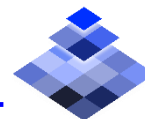


Intro to Computer Vision



Yoni Chechik

www.AliMath.com



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- **Course details**
- What is computer vision (CV)?
- Course outline
- Intro to Python

References

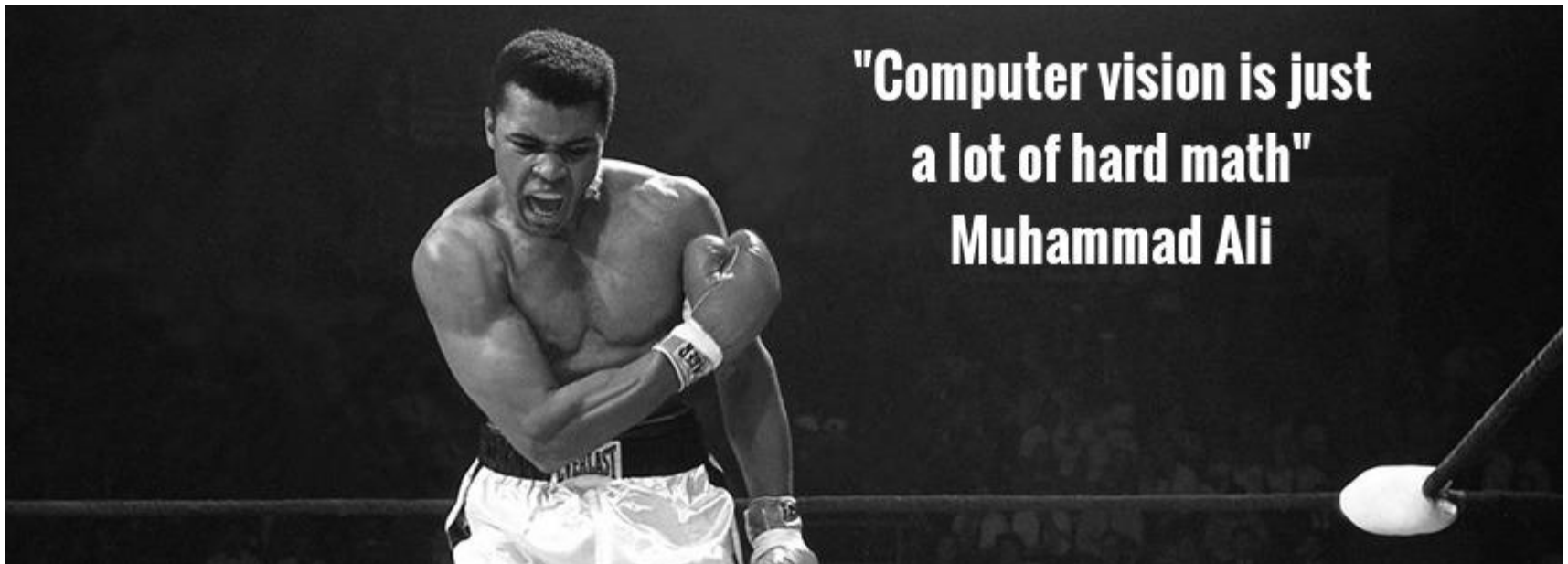
- Lectures Based on the book: **Computer Vision: Algorithms and Applications**, 2010, Richard Szeliski (<http://szeliski.org/Book/>)

Course objectives

- The student will know and understand key algorithms in computer vision.
- The student will be familiar with the algorithmic R&D process, with an emphasis on understanding the advantages and disadvantages of various algorithms and building an algorithmic system that concentrates on computer vision and image processing.
- The student will be able to solve algorithmic problems with computer vision both at theoretical and practical level (in Python using NumPy, Matplotlib, OpenCV & TensorFlow packages).

Prerequisites

- No prior knowledge in signal/image processing is assumed.
- Heavy use in algebra and calculus- mathematical maturity **is assumed.**

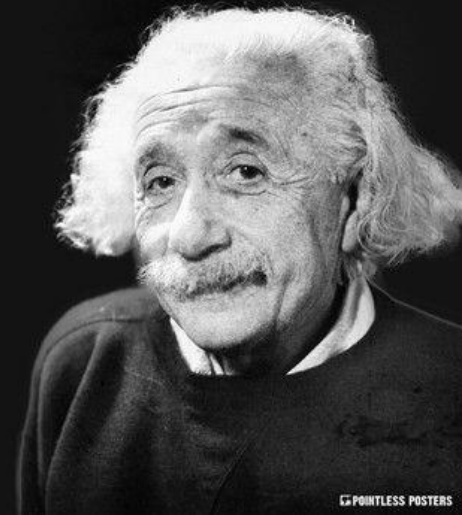


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Don't believe
everything you read
on the internet just
because there's a
picture with a quote
next to it.

ALBERT EINSTEIN

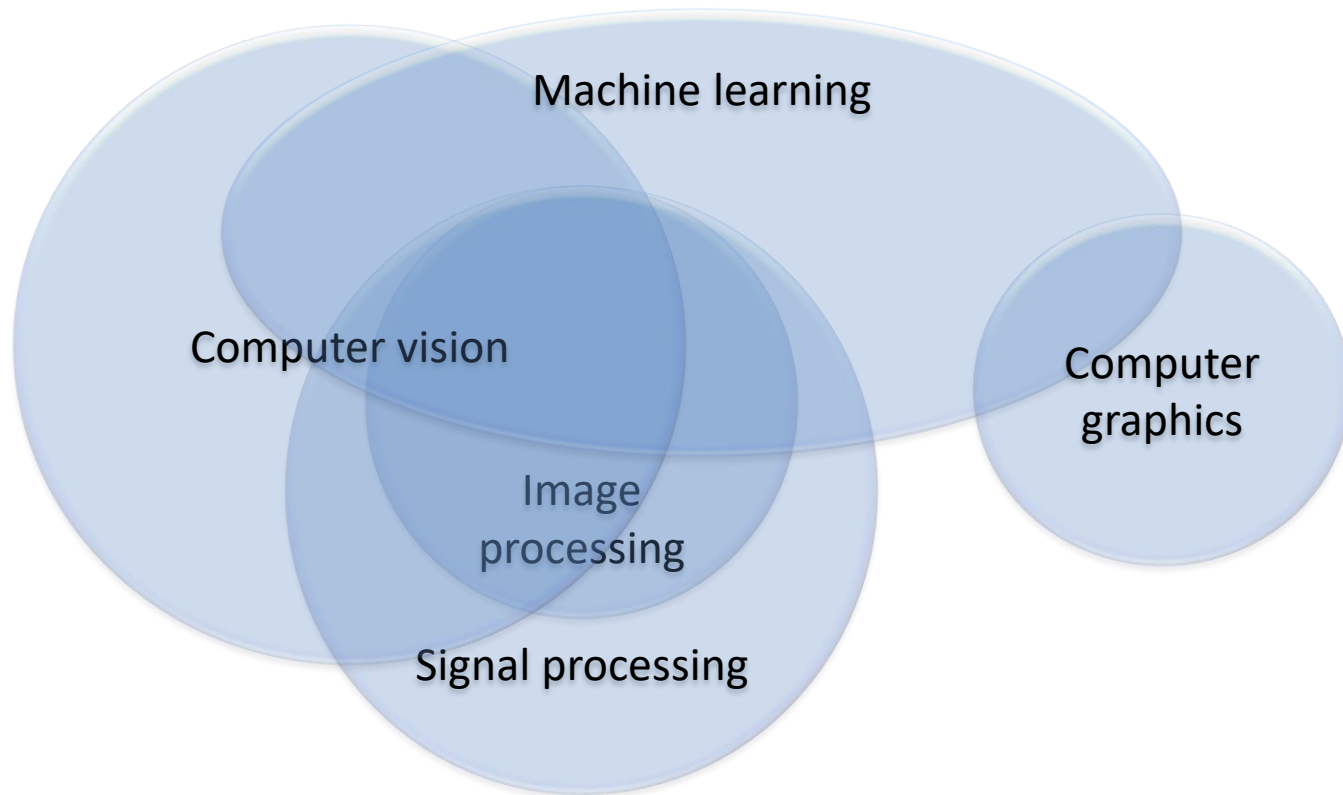


What is CV?

- **Computer vision** is an interdisciplinary scientific field that deals with how computers can be made to gain high-level understanding from digital images or videos. [Wikipedia]
- **Image processing** is an umbrella term for many functions that analyze images or convert one representation of an image into another.

























What is CV?

| Input \ Output | Data | Image |
|----------------|-------------------|-------------------|
| | | |
| Data | Signal processing | Computer graphics |
| Image | Computer vision | Image processing |



Why CV?

Top Public Company Acquirors

| Company | Embedded Vision/Computer Vision M&A | | | |
|---|--|--|---|---|
|  |  October – 2012 \$45.0M |  March – 2013 NA |  July – 2016 NA |  Undecidable! October – 2016 NA |
|  |  November – 2013 \$360.0M |  January – 2016 NA |  January – 2016 NA |  REALFACE February – 2017 NA |
|  |  May – 2005 \$115.0M |  July – 2008 \$3.0M |  August – 2016 \$2.4M |  November – 2016 \$4.7M |
|  |  April – 2012 \$31.0M |  May – 2016 NA |  September – 2016 \$392.1M |  September – 2017 \$15,300.0M |
|  |  January – 2014 NA |  September – 2014 NA |  August – 2017 NA | |

PrimeSense == Kinect

- *Kinect for Xbox 360*: 3D scanner system using **Light Coding** approach for 3D reconstruction.
- KinectFusion [Newcombe et al., 2011] :
<https://www.youtube.com/watch?v=KOUSSIKUJ-A>



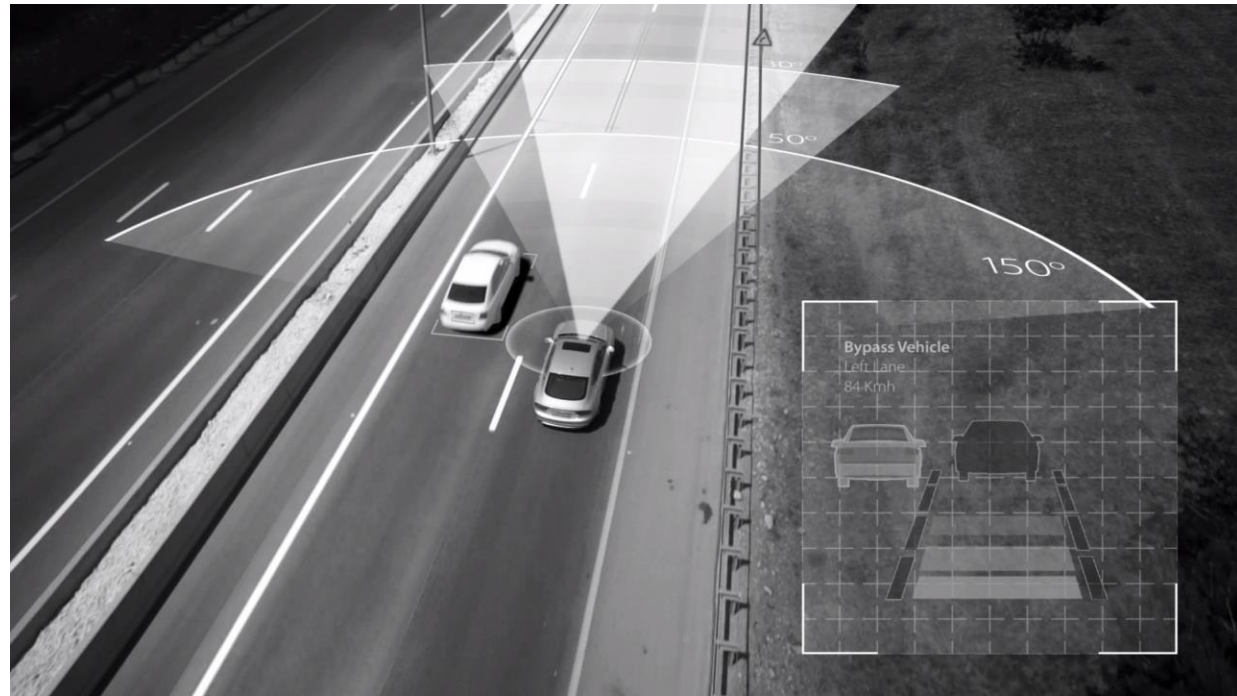
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|  |  January – 2014 NA |  September – 2014 NA |  August – 2017 NA | |

Mobileye

- **Mobileye** is an Israeli subsidiary of Intel corporation that develops vision-based advanced driver-assistance systems (ADAS) providing warnings for collision prevention and mitigation. [Wikipedia]
- <https://www.youtube.com/watch?v=JDUb6CurYJM>
- <https://www.youtube.com/watch?v=fKXztwtXaGo> (Tesla-cooler!)



Why CV?

StartupHub.ai

ISRAEL'S COMPUTER VISION STARTUPS

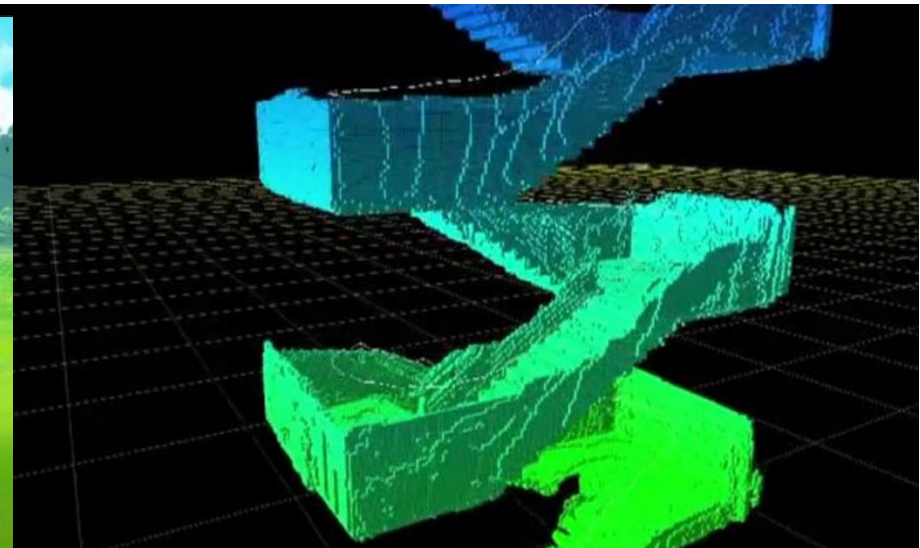


| COMPUTER VISION TECHNOLOGY | | HEALTHCARE | AUTOMOTIVE | AGRICULTURE | INDUSTRIAL | RETAIL | SECTORS |
|---|---|---|--|---|---|---|--|
| CHIPS | VIDEO INTELLIGENCE | MEDICAL IMAGING | AUTONOMOUS | CROP MANAGEMENT | ROBOTICS & UTILITIES | MONITORING & ANALYTICS | SMART CITY |
| Hailo Empowering Intelligence INTEL INTEL | AGENT EyeSafe QUANTUM RGB D Vision viisights GETALERT VIDEOinFORM SENSORITY videocites ZyroBot XR Vision anyvision 1702ai | zebra iz.ai Healthy.io aidoc Body Vision DIA MobileODT maxQ sight Biomedical FDNA innoging HT DeePathology.ai ORCA DENTAL AI PerSimo RADLogics TECHSOMED IBEX XPRINT XRAY MAGENTIQ IMedis Deep Oncology nucleai SCOPIO MedHub-AI | arbe Imagry INNOVIZ TECHNOLOGIES Kodiak i4drive ADASKY oryx Vectoraic RIDEVISION RAM StreetLight.ai CRadar.AI BWV RFISSE IONTERRA VAYAVISION VOYAGE 81 | TARANIS prospera See Tree SKYX fieldin AgroScout arugga GemmaCert SeedX VIBBE HiGrade | Planet Watchers KITOV SYSTEMS DLR COGNITEAM MOWI SKYLINE ROBOTICS IPV ORCA AI pzartech BladeRanger | trax trigo eyezon WISE SHELF memomi MYSTOR-E | SPATIAL LOGIC UTILIS syte donde |
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| DEVELOPMENT | | | IN-CAR MONITORING | HARVESTING | DRONES | | FITNESS |
| missinglink.ai allegro.ai dataloop Clay Sciences | | | MDGO eyesight neteera CLAIR LABS GUARDIAN JUNGO SAVERONE CAARESYS | METOMOTION meshek (76) | XTEND AerialGuard AIROBOTICS skywatch.ai EDGY BEES | | FITSCANNER MyselfFit |
| DATA CREATION | | | TRAFFIC & MOBILITY | NEW MEDIA | SURVEILLANCE & AUTONOMY | ENTERPRISE | REAL ESTATE |
| INNEREYE DataGen Technologies edgecase.ai | | | VALERANN NOTRAFFIC AGENT-TECH EyeWay | Lightricks Magisto Photomyne WIBBITZ tunity DEEPNEN | vhive PERCEPTO | INTERVYO minereye appliTools tuqqi INTELLIGO voca.ai ActiView TechSee | Leaperr Flatspace |
| PLATFORM | | | DEVELOPMENT | TELEOPERATION | CONSTRUCTION | MARKETING | FASHION |
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| EYE TRACKING | | | VR, SURGERY & MONITOR | INSPECTION | INSPECTION & MANAGEMENT | VIDEO, CONTENT & SECURITY | WATER VISION |
| Blink | | | ContinUse Biometrics Augmedics VRHealth | | | Taboola anyclick BrandTotal AdVeriFai CHEQ TAILOR BRANDS minute cedate COMIGO | LYNXIGHT DEEP VISION CORAL RAILVISION Anima SeeVoov |

More CV related topics

- Virtual/augmented reality
- navigation
- Gaming
- medicine
- And much more...

Segmentation Results



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Course outline

| # | subject |
|----|--|
| 1 | Introduction to CV + Python: NumPy, Matplotlib, OpenCV |
| 2 | Image processing recap: convolutions, LPF, HPF, morphology, connected components, gamma correction, decimation, interpolation. |
| 3 | Edge detection: gradient (roberts, prewitt, sobel), Laplacian, DoG (derivative of Gaussian), canny edge detector. |
| 4 | Curve fitting: least squares, total least squares, RANSAC, Hough transform. |
| 5 | Image formation: BRDF, pinhole camera, digital camera |
| 6 | Geometric transformation: 2d->2d, 3d->3d, 3d->2d (perspective and homographic projection) |
| 7 | Camera calibration: extrinsic, intrinsic, radial distortion. |
| 8 | Stereo vision: dual camera rectification, triangulation. |
| 9 | Features: feature detection, feature description, matching, SIFT, panoramas. |
| 10 | Stereo: SfM, Epipolar geometry, rectification, triangulation, matching. |
| 11 | Neural networks 1: intro, perceptron, dense layers, MNIST. |
| 12 | Neural Networks 2: CNN, back-propagation, tensorflow. |

Image processing

- Read more about Lenna – the standard test image:
<https://en.wikipedia.org/wiki/Lenna>

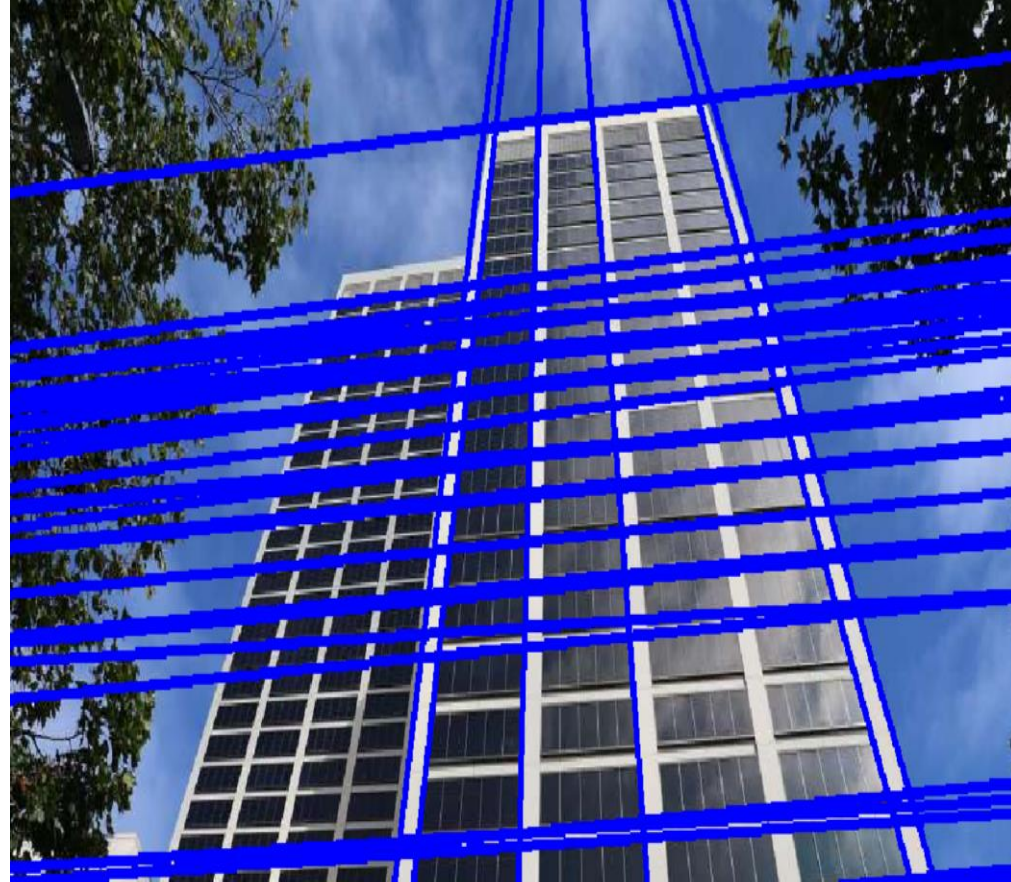
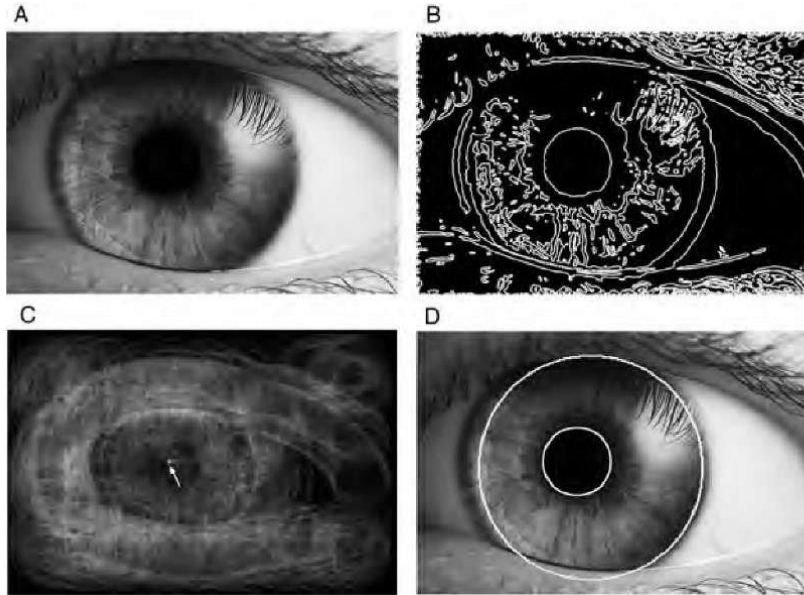


Edge Detection

- <https://www.youtube.com/watch?v=hQ-bpfdWQh8>
- <https://pinetools.com/image-edge-detection>



Curve fitting & Hough transform



Digital cameras

- Image formation:

<https://www.youtube.com/watch?v=dY0K65eXhkA>

- 2D & 3D transformation.

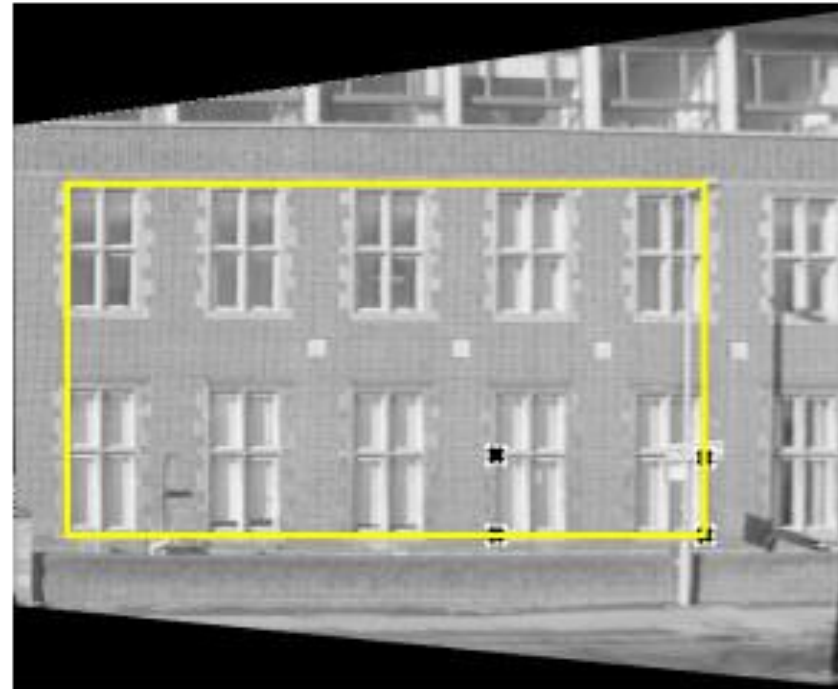
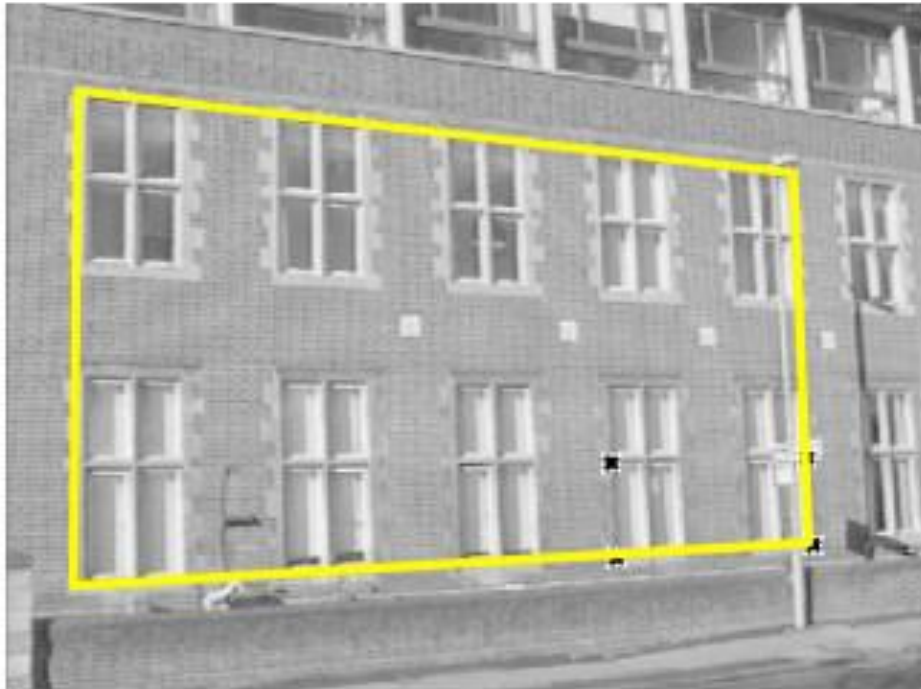


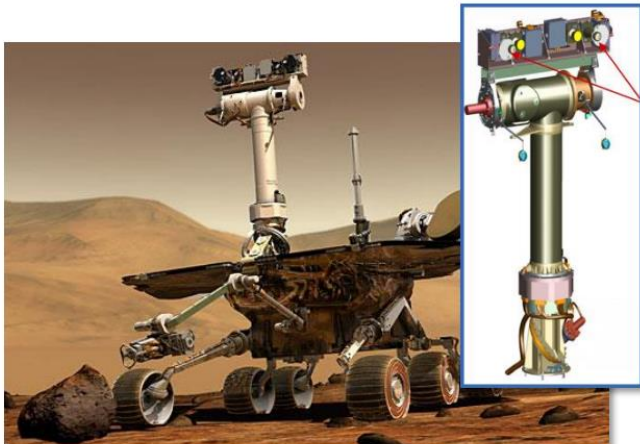
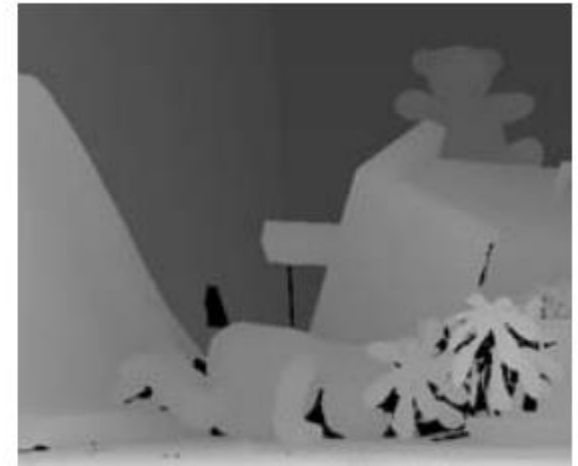
Image calibration

- Fisheye correction from go-pro for example



Stereo & 3d cameras

- https://www.youtube.com/watch?v=PySBQ8Q_R8k



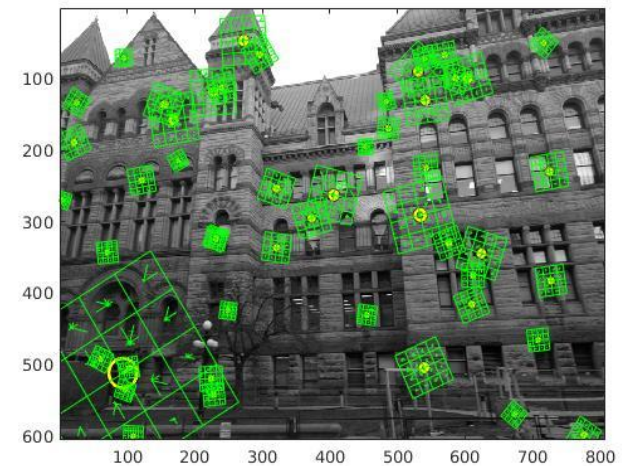
(a)



(b)

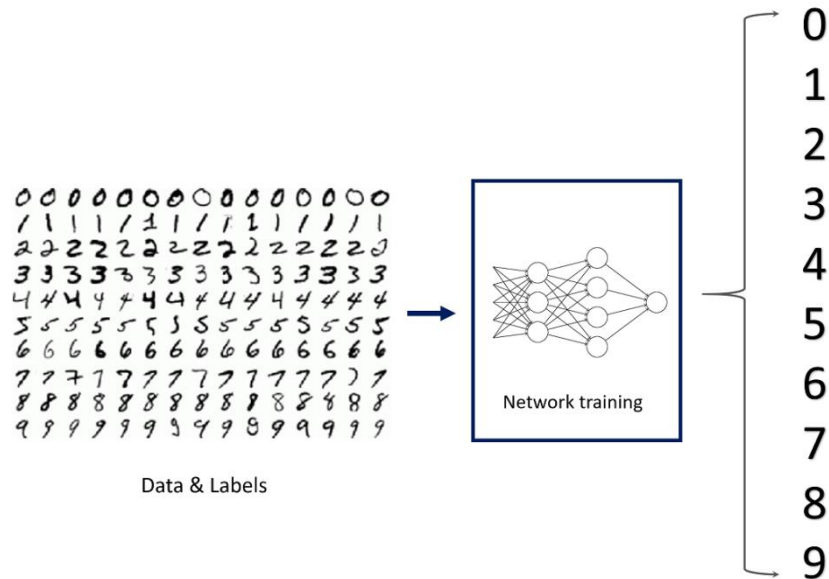
Features

- Extract interesting points from image for later recognition, stitching, learning and more.
- <http://www.in2white.com/>



Neural networks

- <https://deepdreamgenerator.com/generator>
- <https://quickdraw.withgoogle.com>



Dream generator- style transfer



Dream generator- style transfer



And some more AI stuff

- Deep fake
 - <https://www.youtube.com/watch?v=cQ54GDm1eL0>
 - <https://www.youtube.com/watch?v=-QvIX3cY4lc>
- Nvidia GauGAN
 - <https://www.youtube.com/watch?v=p5U4NgVGAWg>
 - <http://nvidia-research-mingyuliu.com/gaugan>

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