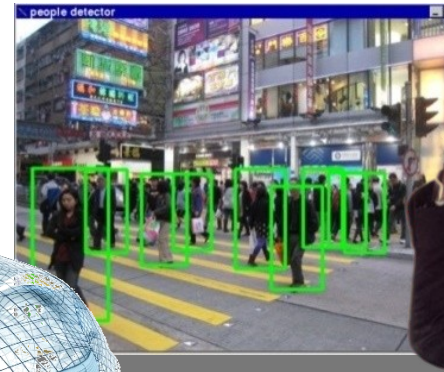
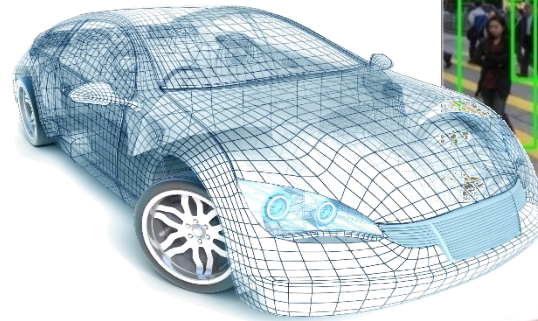


# Embedding Artificial Intelligence into Our Lives

Michael Thompson, Synopsys  
D&R IP-SOC DAYS Santa Clara  
April 2018



# Agenda

Introduction

What AI is and is Not

Where AI is being used

Rapid Advance of AI

Summary

# Artificial Intelligence

Artificial intelligence (AI) is the enabling of a machine to perceive its environment and respond in a way that increases its usefulness to us.



## **It's Been Around for 60 years**

John McCarthy coined the term in 1956 at a Dartmouth conference

## **Moving from Mainframe to Embedded**

Requires very high-performance coupled with low power and cost

## **Evolving Rapidly**

Today encompasses range of applications from search in the cloud, to cars, robotics, games, speech recognition and translation, vision, and more

# Realizing AI's Full Potential

*Humans are Fallible Drivers*

## Annual Global Road Crash Statistics

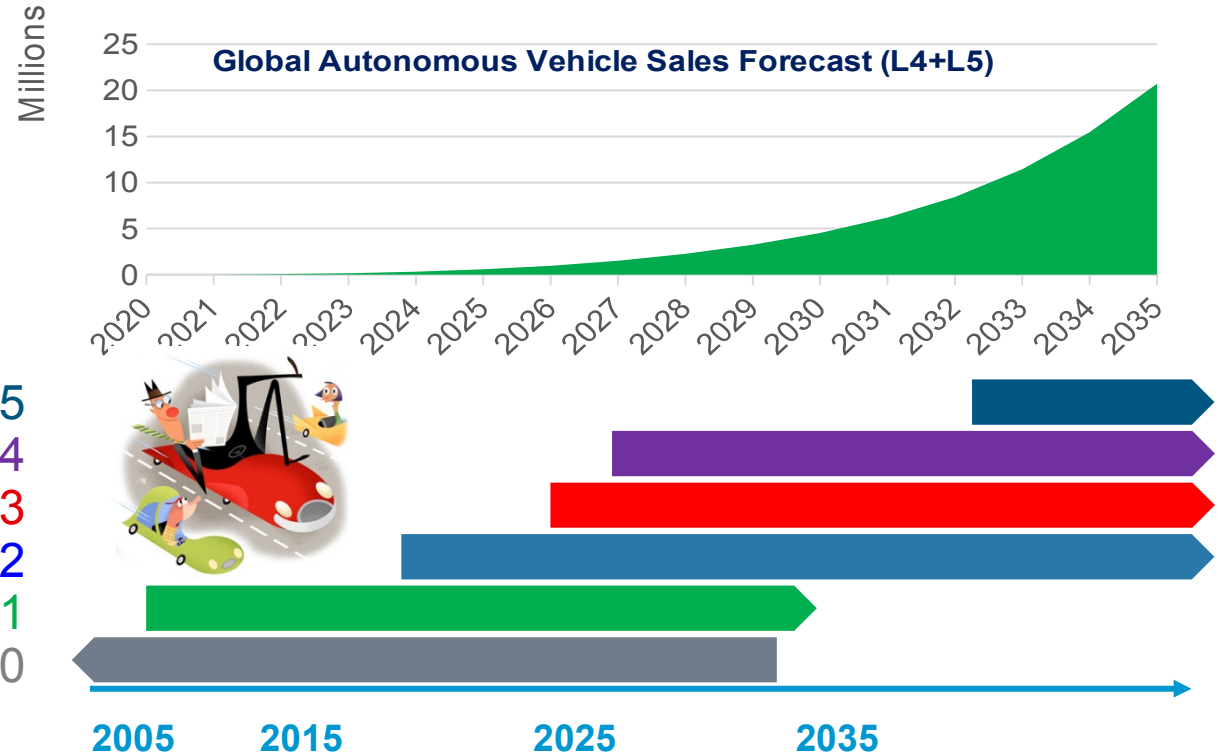
- 1.3 million people die in road crashes, 3,287 deaths a day.
- Additional 20-50 million are injured
- Road crashes cost USD \$518 billion globally

94% of accidents caused by human error

– 2% environment, 2% mechanical, 2% margin error

## ADAS Systems

- Lane keeping, lane change, lane departure
- Pedestrian Detection
- AEB/Automatic Emergency Braking), forward collision
- Adaptive cruise control
- Traction and stability control
- Blind spot monitor



It will take years to realize the full potential of AI

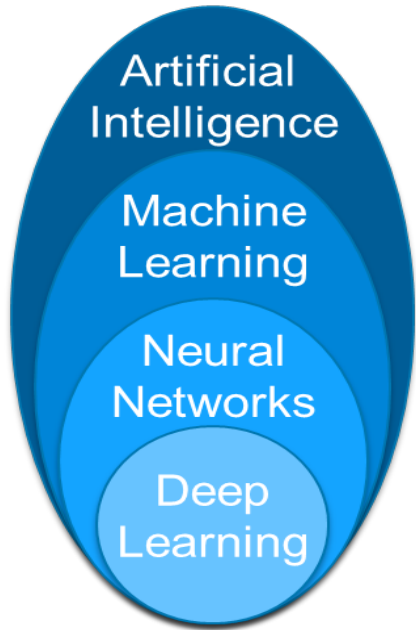
# What Does This Look Like in 20 Years?

*We Are Entering the AI Era*



AI will increase productivity, data access, safety and change how we interact, work, live

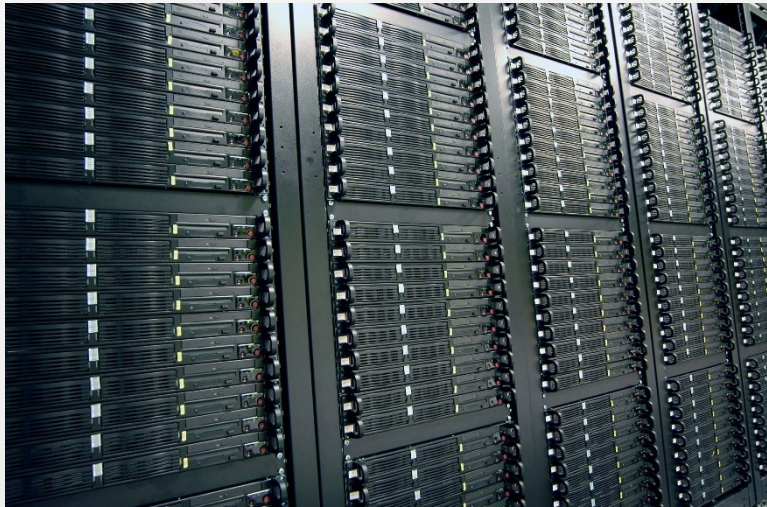
# Artificial Intelligence and Deep Learning



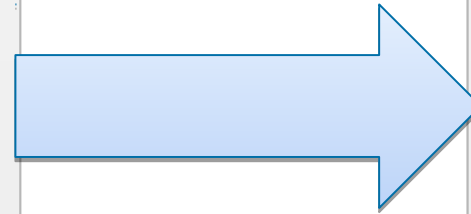
- Artificial Intelligence
  - \_ Narrow AI (weak AI): Technology outperforming humans in a narrowly defined task
  - \_ Artificial General Intelligence (strong AI): Human levels of intelligence exhibited by machines
- Machine Learning
  - \_ Application of AI uses algorithms to analyze data and infers information about real world
- Neural Networks
  - \_ Class of machine learning algorithms modeled after the human brain
  - \_ Neuron represents the computational unit, network describes how units are connected
- Deep Learning / Deep Neural Networks
  - \_ A subset of machine learning using artificial neural networks
  - \_ Deep neural networks are capable of learning using large data sets

# AI Moving from Cloud to Embedded

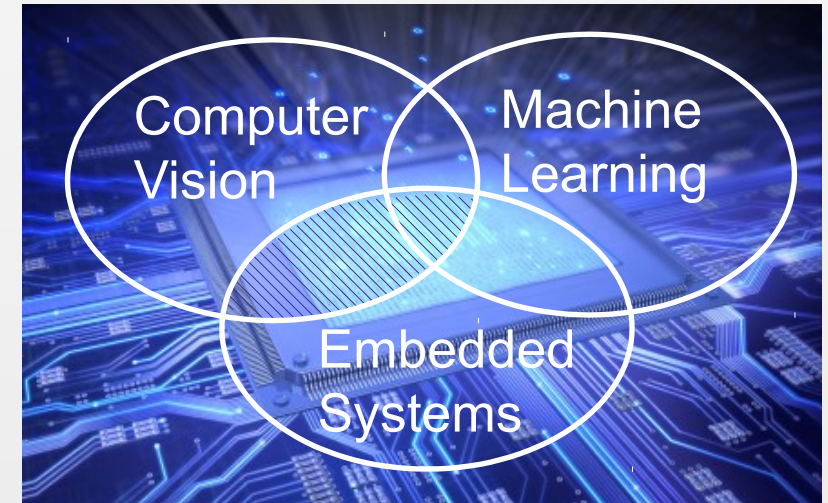
## From Computer Vision



- Large scale server farms
- High cost
- High energy use
- Large footprint



## To Embedded Vision



- On-chip
- Cost effective
- Energy efficient
- In your pocket

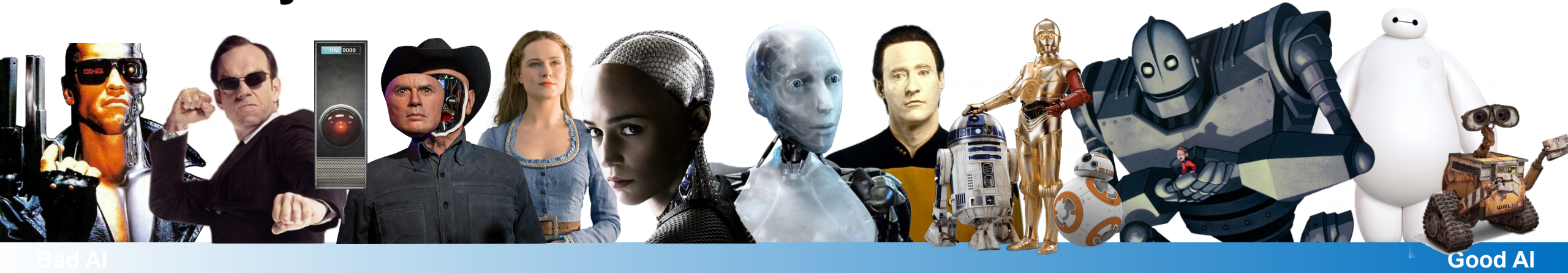
# Is AI Intelligence?

- Not everyone considers AI to be intelligence
  - Sophisticated manipulation of data and our emotions
  - This point of view is not unreasonable
- Intelligence can be defined as:
  - Ability to perceive the environment and take actions to maximize the chance of success
    - What AI is today
  - Can also be defined as the skilled use of reason
    - What humans do
    - AI will eventually encompass the ability to reason and will likely eclipse human intelligence
    - But ability to reason and human intelligence are very complex processes





# AI Today



- When we think of AI we tend to think of humanoid machines
- Reality is more Amazon Echo
  - Combines voice recognition (perception), fast processing (decision making), and an action (response)
- Perception: Sensors, cameras, a database, spoken request or other sources
- Processing: local processor, in the cloud, or both to increase performance
- Response: audio, mechanical, database update, visual, something else



# Levels of AI in Use Today

- Low-end - Chess games
  - Use brute force to analyze all moves with next move based on a series of moves with the highest chance of winning (Deep Blue, DeepChess)
- Mid-range – Object recognition and classification
  - Requires an understanding (training) of what is being looked for
- High-end - Language translation
  - Requires an understanding of word structure and context in the language that the words are being translated to and from
  - More than brute force computation
- These are all Narrow AI (weak AI) and do not require human levels of thinking



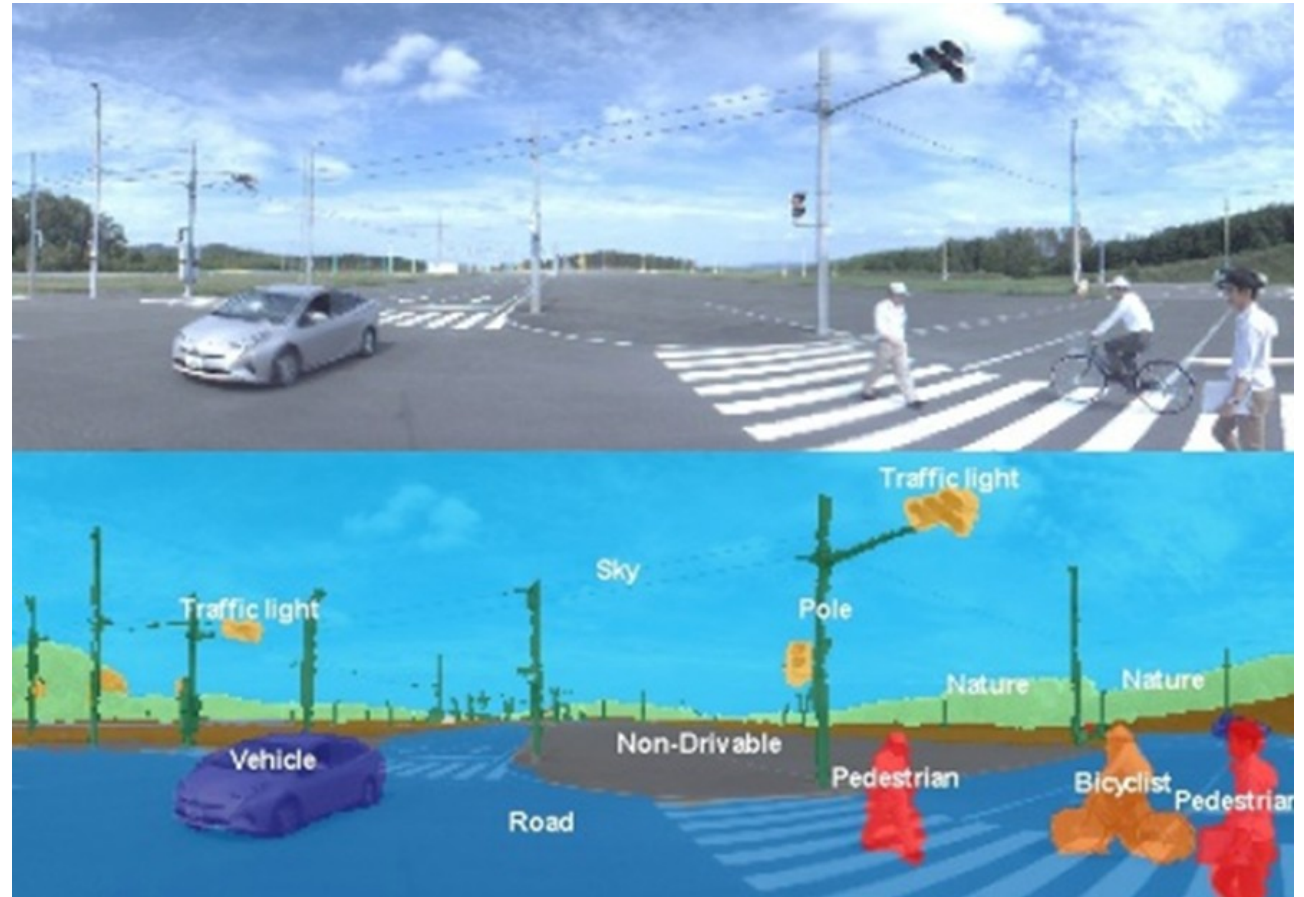
# Definition of What is AI Changes Over Time

- Tasks that were once defined as AI have been removed from the list
  - Optical character recognition and expert systems
  - No longer considered AI because they are considered routine
- A List of things that are generally considered to be AI in 2018
  - Competing at a high level in a strategic game (chess and Go)
  - Understanding language
  - Interpreting complex data
  - Intelligent routing in content delivery networks
  - Autonomous vehicles
  - Machine vision
- List will change over time
  - Due to advancements in AI
  - As applications become routine



# Machine Vision

- Has been around for years
- Evolving and moving to embedded
- Machines now achieve higher levels of accuracy than human experts
- Orders of magnitude faster than humans
- New algorithms are faster and more accurate
- Scene segmentation can be done on HD video at 60 fps
- The results are truly amazing



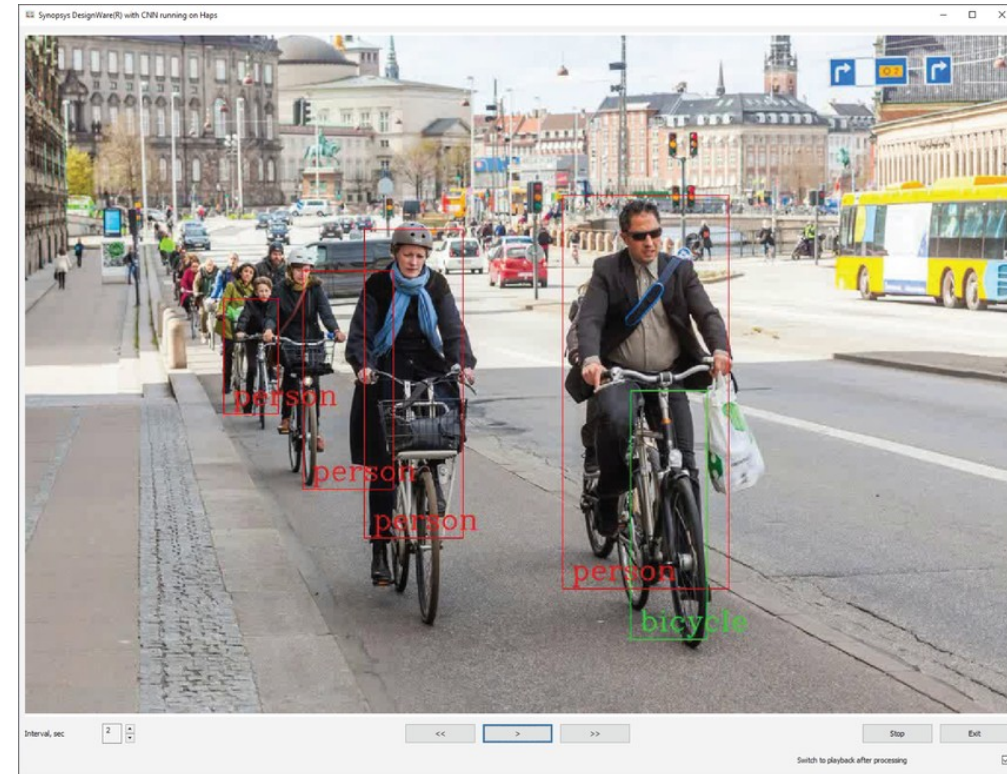
# Skyfall YOLO v2 Video



[YOLO v2 Video](#)

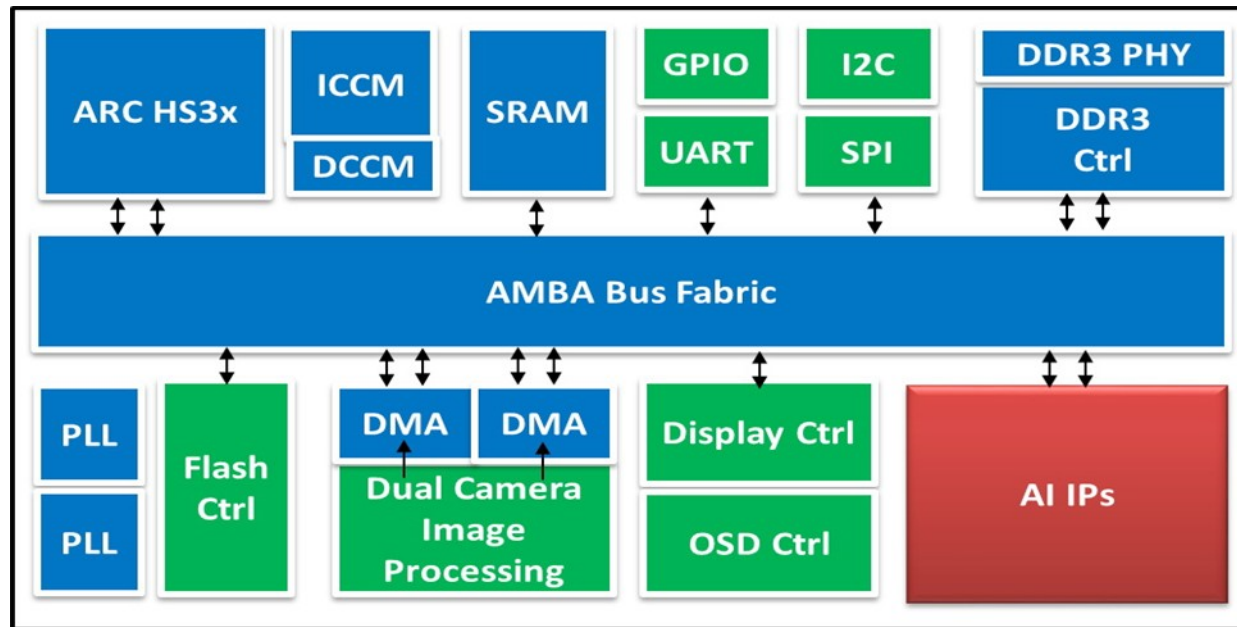
# Neural Networks

- Widely used for machine vision
- Have dramatically increased accuracy
  - Mimic the way our brain learns
  - Uses information and training to recognize patterns
  - New algorithms are faster, more accurate, and simpler
- Used in other applications too
  - Character recognition
  - Text generation
  - Language translation
  - Audio
- NASA uses NN to analyze data from telescopes
  - More accurate than humans and much faster
  - Recently found an 8<sup>th</sup> planet revolving around Kepler-90 that is 2545 lights years away
    - First known solar system with 8 planets outside of our own



# Implementing AI in Embedded Applications

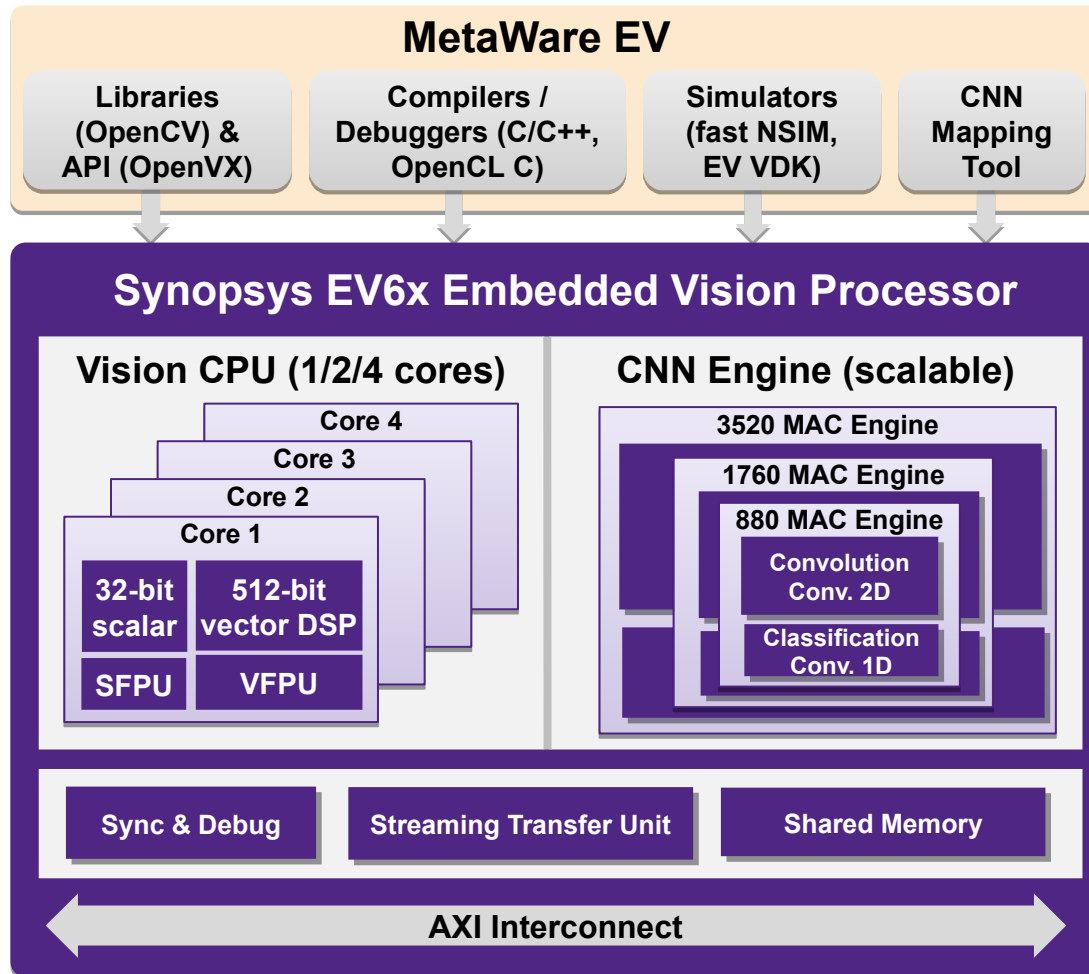
- Being facilitated by advancements in microprocessor capabilities
- Combined with advancements in process technology
- Enabling very small processors with performance levels that were unattainable a few years
- ARC HS cores deliver up to 7500 DMIPS per core, fit into 0.06mm<sup>2</sup> and use 50uW/MHz power
- Can be scaled to even higher performance with dual-core and quad-core versions



AI development platform using ARC HS that can be used for various AI applications developed by NARL in Taiwan

<http://www.cic.org.tw/aisoc/aisoc.jsp>

# Specialized Embedded Vision Processors

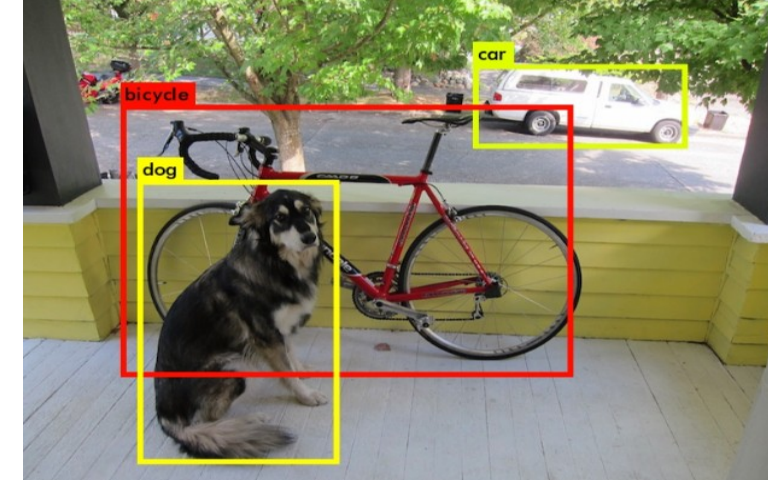


- Offer the highest performance for embedded applications
- Target vision applications and use Neural Network capabilities
- Replacing GPUs in many applications
- Synopsys EV6x processors deliver up to 4.5 Tera MACs per second
- Support for full range of CNN algorithms
  - AlexNet, GoogLeNet, ResNet, SqueezeNet, TinyYolo, Yolo v2 and others
- High productivity standards-based toolset
  - OpenCV libraries, OpenVX framework, OpenCL C compiler, C/C++ compiler and CNN mapping tools

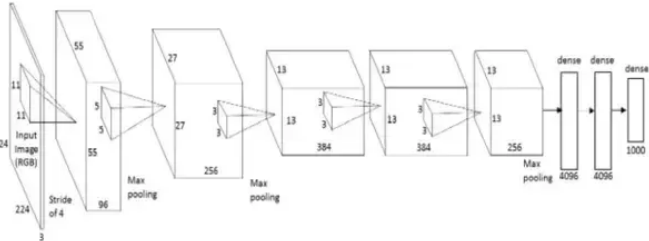


# Dramatic Algorithm Improvement

Object Classification with CNNs



## AlexNet



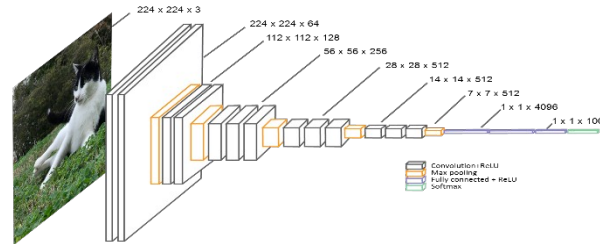
2012

Classification (1000)

8 layers, 15.4% error

*Coming out party for deep learning techniques at ILSVRC*

## VGG16



2014

Classification (1000)

16-19 layers, 7.3% error

*Simple 3x3 convolutions and deeper layers*

## GoogleNetv1



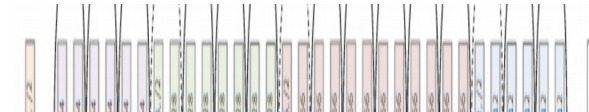
2014

Classification (1000)

22 layers, 6.7% error

*Introduced the idea that CNN layers didn't always have to be stacked up sequentially*

## Resnet



2015

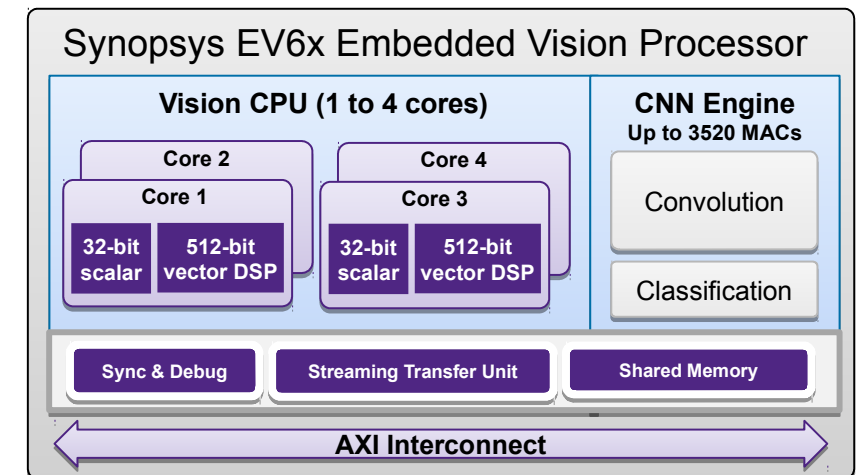
Classification (1000)

152 layers, 3.6% error

CNN Graphs for Classification

# The AI Era Begins

- Interesting to see how AI develops over the next 10 years
  - Cars will drive themselves,
  - Personal assistants will be a great deal more clever
  - Seamless natural language translation
- Amazing new AI applications that haven't been thought of yet
- Enabled by advanced processors like Synopsys EV6x family
- We are on the leading edge of the era of artificial intelligence and just starting to see the capabilities
- AI won't replace us as some fear, but as it evolves over the coming years it will have a profound impact on our lives



# Thank You

