Trends and Opportunities in Consumer Electronics

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About the IEEE Consumer Electronics Society

- Founder chair of the Bangalore Chapter, started in 2010

- Awarded "Best Chapter" of the year, 2014, by IEEE section

- Advanced Graphics (GFX) workshops being held every year, since 2011

- The goals of the chapter are to:

  - 1. Help current CE practitioners improve their capabilities, and lead to further fundamental CE research and development in the Bangalore area, and India in general.

  - 2. Mentor and groom the next generation of CE Engineers by working directly with local and national Engineering Colleges and Universities.

  - 3. Provide a common platform for CE organizations to share experiences and knowledge, and create common India specific standards in the longer term.

- ==> Please plan to join IEEE CE Society as a volunteer, member !!

Overview of Todays Talk

- What is a Consumer Electronics (CE) device ?

- Core components of Next-Gen Consumer Electronics

  - Sensors

  - Display & Graphics

  - User Interfaces

  - Machine Learning

  - Cloud storage and Processing

- CE Applications

  - CE in Automobiles

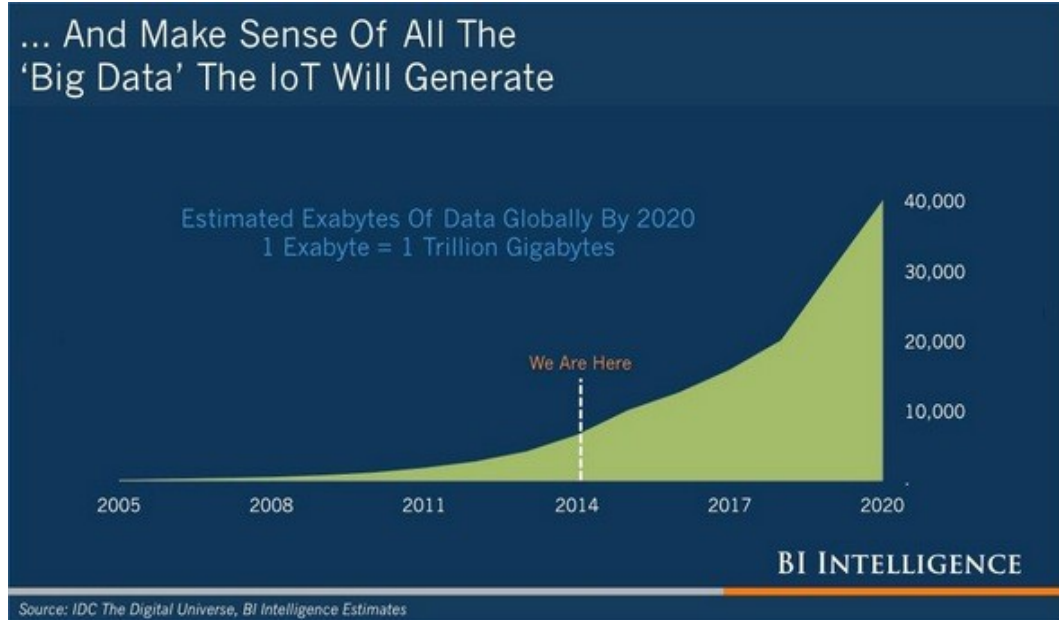# Which is a Consumer Electronic Device ?

Part1 - Sensors

Sensors

- **Examples of Sensors**

  - Camera – Types

- **A high end phone (like the Samsung S6) has > 10 sensors**

- **Lot of data gets generated**

- **Sampling rate ?**

  - Gyro

  - Audio ?

  - Camera ?

- **How to make sense of all this data ? Machine Learning is key**

... And Make Sense Of All The 'Big Data' The IoT Will Generate

Estimated Exabytes Of Data Globally By 2020
1 Exabyte = 1 Trillion Gigabytes

40,000
30,000
20,000
10,000

We Are Here

2005   2008   2011   2014   2017   2020

BI INTELLIGENCE

Source: IDC The Digital Universe, BI Intelligence Estimates

Sensor Evolution

- Advances in MEMS have contributed to significant new IP integration

- Kinds of sensors

  - Always-on

  - Auto triggered

  - User triggered (Ex, Camera)

- Providing a good user experience @ Low power is critical to sensor system design

- Ex, Camera has to be started almost instantaneously

  - (< 1 sec delay) from click to preview

Device Motion

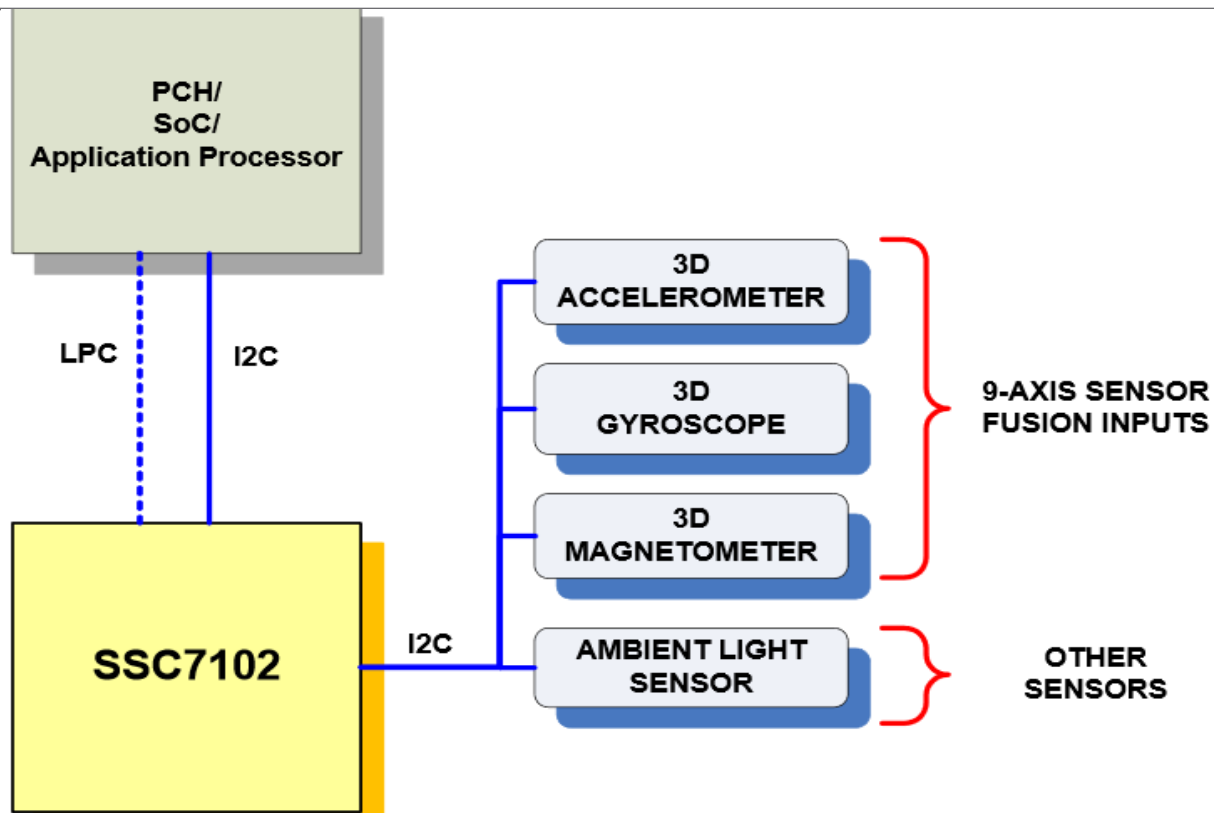Sensor Power Consumption (mW)

9-axis
Always On
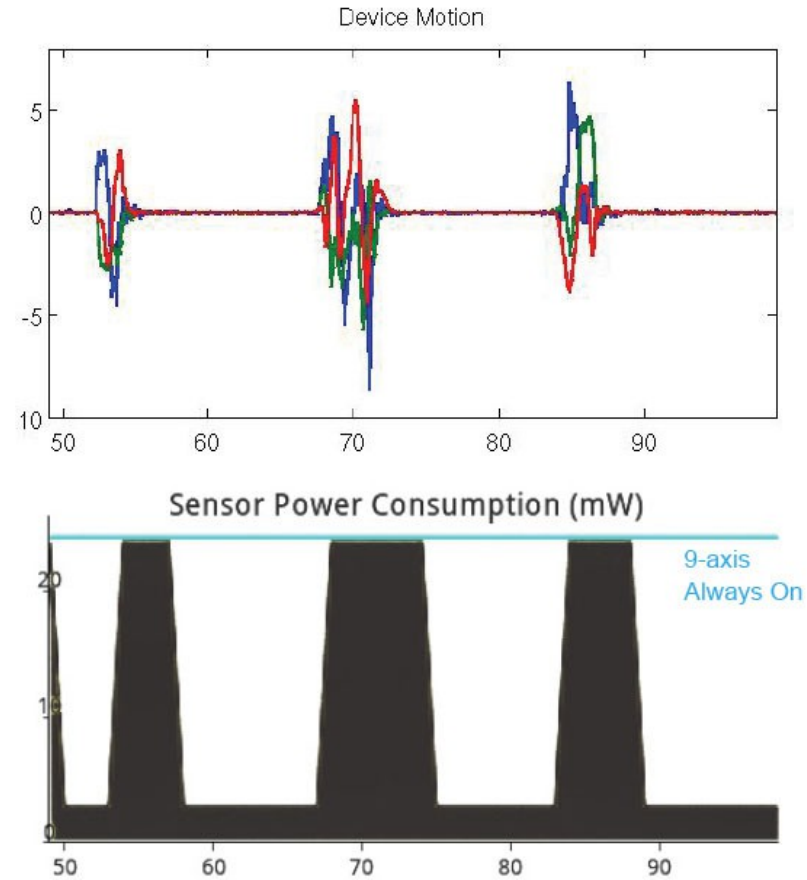
Sensor Fusion

- A group of related sensors used together

    - Ex, different type of camera sensors – RGB, Depth

    - Ex, Accelero + Gyro + Magnetometer

- Can derive more useful/ Robust information from this group, than individual sensors

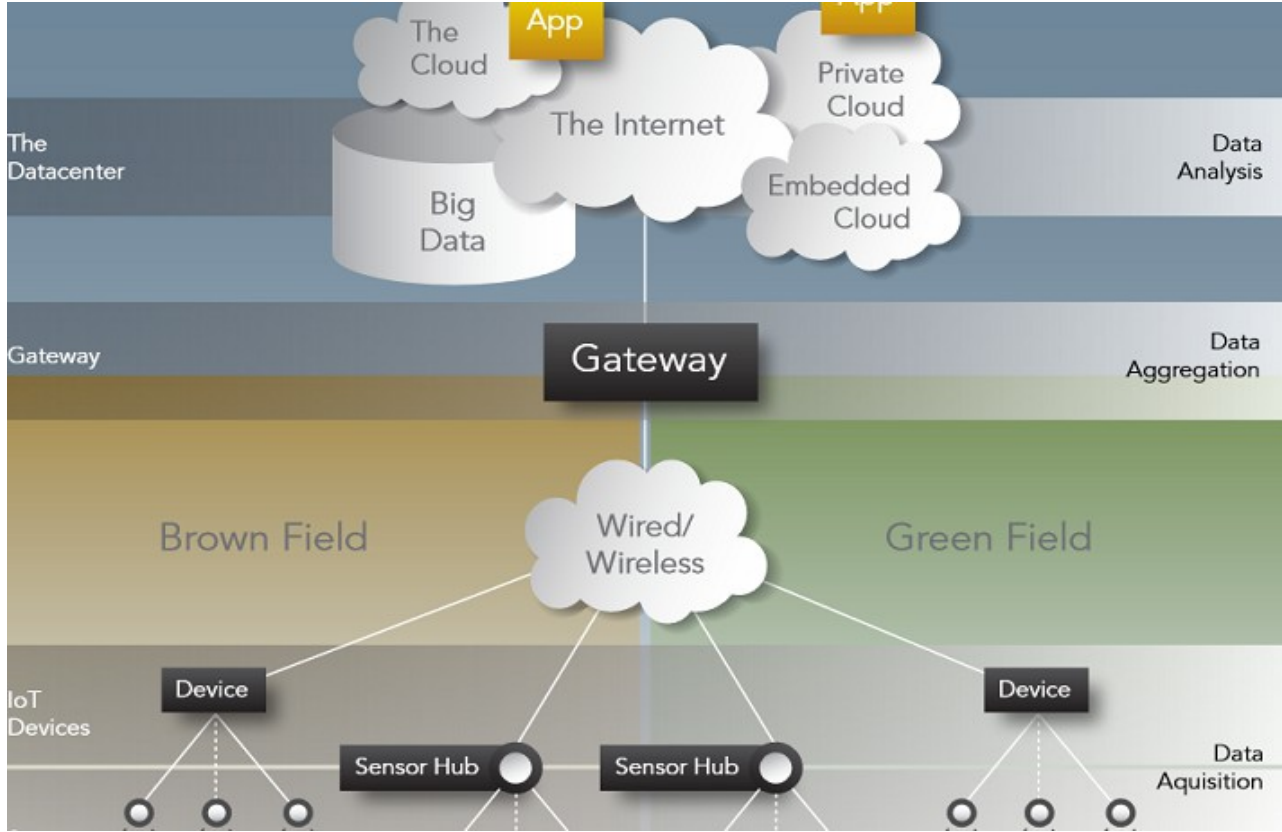- Separate HW for Sensor "Hub" now almost always used

From IMU (mdpi)
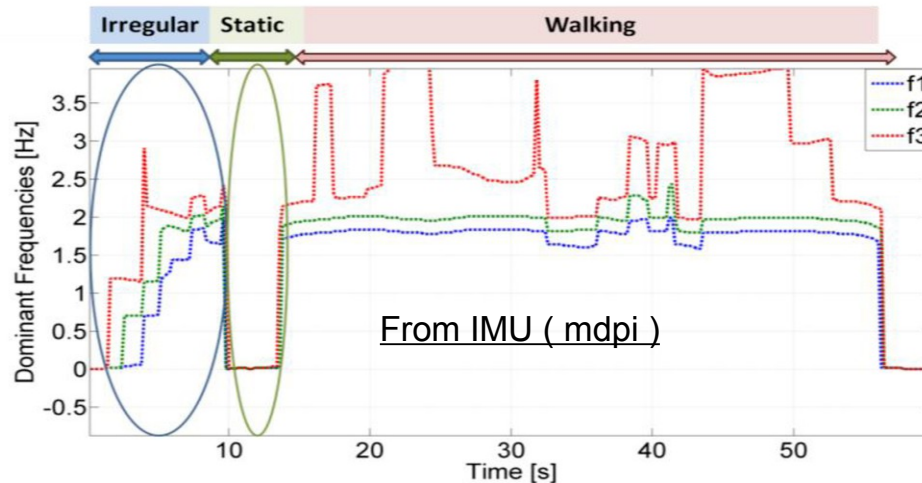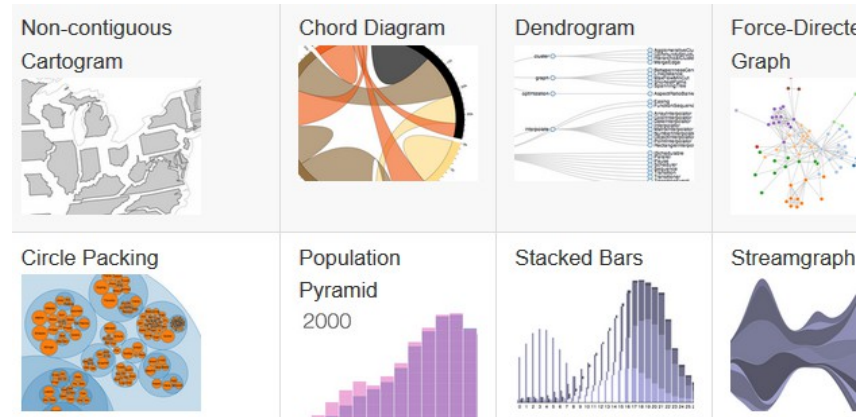
Sensor Fusion Example (MicroChip)

Sensors, IoT and Security

Sensors & IoT enablement

- IoT - Connected devices

- Small devices, big data – How to process, visualise ?

- New visualisation techniques

  – Javascript frontends (d3.js)

- New cloud based techniques

- Security of transmitted data

Sensors - Summary

- Hundreds of sensors will be carried by every one in the next couple of years

- Low power, Always-on designs for all sensors are still not feasible

- Making use of all this data, will require enormous amount of Machine Learning resources

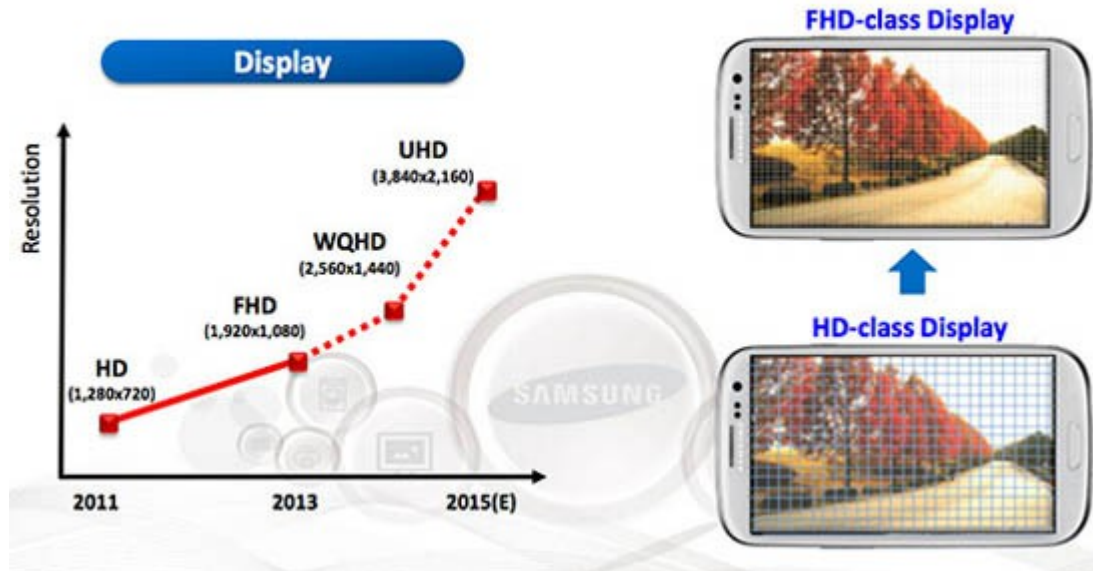- Discussion – Which new type of sensors will improve our quality of Life ?

Display & Graphics

Introduction

- To display one page of Facebook, how many Pixels need to be updated ?

  –

GPU HW Architectures

- CPUs are programmed with sequential code

  - Typical C program – linear code

  - Well defined Pre-fetch architectures, cache mechanisms

  - Problem ? Limited by how fast "a" processor can execute, read, write

- GPUs are parallel, and Graphics is rendered differently from Video

  - Small & same code, multiple data

  - No control dependencies ideally

    - If used improperly can reduce throughput

  - "Output" is a result of a matrix operation (n x n)

    - Graphics output – color pixels, Computational output – matrix values

Video and Graphics

- **Graphics is computed creation**

  - Video is recorded as-is

- **Graphics is object – based**

  - Video (today) is not

- **Graphics is computed every frame fully**

  - Video is mostly delta sequences

    - Motion-detection, construction, compensation

    - But extensions like swap_region (Nokia) exist

GPU integrated SOCs

- The A5, A6, A7 chipsets

On A5, CPU size ~= GPU size
On A6X and A7, CPU size < GPU size!
GPU core sizes ~ 35 mm2 @ 28nm

Xbox One vs Sony PS4 (40+ Watt devices)

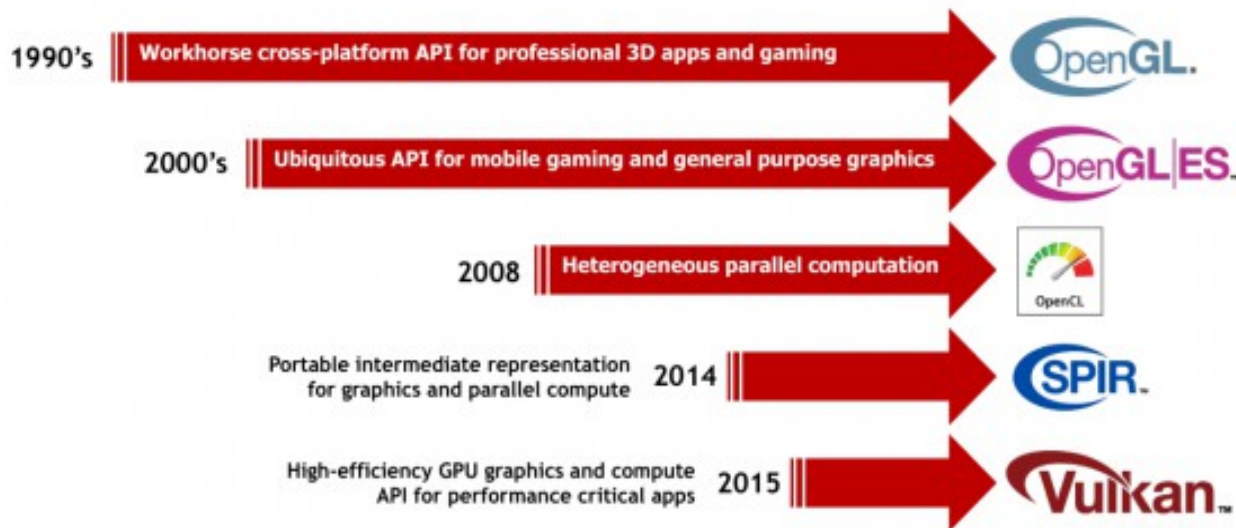| Microsoft Xbox One vs. Sony PlayStation 4 Spec comparison			
	Xbox 360	**Xbox One**	**PlayStation 4**
CPU Cores/Threads	3/6	8/8	8/8
CPU Frequency	3.2GHz	1.6GHz (est)	1.6GHz (est)
CPU µArch	IBM PowerPC	AMD Jaguar	AMD Jaguar
Shared L2 Cache	1MB	2 x 2MB	2 x 2MB
GPU Cores		768	1152
Peak Shader Throughput	0.24 TFLOPS	1.23 TFLOPS	1.84 TFLOPS
Embedded Memory	10MB eDRAM	32MB eSRAM	-
Embedded Memory Bandwidth	32GB/s	102GB/s	-
System Memory	512MB 1400MHz GDDR3	8GB 2133MHz DDR3	8GB 5500MHz GDDR5
System Memory Bus	128-bits	256-bits	256-bits
System Memory Bandwidth	22.4 GB/s	68.3 GB/s	176.0 GB/s
Manufacturing Process		28nm	28nm

Embedded markets require <10W !

From – AnandTech

Khronos Open Standards for Graphics and Compute
A comprehensive family of APIs to address the full spectrum of developer requirements

1990's	Workhorse cross-platform API for professional 3D apps and gaming	OpenGL.
2000's	Ubiquitous API for mobile gaming and general purpose graphics	OpenGL|ES.
2008	Heterogeneous parallel computation	OpenCL
Portable intermediate representation for graphics and parallel compute 2014		SPIR.
High-efficiency GPU graphics and compute API for performance critical apps 2015		Vulkan.

All APIs will be evolved and maintained to meet industry needs.
Rich mix of open technologies for future innovation

Graphics - Summary

- GPU is a critical portion of a Display based device

- GPU operates quite differently from a CPU

- A GPU programmer needs to know Graphics Oriented APIs (like OpenGL)

-

- Discussion – Is there a relation between a GPU and Usability of a Consumer Device ?

User Interfaces

User Interfaces

- Touch screen based interfaces considered to be on the way out

- More natural interfaces based on Gesture, Voice, Gaze … being rolled out

- Consider Virtual Reality based interfaces

Virtual Reality - Interfaces

-Tracks eye movements
-Uses IR LEDs to track

-Can transfer Real-life
Movements to VR Avatar

Virtual Reality (2) – Foveated Rendering

Can use Eye tracking to
reduce processing !

Produce real effects where the eye is
Focusing. Approximate other areas.

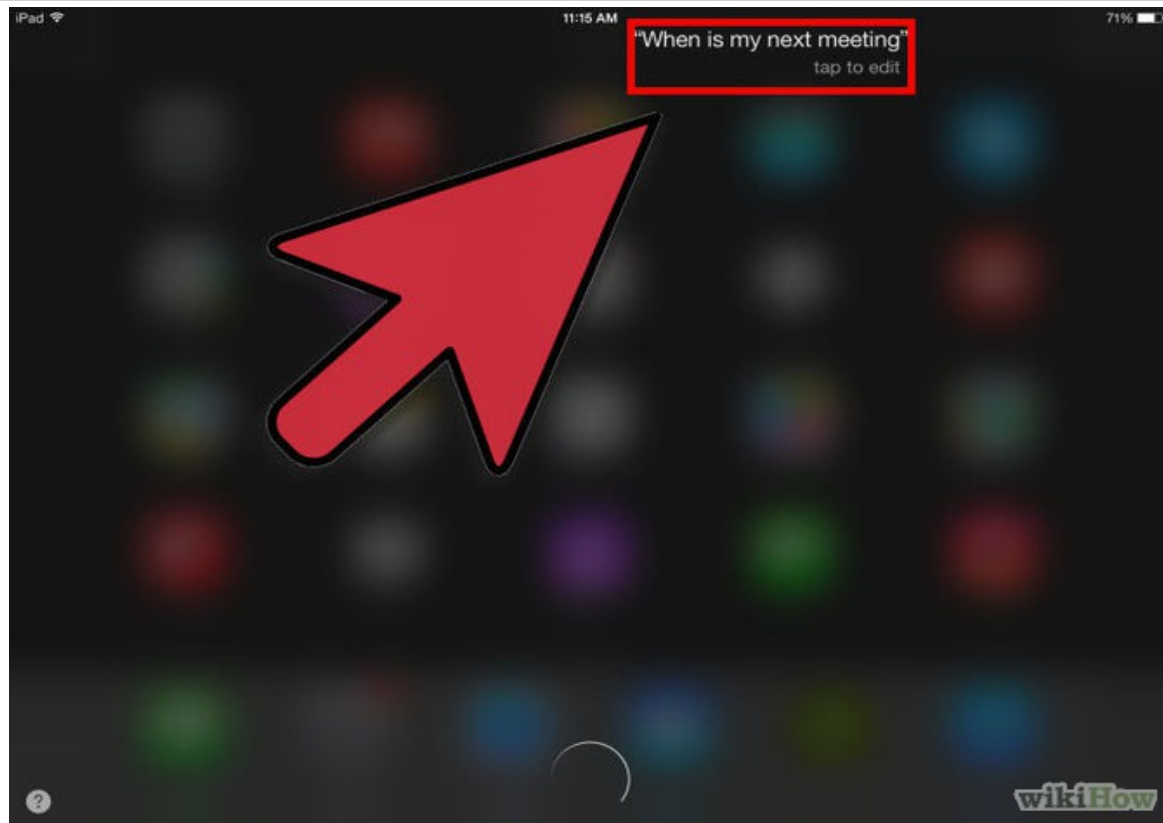# Examples of New User Interfaces - Input

- Pictures of the hand-gesture based tracking system

- Imagine – Not just TVs, but also computers, phones, Automobiles

Voice based Interfaces - Input

- Limited word systems

- TeslaTouch (Disney Research)
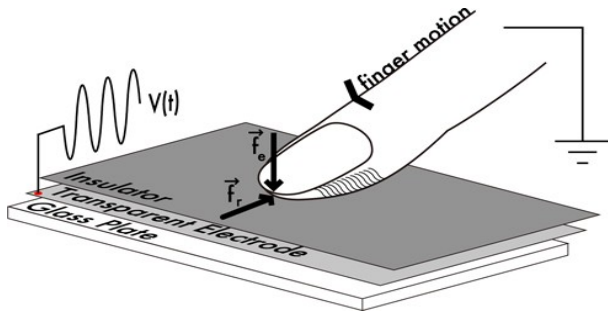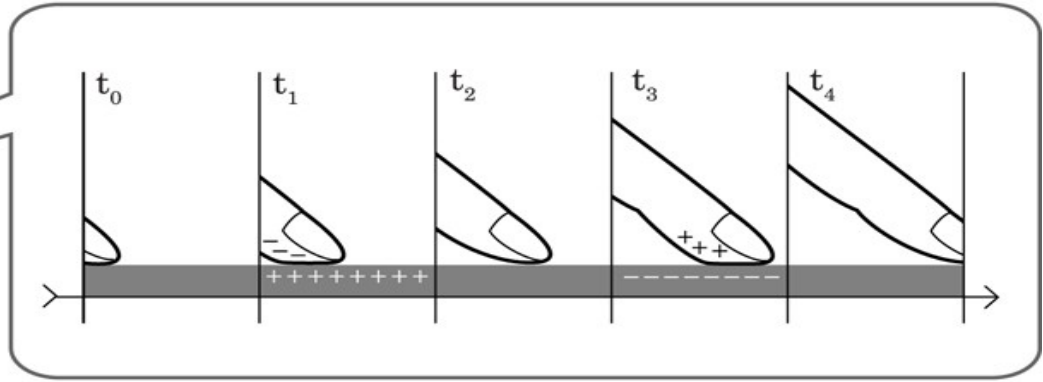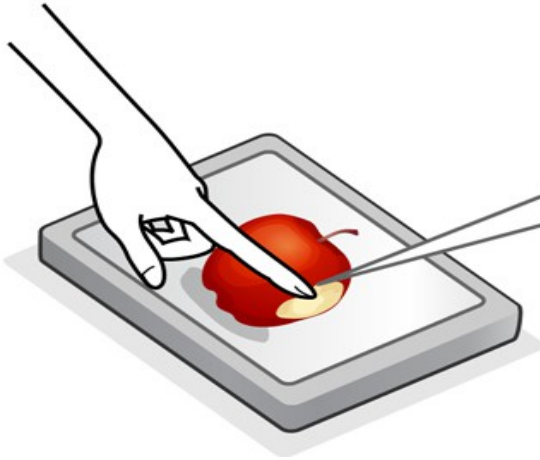
User Interfaces - Summary

- Interesting and more natural User Interfaces will be integrated across all categories of devices – CE and Embedded …

- Speed of response, and Accuracy of recognition are key for input

- Natural response is key for Output (ex, Haptics)

- Discussion
    - Which User Interface will you prefer, why ?

Machine Learning in CE

Where is Machine Learning applied ?

- ML has been applied primarily in areas like automatic Image classification

- Ex, Gallery application in mobile phones

-

- Very soon, Machine Learning is planned to be applied in even more areas

  - Robotics

  - Power and Dynamic Memory reduction in Portable devices

  - User adaptation

  - Security (ex, Malware detection), Safety (Detection of unsafe environments)

  - Health

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Error Rates in Scene Classification - Time

| Team	Year	Place	Error (top-5)	Uses external data
SuperVision	2012	1st	16.4%	no
SuperVision	2012	1st	15.3%	Imagenet 22k
Clarifai	2013	1st	11.7%	no
Clarifai	2013	1st	11.2%	Imagenet 22k
MSRA	2014	3rd	7.35%	no
VGG	2014	2nd	7.32%	no
GoogLeNet	2014	1st	6.67%	no

Machine Learning in Simple Robotics

- Powerful processors now even in Educational Robots like LEGO EV3

- ARM9 processor with memory and storage

- Run an Ubuntu desktop on the EV3

    - Ev3dev

- Can be used to apply Machine Vision in real-time
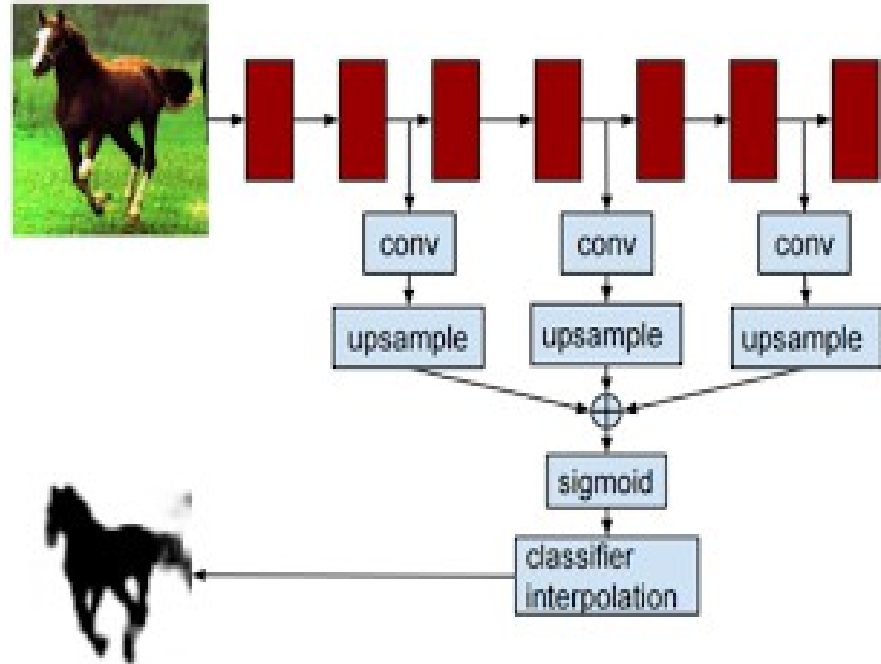
Basics of Machine Learning

Microsoft Azure Machine Learning: Algorithm Cheat Sheet
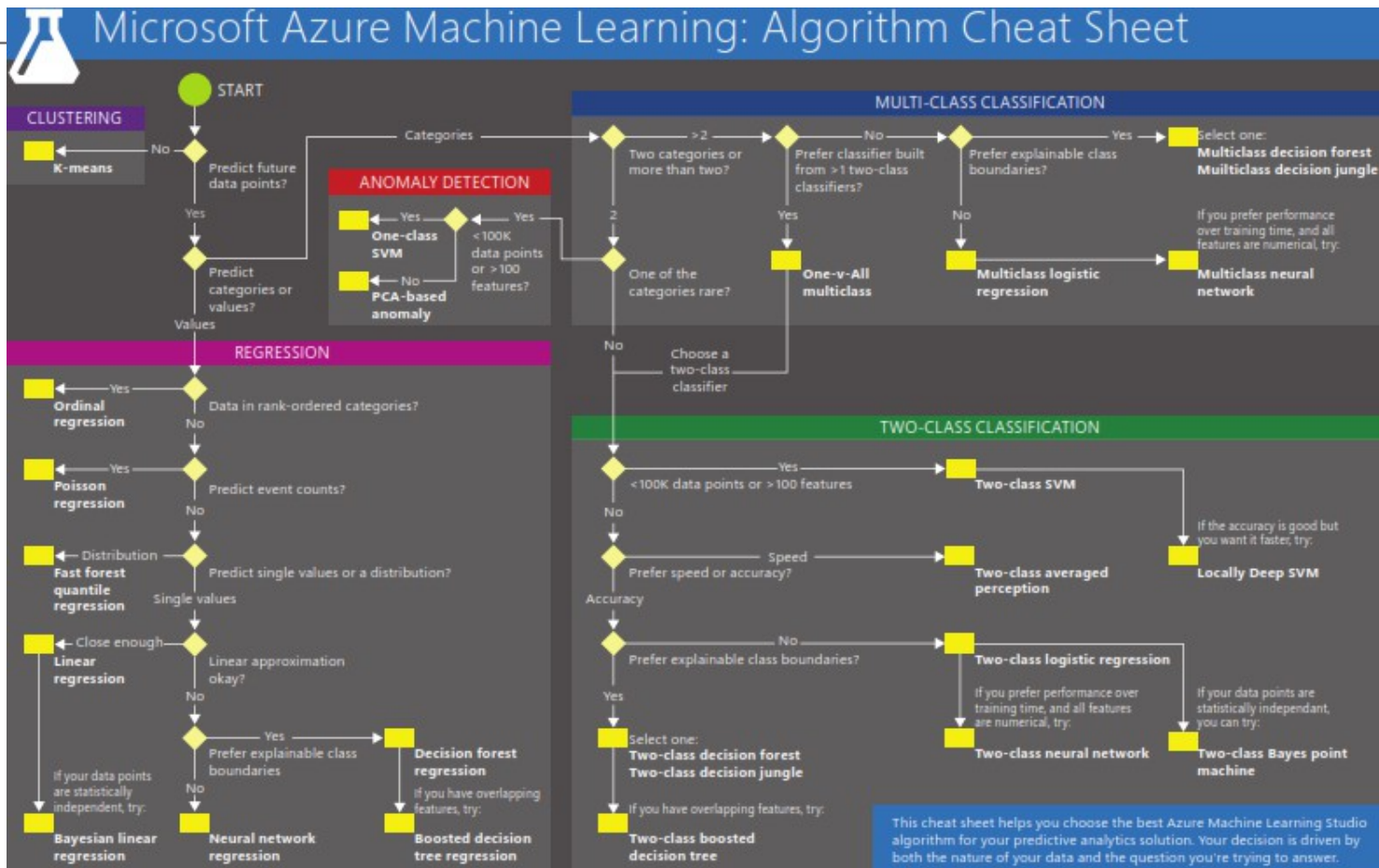
Recent advances in ML

- CNN for Image Slassification, Segmentation

- Image search

- Ex, photos.google.com
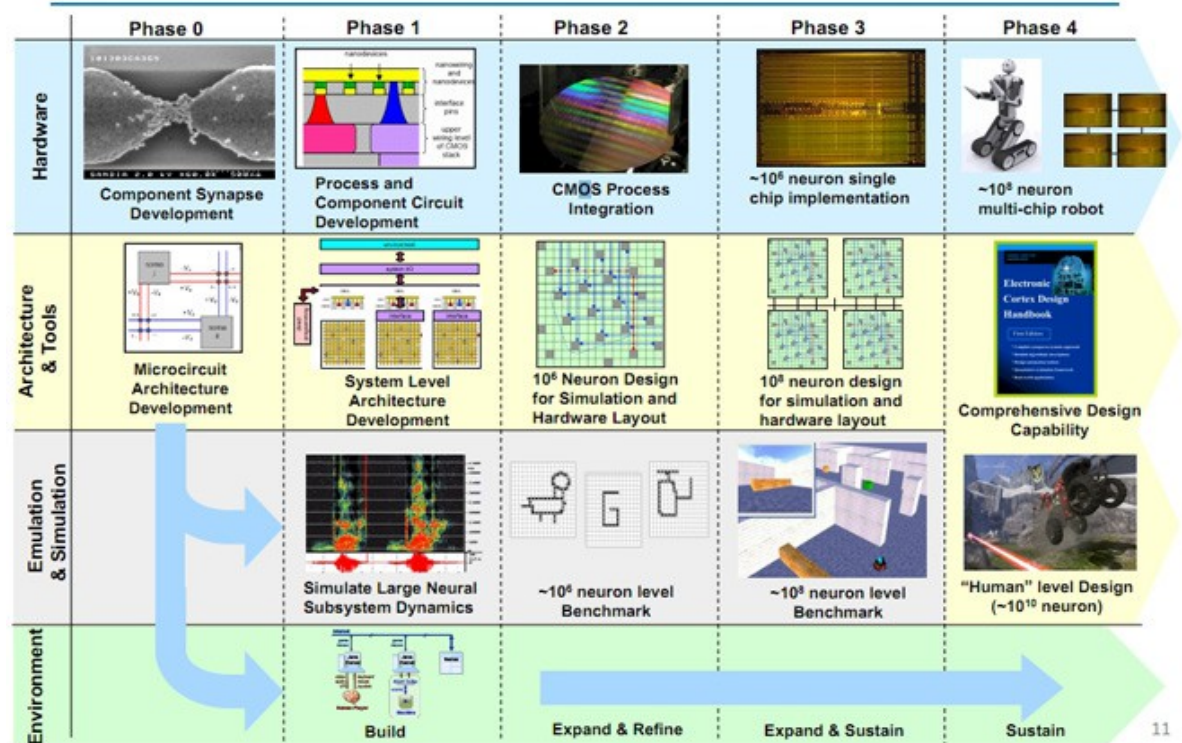
Hardware acceleration of Machine learning

- VLSI integration

- IBM / DARPA

- Qualcomm Zeroth

- ...

Machine Learning summary

- Classic techniques like SVMs are still widely used – Fruit sorting, ...

- Recently new configurations of Neural Networks have been introduced

- Scene/ Image classification has made huge strides with Convolutional Neural Networks
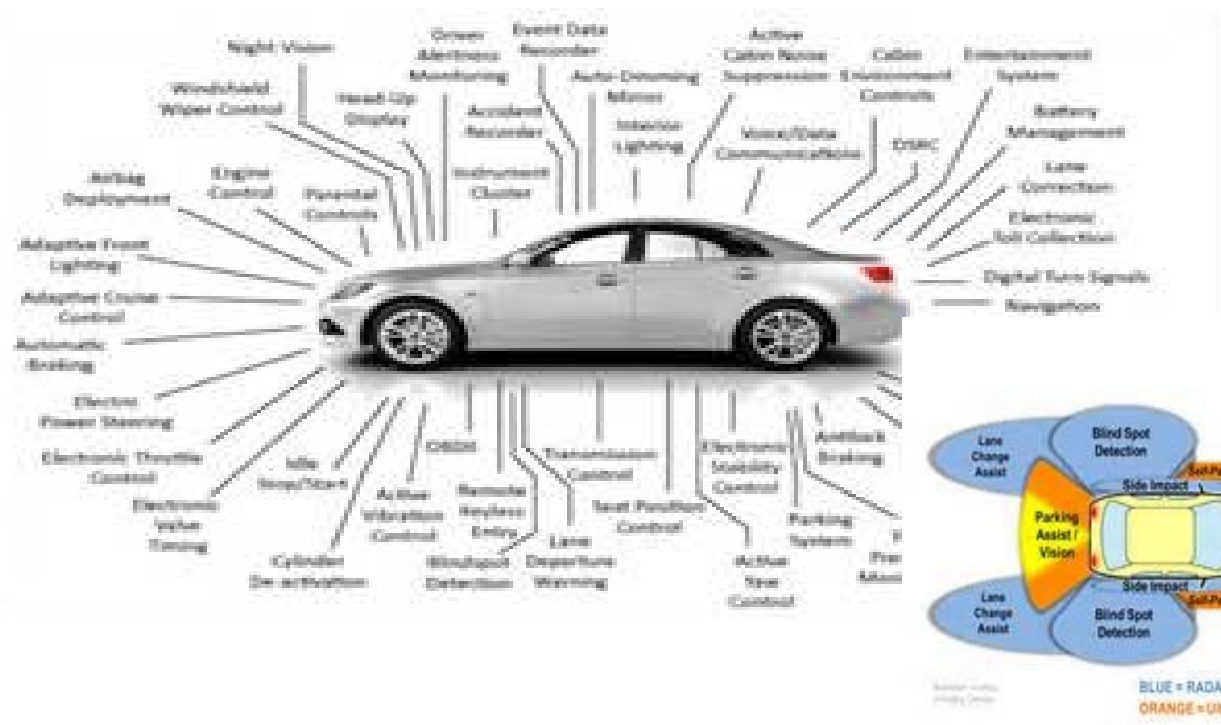
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- Discussion

  – Where can ML be used more efficiently ?

Use-cases – CE in Automobiles

Electronics in Automobiles

CE in Automobiles

- Apple carplay

- Android Auto

Control with a word. Or a touch. Or a twist.

CarPlay features Siri voice control and is specially designed for driving scenarios. It also works with your car's controls — knobs, buttons, or touchscreen. And the apps you want to use in the car have been reimagined, so you can use them while your eyes and hands stay where they belong.

Voice
To activate Siri voice control, just press and hold the voice control button on the steering wheel.

Touch
If your CarPlay–equipped vehicle has a touchscreen, you can use it to control CarPlay.

Knobs and Controls
CarPlay also works with the knobs, dials, or buttons in the car. If it controls your screen, it controls CarPlay.

Integration of CE into Automobiles

- 5 years back – Dashboard

- Future dashboards

- Need of Graphics and Compute

- Driver-less cars

- Safety

| Criteria	Apple CarPlay	MirrorLink 1.1	OEM Solutions	Harman Aha
Support OS	IOS	OS Agnostic	Android, IOS mainly	Android, IOS
Number of Apps	Limited	Limited	Ford Ranks very High	High-Delivery as Radio Stations
Type of Apps	Music, Navigation with Traffic	Parking, Music and LBS	Music, LBS, Navigation, Social Networking, etc.	Music, LBS, Social Networking
Natural Speech Support	SIRI Integration	Dependent on OEM Voice Option	In-car Voice Recognition	In-car Voice Recognition
Uptake Rate	Nascent Deals with 60% OEMs	VW, PSA, and After-market Devices	Ford Ranks Highest, Others Limited Appeal	Available on More than 60% US OEMs
Other Features	Hands-free Calling, Messaging	NA	Hands-free Calling, Messaging, Emailing	NA
USP	Apple I Devices, Volumes, Developer Ecosystem	Driver Distraction Guidelines Set by Consortium of Auto Players	OEM Control over Features, Apps, and Integration Level – Customer Focused	Delivering Apps Over Radio Stations And Controlling it with Voice

Security in Automobile Electronics

Hacked !!

CENTER FOR AUTOMOTIVE EMBEDDED
SYSTEMS SECURITY

How critical is Safety ?

- "Toyota has agreed to a $1.2 billion fine to settle a U.S. government criminal case over unexpected acceleration in Toyota and Lexus vehicles that resulted in injuries and deaths. A jury in Oklahoma found that, in one case at least, the culprit was the ***firmware***"
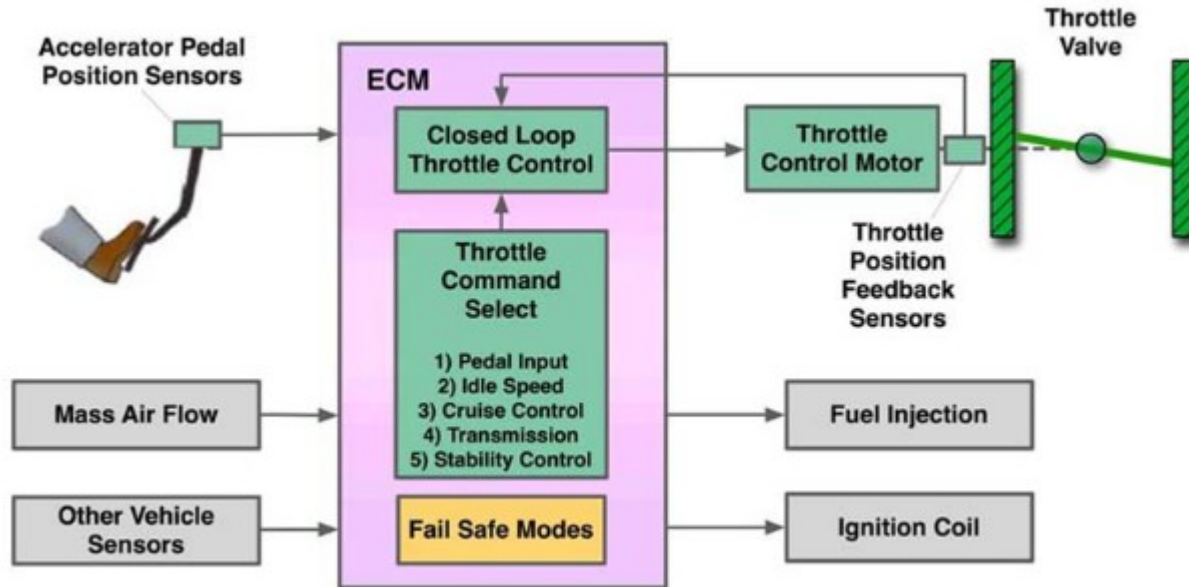
Automotive Radar - Safety and Convenience

- Medium range for Pedestrian detection

- Short range for in-cabin use-cases

- Advantages

  - Blind Spot Detection

  - Distinguishes easily between static and moving objects

  - Realizes high spatial resolution in a narrow bandwidth

  - 24 GHz – 80 GHz

  - Can separate objects in space, speed and angle already in the raw data measurements

CE in Automobiles - Summary

- Machine Learning, Intuitive Graphics, and Safety – will determine which technologies win in the automotive space

- In addition to pure computational throughput, Safe processing (including Redundancy) will need to be enabled in Automobiles

Research Trends in Consumer Electronics

- Camera and Sensors – Bringing them always on

- Sensor fusion to derive more use-cases (ex, 3D scanning using Color + Depth cameras)

- Low power HW architectures for CPUs and GPUs

- Battery chemistry - techniques

- CNN based Machine Learning for Recognition, Classification …

- Protocols for IoT networks

-

- How to keep ahead ?

    - Use http://arxiv.org/ !!!

Summary

- Covered top 5 important areas for Consumer Electronics and related fields

- Discussed new use-cases employing Sensors and User Interfaces

- Identified and discussed Research Trends in CE

Thank you !!

2015