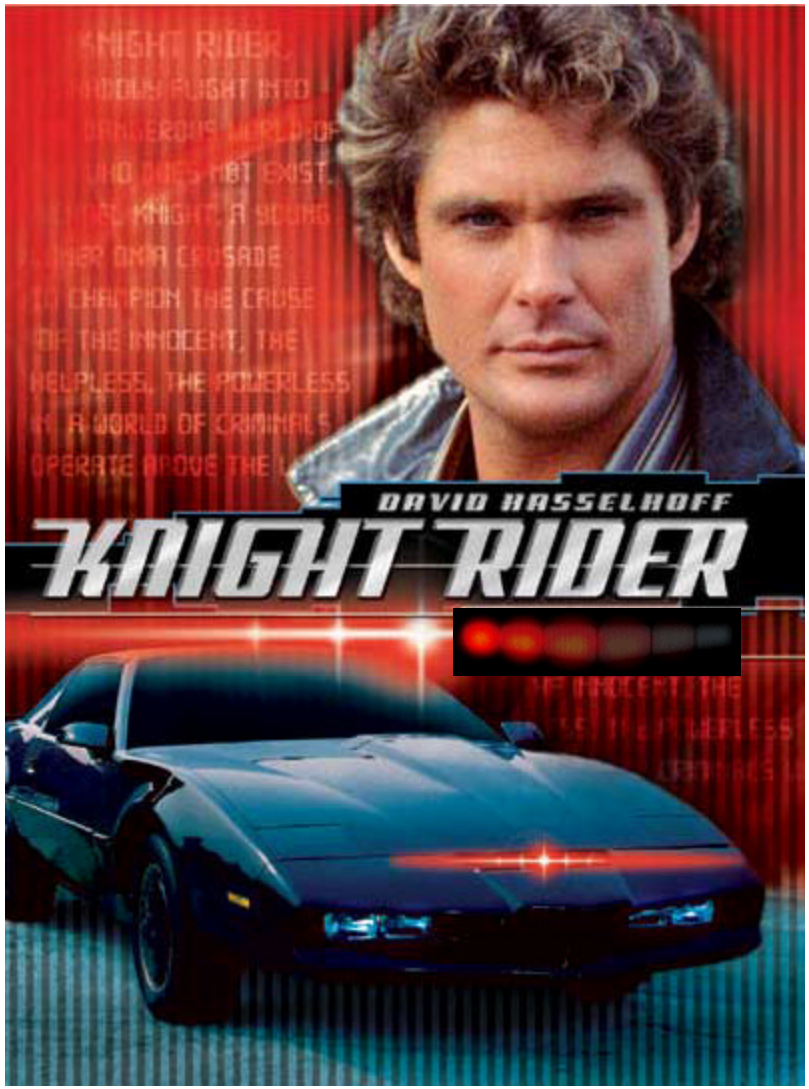
In the long run:

- active pedestrian avoidance
- active crash prevention and stabilization
- communication with infrastructure:
  - Traffic lights
  - Cameras
  - Speed signs

...and even maybe...

...get a ride
with Knight Rider's
KITT, which can:

- see, learn, think
- communicate
- have a personality



in “terms” of Computer Science:

- computer vision/pattern recognition

  speed limit recognition, lane departure warning system, blind spot information system, parallel park assistance, fingerprint apps, driver fatigue recognition, active cruise control, active crash avoidance/stabilization

- signal processing

  speech recognition, night vision

- graphics

  infotainment apps, head-up display

- networking

  car-to-car communication, telematic apps, communication with infrastructure, Internet connection

GPUs are good fit for...

- computer vision/pattern recognition

  speed limit recognition, lane departure warning system, blind spot information system, parallel park assistance, fingerprint apps, driver fatigue recognition, active cruise control, active crash avoidance/stabilization

- signal processing → with GPU computing, also good at tasks with **data-level parallelism**

  speech recognition, night vision

- graphics → naturally good at

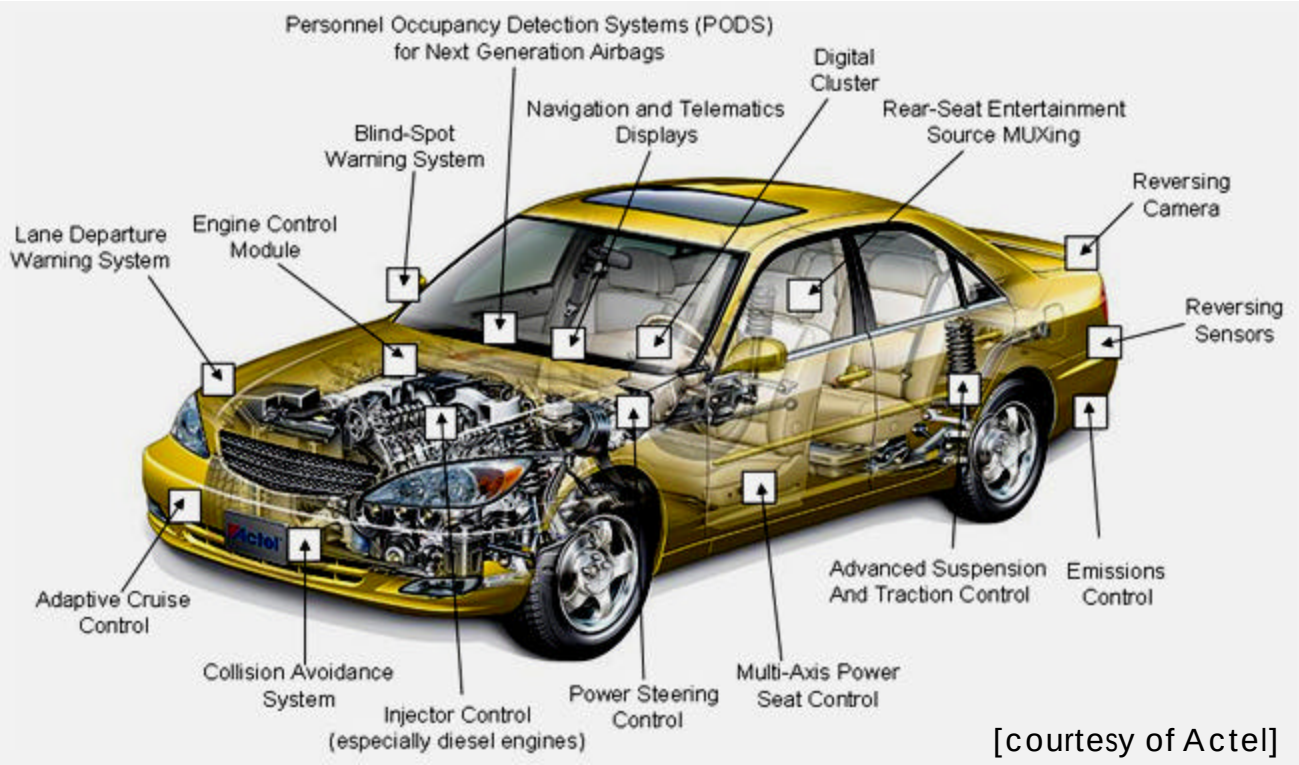
  infotainment apps, head-up display

- networking → not suited for

  car-to-car communication, telematic apps, communication with infrastructure, Internet connection

GPU vs others

- Today's vehicles use dozens of:
  - Automobile Specific Integrated Circuits (ASICs)
  - Application Specific Standard Products (ASSPs),
  - Programmable Logic Devices (PLDs)
  - Field Programmable Gate Arrays (FPGAs)



[courtesy of Actel]

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  - simplify vehicle design

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- Due to economies of scale:
  - adding a GPU to the production line is cheap

- With its programmability, GPUs offer ability to:
  - rapidly prototype
  - improve functionality with software updates

our project

- We focus on three tasks:
  - computer vision techniques for recognizing traffic signs
  - augmented display techniques for enhancing the visual aids
  - speech recognition techniques for controlling the body electronics

  => GPUs are good fit for above

- Will use CUDA, NVIDIA GPU and a host CPU.

speed sign recognition

- We are investigating the use of parallel algorithms to detect speed signs with GPUs.

- Here are details from Vladimir, who worked on this project over the summer at BMW Group Technology Office in Palo Alto…

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Technology Office
Palo Alto

Innovation at the BMW Group.

BMW Technology Office - Palo Alto CA

EU Speed Limit Detection

Vladimir Glavtchev

BMW Group

Rolls-Royce
Motor Cars Limited

MINI

BMW Group
Technology Office
Palo Alto

EU Speed Limit Sign Recognition.

The Problem

Can a G86 be used as an embedded processor in a vehicle to perform speed limit sign recognition in real-time?

What algorithms are best suited for parallelization (e.g. can be done in CUDA)?

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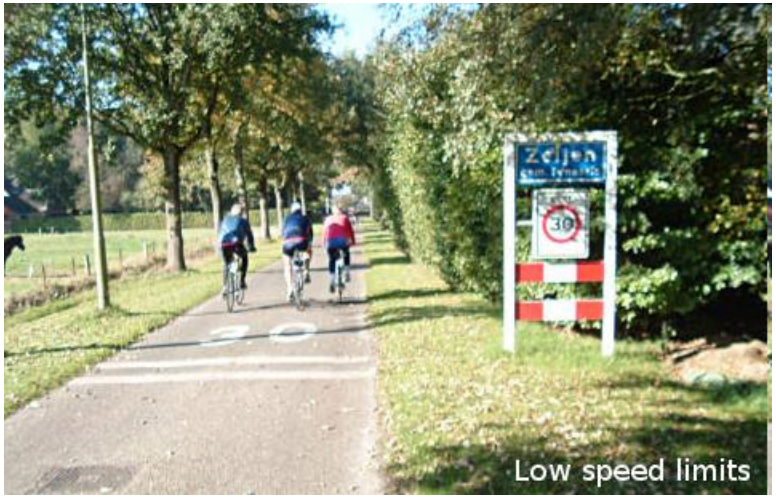
EU Speed Limit Sign Recognition.
Challenges

Real-time constraints

Embedded hardware requirements

Robustness



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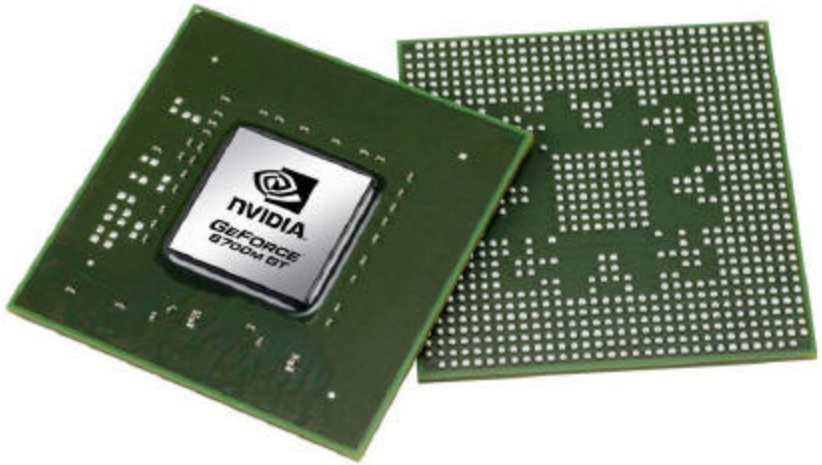
EU Speed Limit Sign Recognition.

Built-in GPU hardware advantages

Line interpolation
Image resizing
Triangle rasterization
Large available memory – for storing vertex arrays
Tons and tons of compute power!



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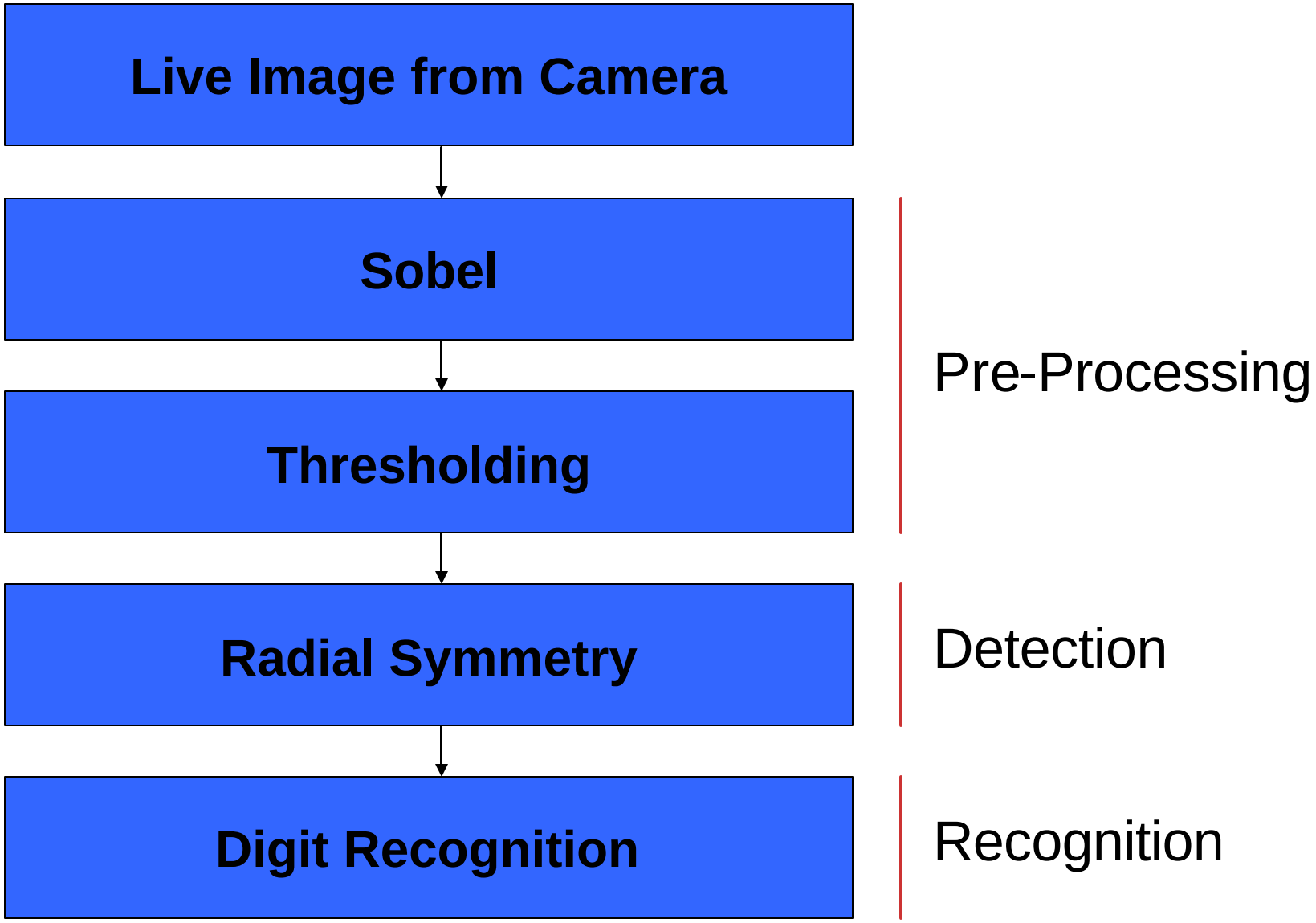
EU Speed Limit Sign Recognition.

A GPU-oriented solution



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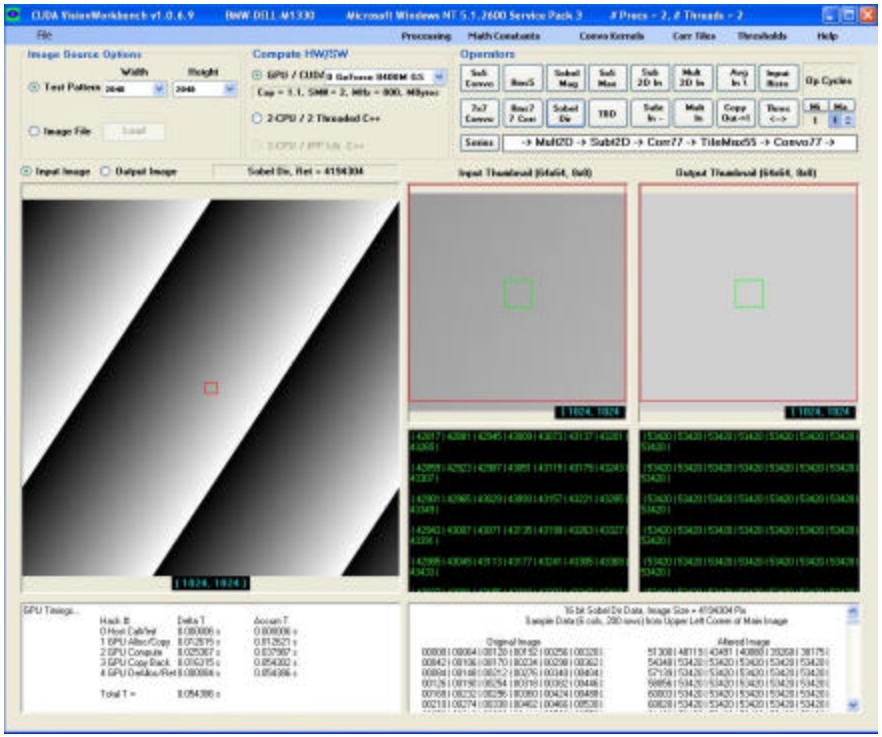
EU Speed Limit Sign Recognition.

Project Structure

- Project interface:
  - Integrate into CUDA VisionWorkbench (CVWB) from John Roberts / Joe Stam
  - Use CVWB graphic user interface
  - Use the existing Sobel and add simple thresholding



Credit: nVidia (John Roberts, Joe Stam, James Fung)

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EU Speed Limit Sign Recognition.

Original Image: EU speed limit sign

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EU Speed Limit Sign Recognition.

Pre-Processing: Sobel with thresholding

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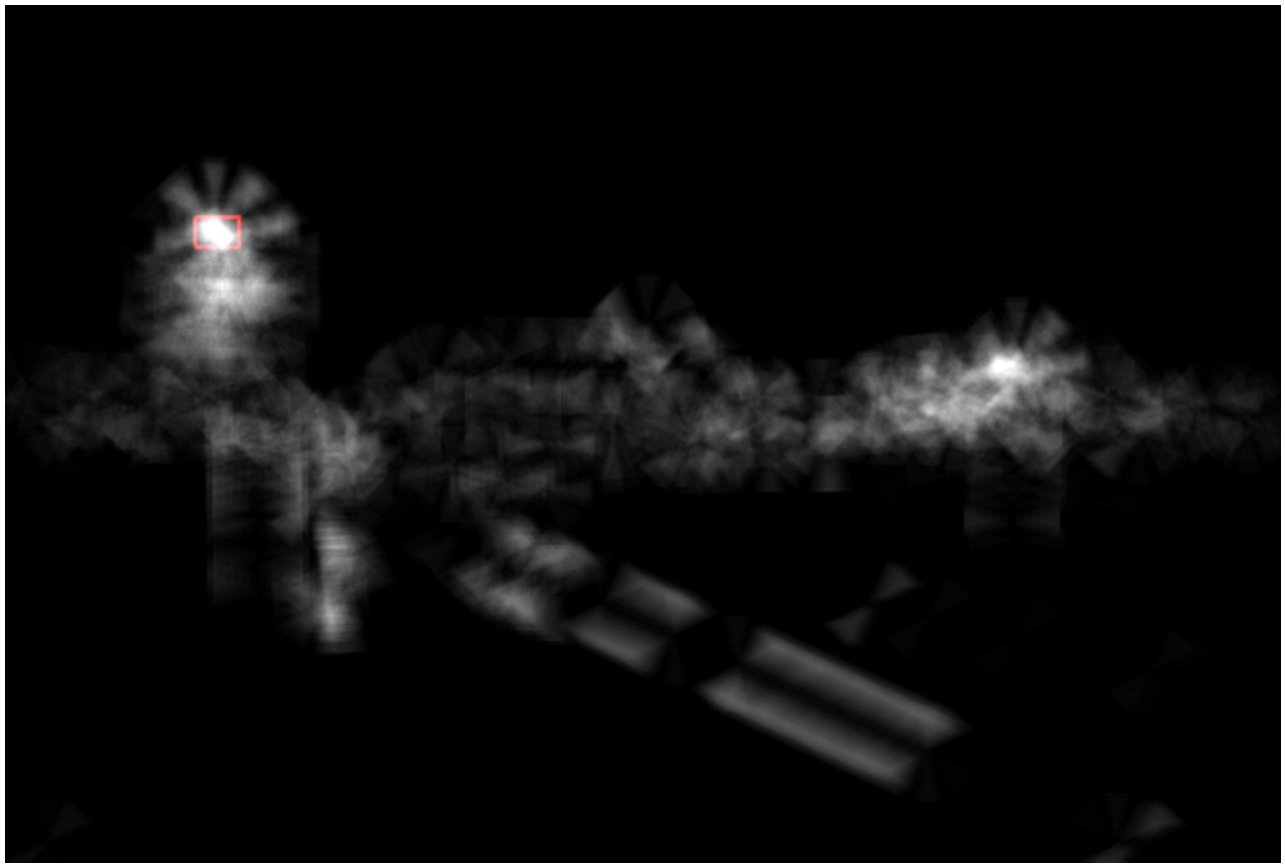
EU Speed Limit Sign Recognition.

Detection: Radial Symmetry



Algorithm developed by: Vladimir Glavtchev, Joe Stam, James Fung

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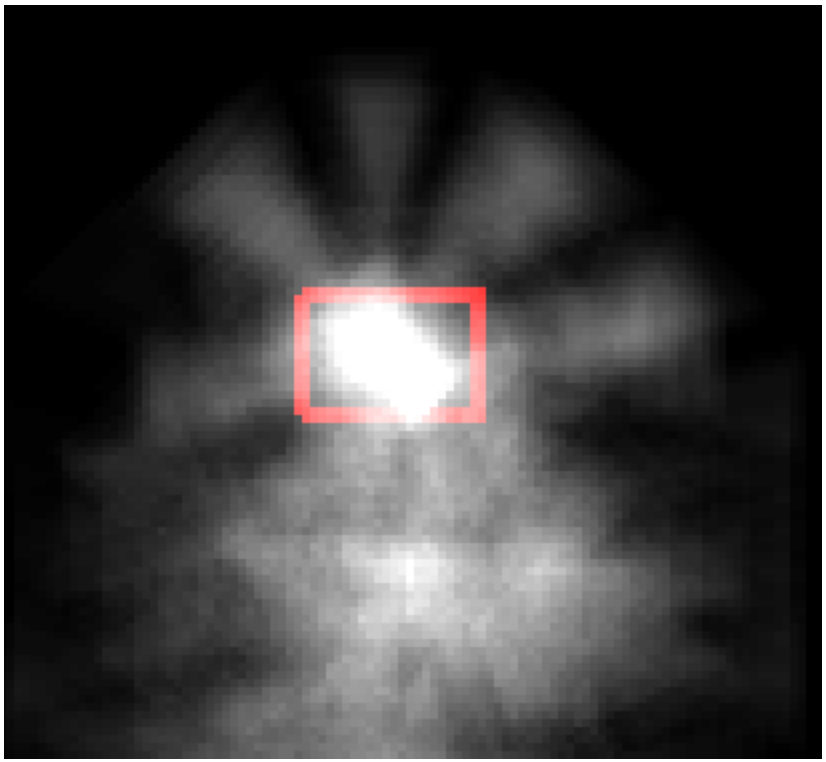
EU Speed Limit Sign Recognition.

Detection: Radial Symmetry voting



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Detection: Region of interest isolation

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Recognition: Digit recognition

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Recognition: Digit isolation

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Identification: Digit probability output

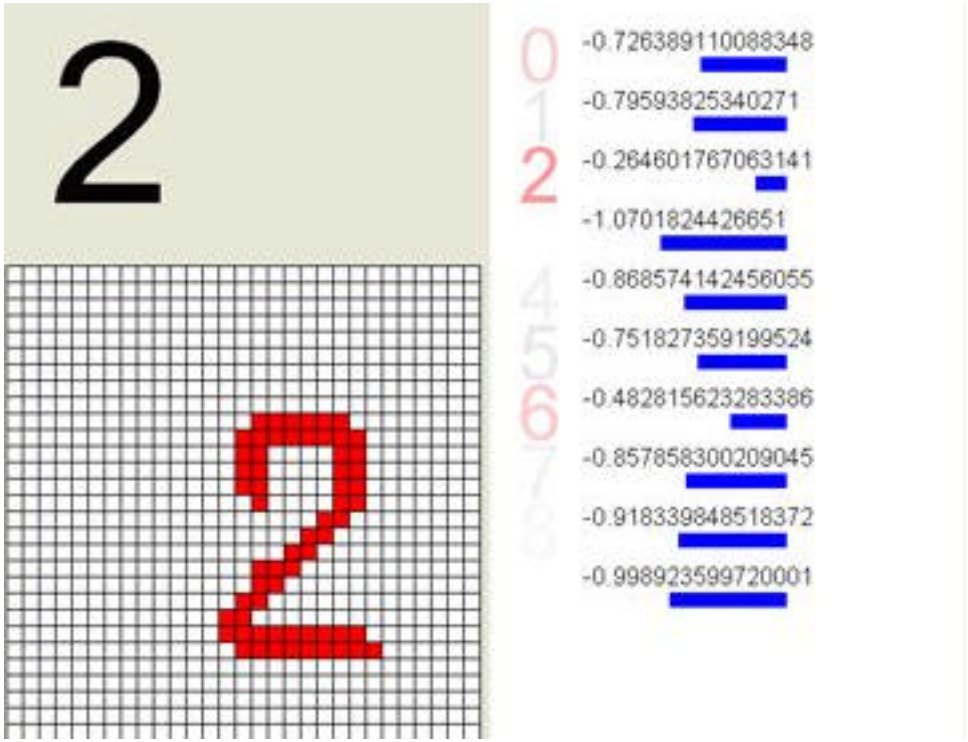

Image and Concept Credit: Cheng-Kai Chen and Shi Yan

standardization efforts

- No APIs exist for apps we focus on

- We would like to create a **common platform**:
  - have data-parallel embedded computing interface for automotive apps
  - allow multiple vendors to compete and give auto manufacturers more choice
  - allow reuse of the algorithms we developed

challenges

- Allowing the GPU to multitask between the three tasks we focus in our project
- Delivering real-time performance guarantees
- Dealing with embedded system constraints
- Integrating CPU-GPU

our group

- IDAV at UC Davis :
  - Pinar Muyan-Özçelik, Vladimir Glavtchev, Dr. John D. Owens
- BMW Group Technology Office in Palo Alto:
  - Vladimir Glavtchev, Jeff Ota
- NVIDIA Corporation in Santa Clara :
  - Joe Stam

Thank you!

Questions?