# EBU7240
# Computer Vision
## - Introduction -

*Semester 1, 2021*

**Changjae Oh**

# What is coming?

# What is missing?



Machines are blind



Machine vs Human

# Computer Vision in Four Words?

**Making** **computers understand** **images**

## How simple is that?

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# Computer Vision in Four Words?

## :: Making computers understand images

- How many **people** are here?
- Who is a **person in the portrait**?
- What is this **building**?
- How is the **weather**?
- Where is **this city**?
- What is **written**?
- Is there any **gate**?

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# Computer Vision in Four Words?

## :: Making computers understand images

- How many **people** are here? → **Object detection**
- Who is a **person in the portrait**? → **Face detection/recognition**
- What is this **building**? → **Object recognition**
- How is the **weather**? → **Scene recognition**
- Where is **this city**? → **Place recognition**
- What is **written**? → **Character recognition**
- Is there any **gate**? → **Object detection**

# What is vision?

- What does it mean, to see? "*to know what is where by looking*".

- How to discover from images what is present in the world, where things are, what actions are taking place.

- "Vision can be understood as an information processing task which converts a numerical image representation into a symbolic shape-oriented representation."



Human
Arm
Forearm
Hand

Credit: Marr, 1982
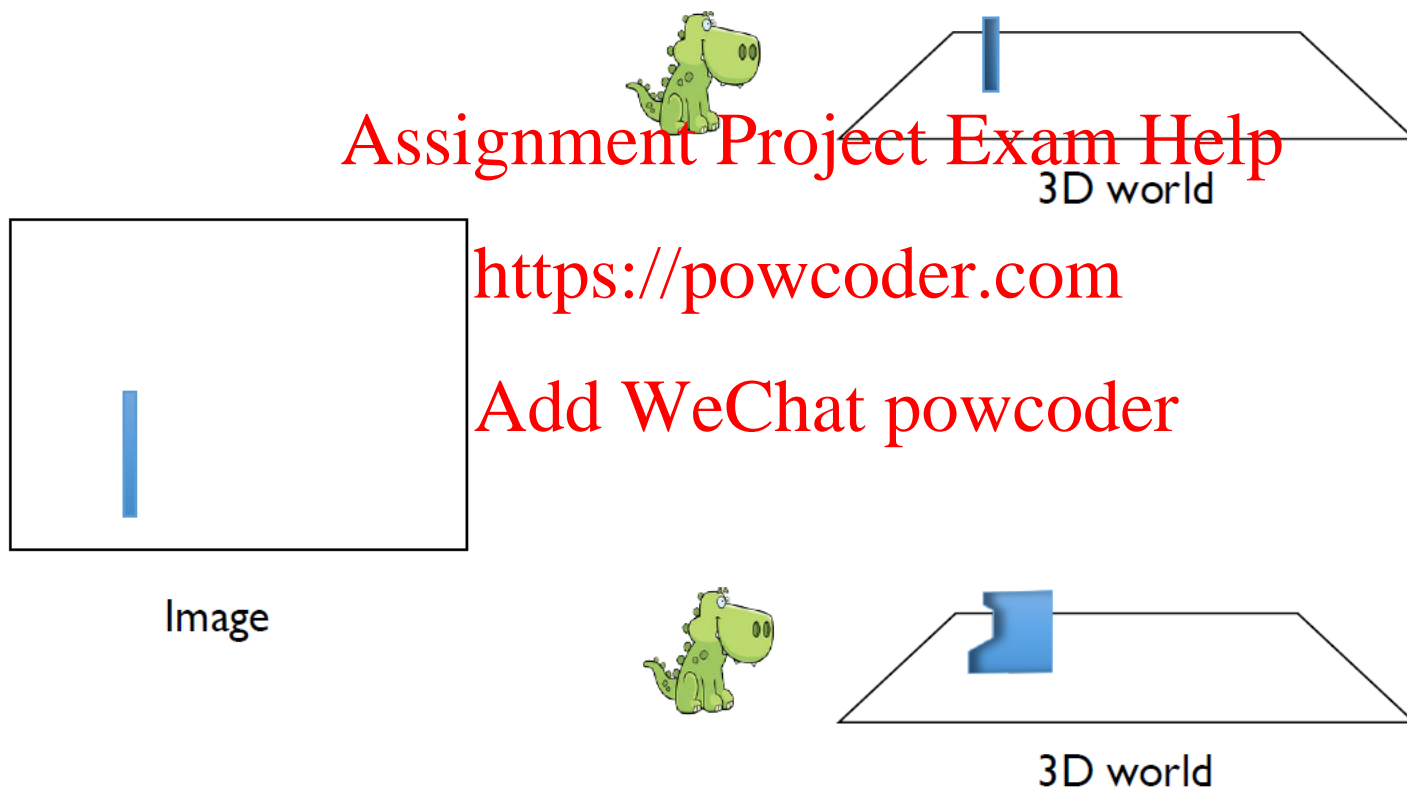
# Why is vision so hard?

- 3D: Viewpoint

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Image

3D world

3D world

# Why is vision so hard?

- 3D: Viewpoint

# Why is vision so hard?

- **Light**

Credit: A. Torralba

# Why is vision so hard?

- **Shadow**



Edward H. Adelson

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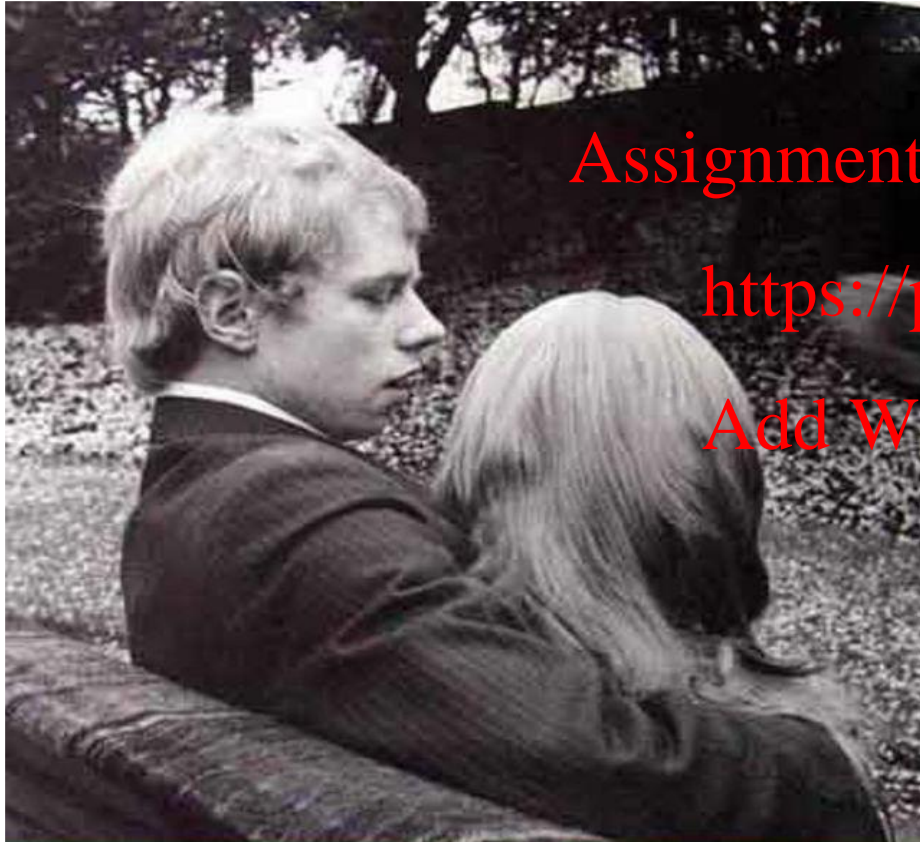
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# Why is vision so hard?

- **Shadow**



Credit: Mike Webster

# Why is vision so hard?

- **Transparent objects**
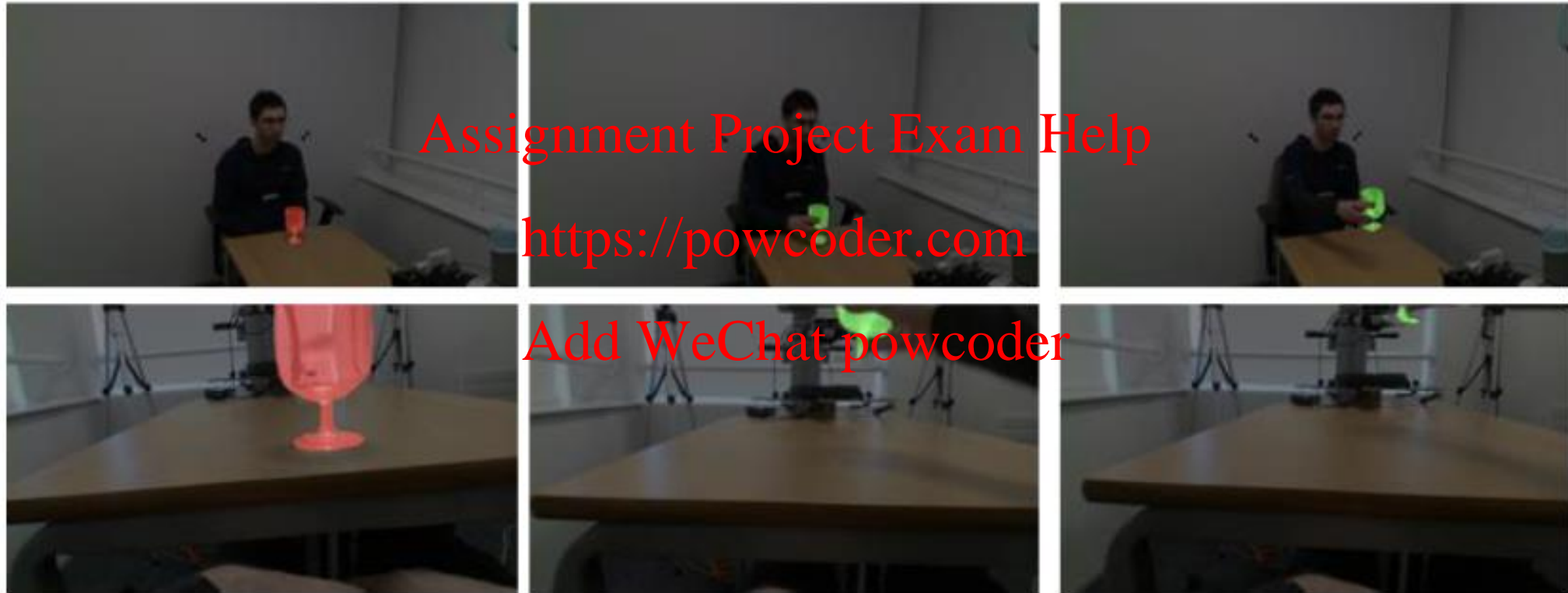
Credit: Hengyi Wang (JP Final project 2021)
http://corsmal.eecs.qmul.ac.uk/

# Why is vision so hard?

- **What is this object?**

# Why is vision so hard?

- **What is this object?**

# Why is vision so hard?

- **What is this object?**



Look-Alikes by Joan Steiner
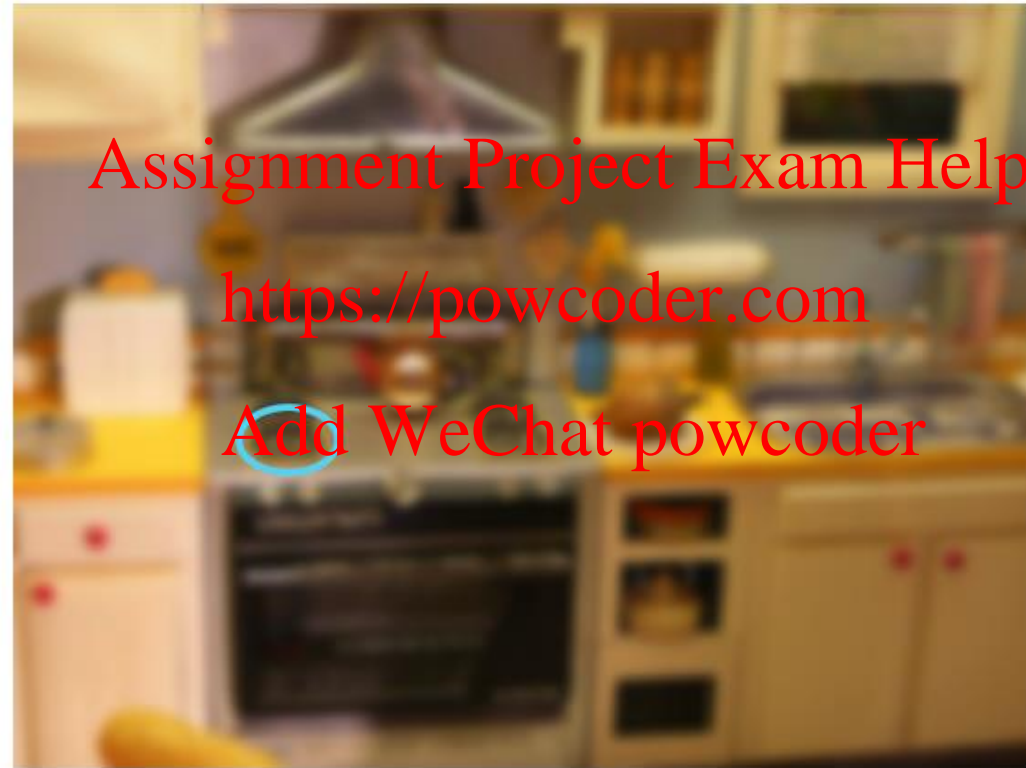
It is not just about pixels!

# Computer Vision and Image Processing?

- **Computer Vision begins with Image Processing!**

Machine Learning
Artificial Intelligence

**Computer Vision**

Audio Processing

**Image Processing**

Signal Processing

Mathematics
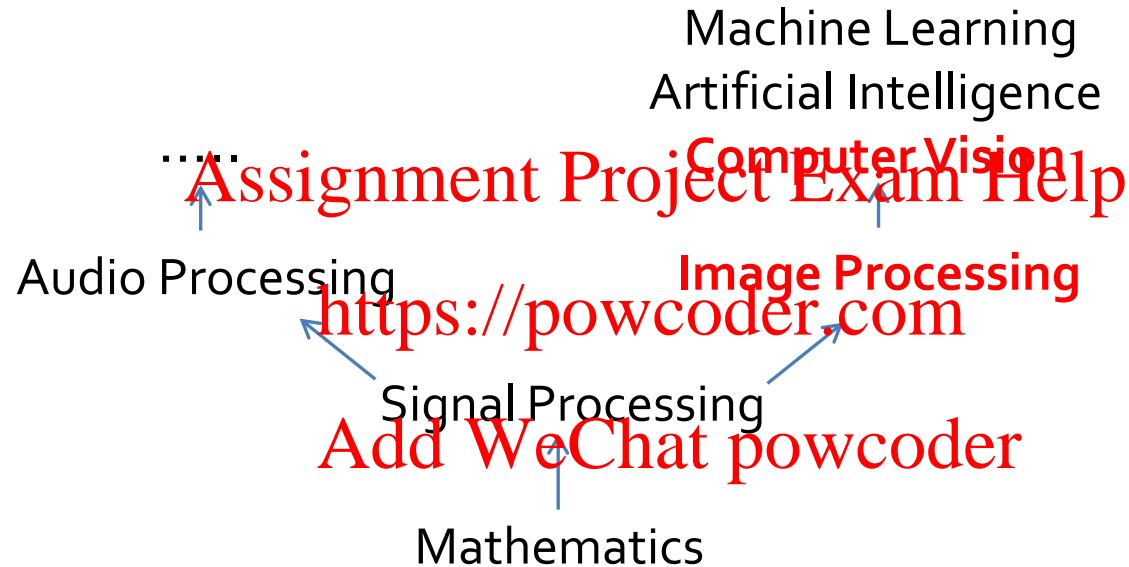
- **Computer Vision**: techniques for enabling a computer to see a real-world using **images** as the human being does.

- **Image Processing**: fundamental techniques for image acquisition, processing, analysis

# Computer Vision and EBUxxxx?

EBU6018
Advanced
Transform Methods

EBU5303
Multimedia
Fundamentals

EBU6230
Image and
Video Processing

EBU7240
Computer
Vision

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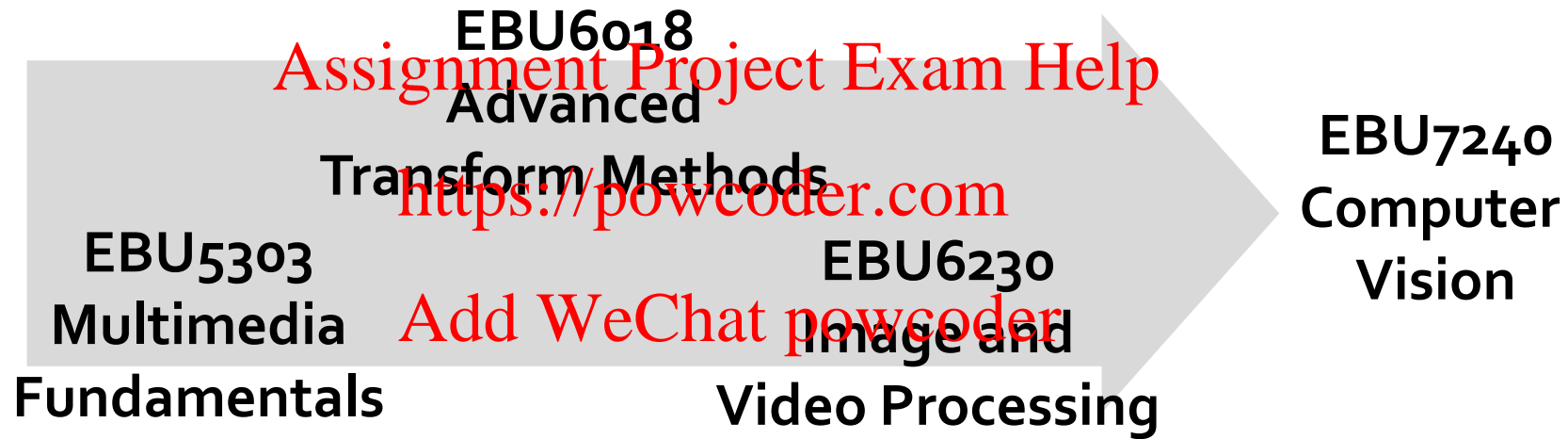
# Computer Vision: Low-level Vision

**Low-level vision**

- Enhancement

- Restoration

- Filtering

- Feature extraction

Mid-level vision

- Fitting

- Grouping

- 3D reconstruction

- Tracking

High-level vision

- Classification

- Detection

- Tracking

- Action & Pose

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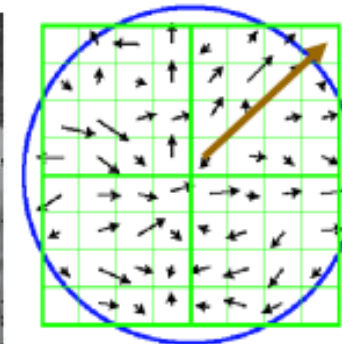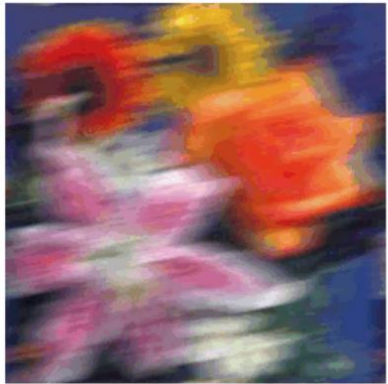
Image gradients
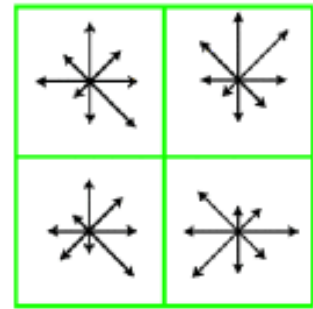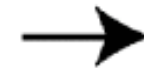
Keypoint descriptor

# Computer Vision: Mid-level Vision

**Low-level vision**

- Enhancement
- Restoration
- Filtering
- Feature extraction

**Mid-level vision**

- Fitting
- Grouping
- 3D geometry
- 3D reconstruction
- Tracking

**High-level vision**

- Classification
- Detection
- Tracking
- Action & Pose
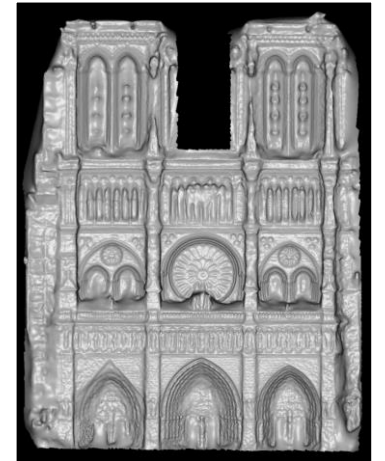
# Computer Vision: High-level Vision

**Low-level vision**

- Enhancement
- Restoration
- Filtering
- Feature extraction

**Mid-level vision**

- Fitting
- Grouping
- 3D reconstruction
- Tracking

**High-level vision**

- Classification
- Detection
- Tracking
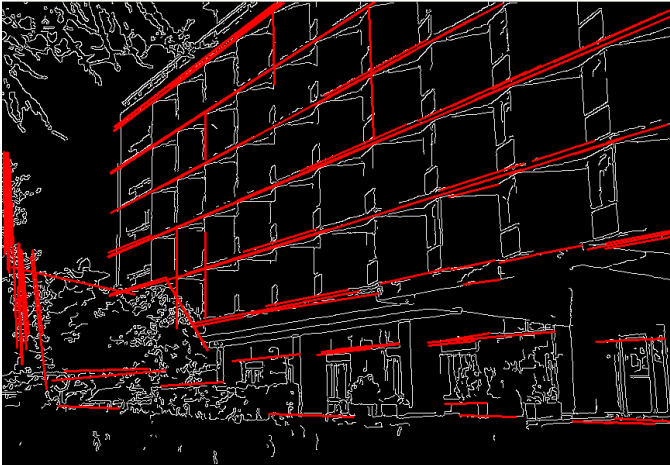- Action & Pose

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CAT

CAT

CAT, DOG, DUCK

#005 #100
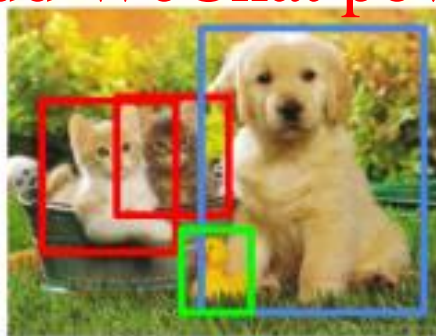
# Computer Vision: Deep learning approach

- **Multiple levels of (learned) representation**



$224 \times 224 \times 3$   $224 \times 224 \times 64$

$112 \times 112 \times 128$

$56 \times 56 \times 256$

$28 \times 28 \times 512$

$14 \times 14 \times 512$

$7 \times 7 \times 512$

$1 \times 1 \times 4096$   $1 \times 1 \times 1000$

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- convolution+ReLU
- max pooling
- fully connected+ReLU
- softmax

# EBU7240
# Computer Vision
## – Applications–

*Semester 1, 2020*

**Changjae Oh**

# Why computer vision matters?


Safety


Health


Security


Comfort


Fun
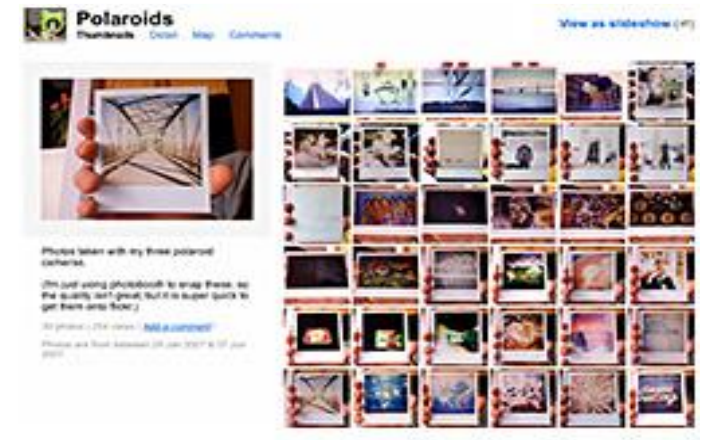

Access

# Ridiculously brief history of computer vision

- 1966: Minsky assigns computer vision as an undergrad summer project

- 1960's: interpretation of synthetic worlds
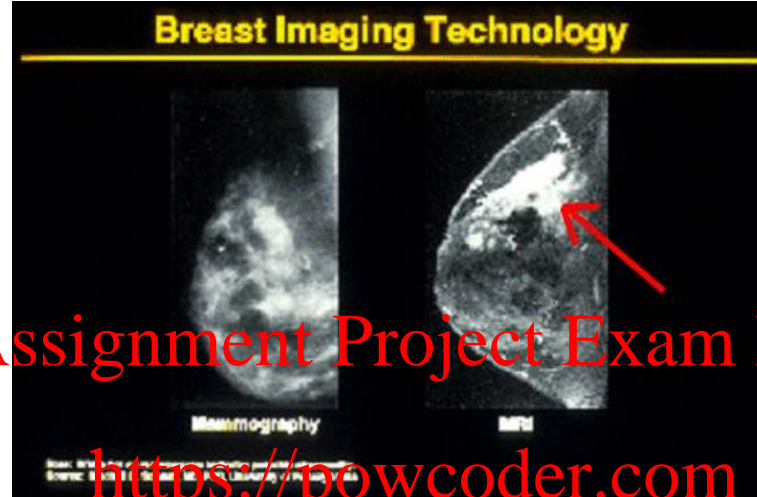
- 1970's: some progress on interpreting selected images

- 1980's: ANNs come and go; shift toward geometry and increased mathematical rigor

- 1990's: face recognition; statistical analysis in vogue

- 2000's: broader recognition; large annotated datasets available; video processing starts

- 2010's: Deep learning with ConvNets

- 2020's: Widespread autonomous vehicles?

- 2030's: robot uprising?



Guzman '68



Ohta Kanade '78



Turk and Pentland '91

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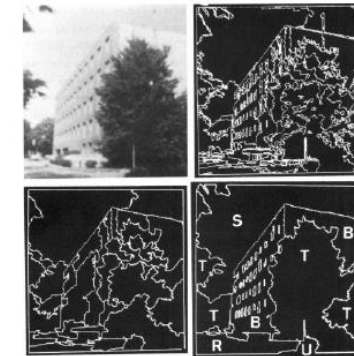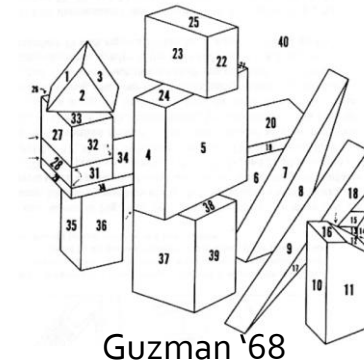
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# Applications – Motion capture

Microsoft XBox Kinect

# Applications – Face recognition



How the Afghan Girl was Identified by Her Iris Patterns

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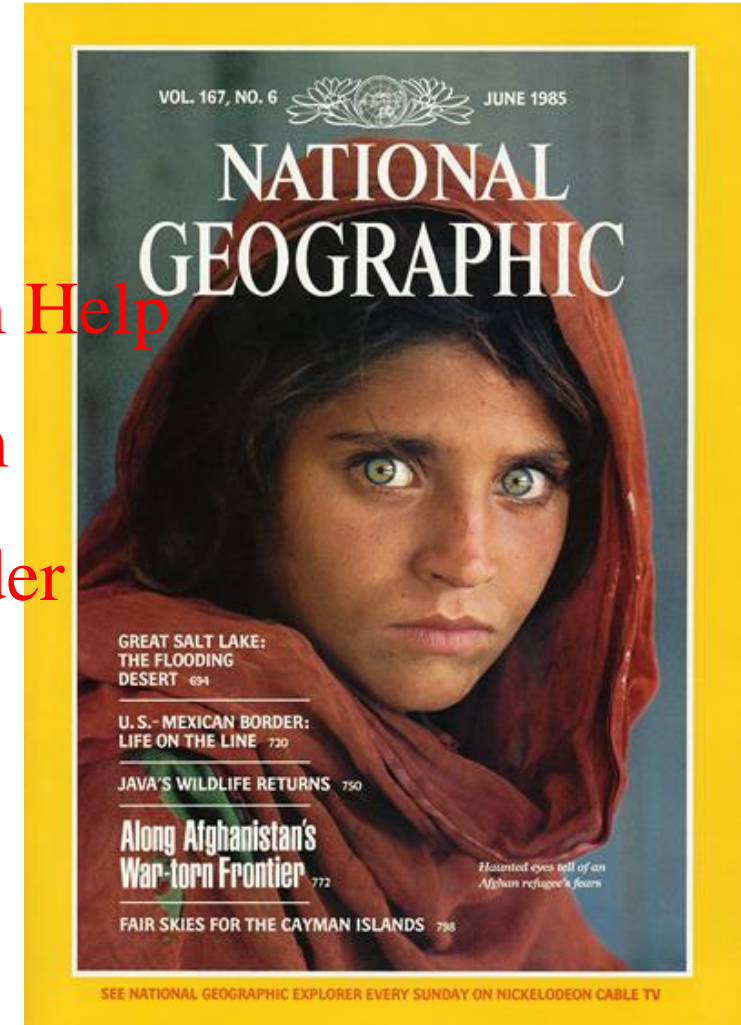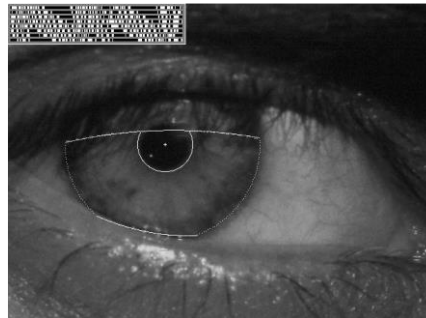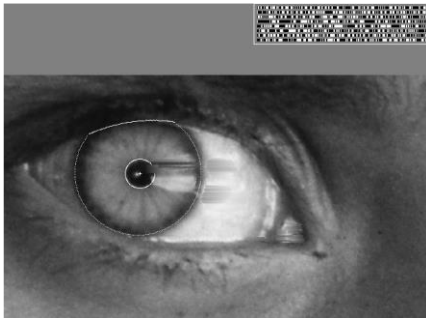
# Applications – Face Alignment



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# Applications – Smile detection



**The Smile Shutter flow**

Imagine a camera smart enough to catch every smile! In Smile Shutter Mode, your Cyber-shot® camera can automatically trip the shutter at just the right instant to catch the perfect expression.

Slide credit: Steve Seitz

# Applications – Optical character recognition (OCR)

Slide credit: Steve Seitz
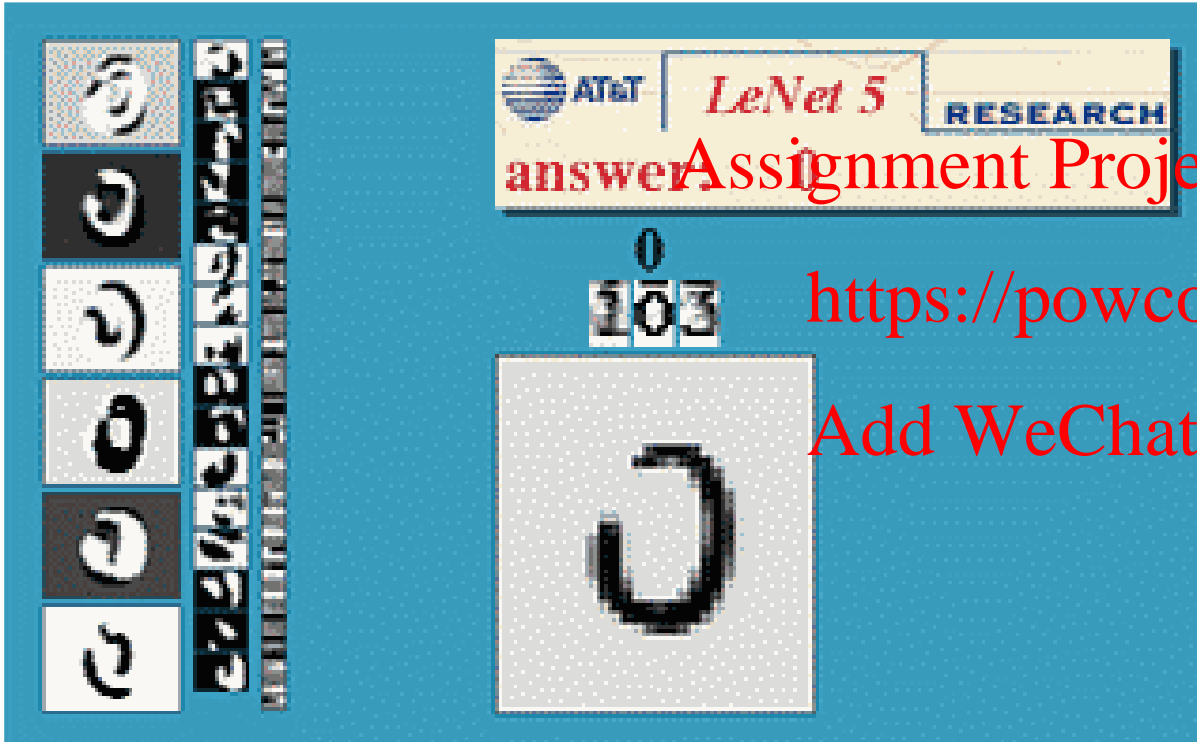
# Applications – Defect detection

https://deepsystems.ai/solutions/road-defects-detection
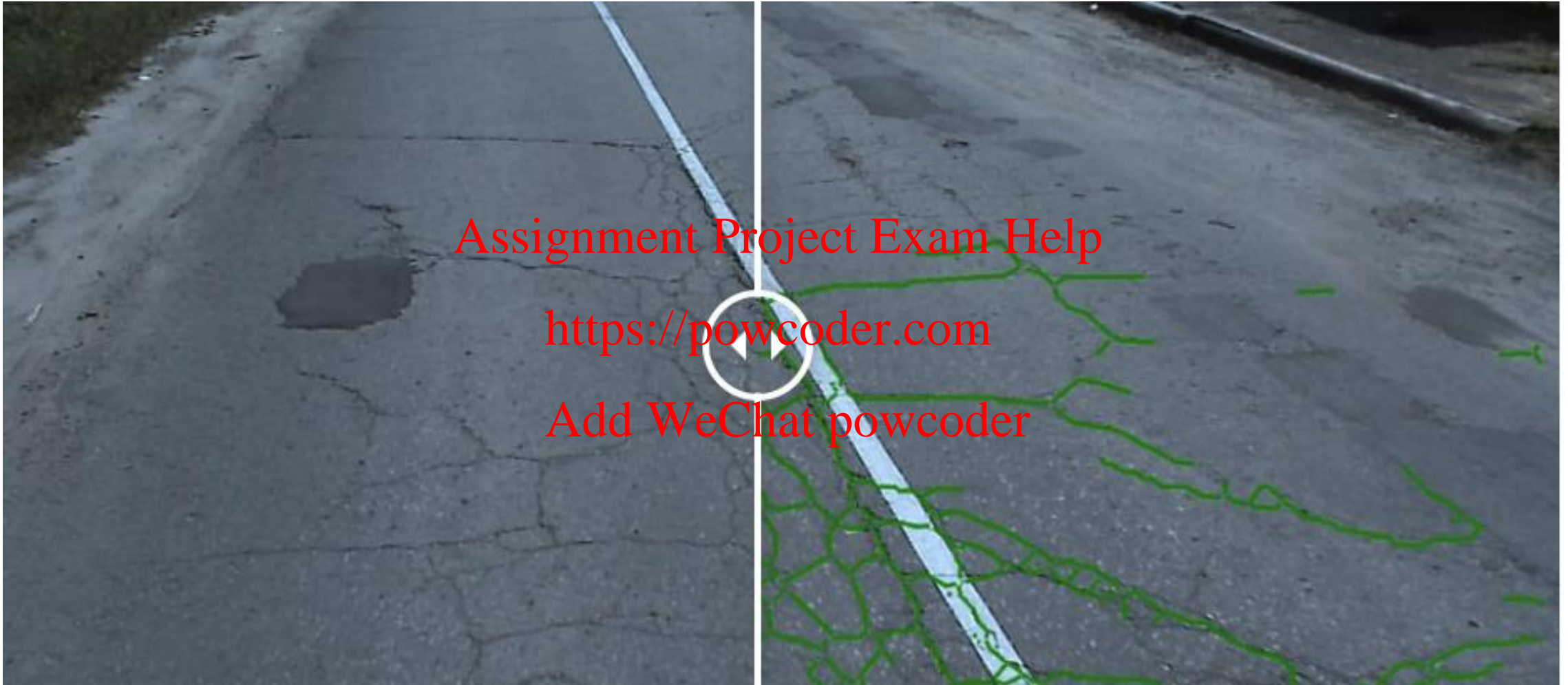
# Applications – Cleaning robot



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# Applications – Sports



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# Applications – Object recognition

# Applications – 3D from mobile phone



created 3D model

https://youtu.be/8M_-ISYqACo

# Applications – Indoor scene reconstruction



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https://youtu.be/Ebyz8xxoK1w

# Applications – Video Matting/Composition



COME INTO MY
WORLD

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# Applications – Style Transfer
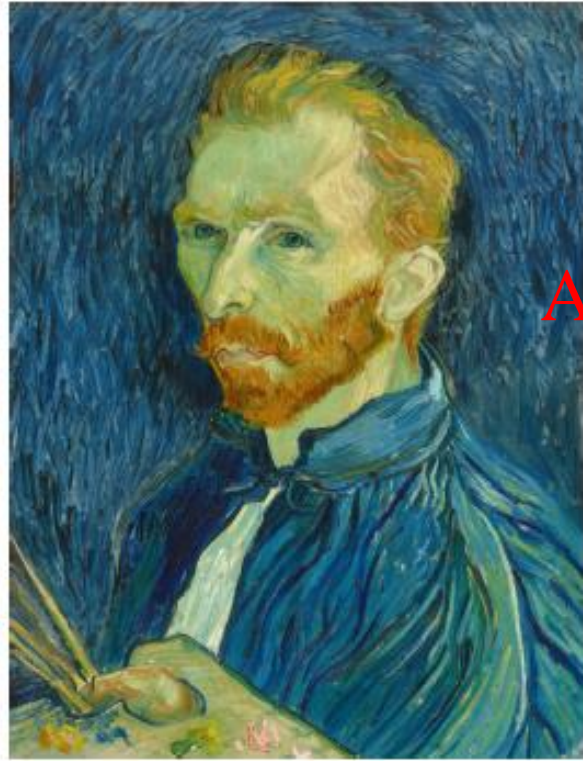


Source image (**Style**)    Target image (**Content**)    Output (deepart)

A Neural Algorithm of Artistic Style [Gatys et al. 2015]

# Applications – Self-driving cars

# Applications – Healthcare



Intensity Clipping Artifact

Source

Motion magnified x20
Linear [Wu et al. 2012]

Motion magnified x20
Phase-based

# Why is computer vision timely?

- Lots of image data is being collected

# Why is computer vision timely?

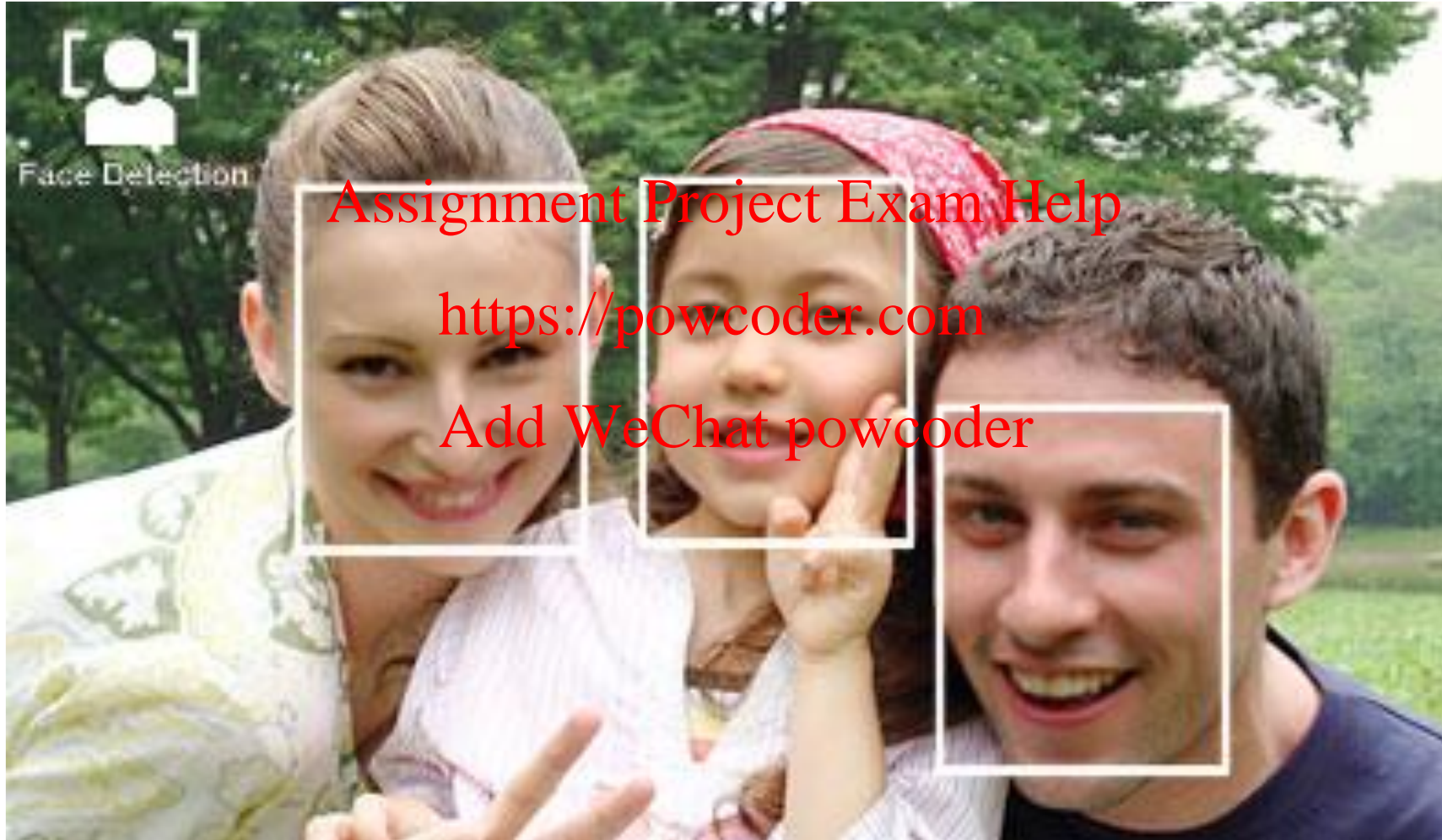- **Lots of image data is being collected**
  - Bigger data is coming



every person

every car

every place

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# Why is computer vision timely?

- **There is a lot of information in images**

# Why is computer vision timely?

- **Computer vision is starting to work …**



Face Detection

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http://www.sony-asia.com/article/271940/section/product/product/dsc-wx1

# 50 years ago

# 10 years ago...

# Next topic

- **Let's talk about a computer's eye (a.k.a. camera)**
  - Prerequisite
    - Review EBU6230 Image/Video Processing - Week2: Image Transformations

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