

# Intro to Computer Vision



Yoni Chechik

Computer Vision – course #####

# contents

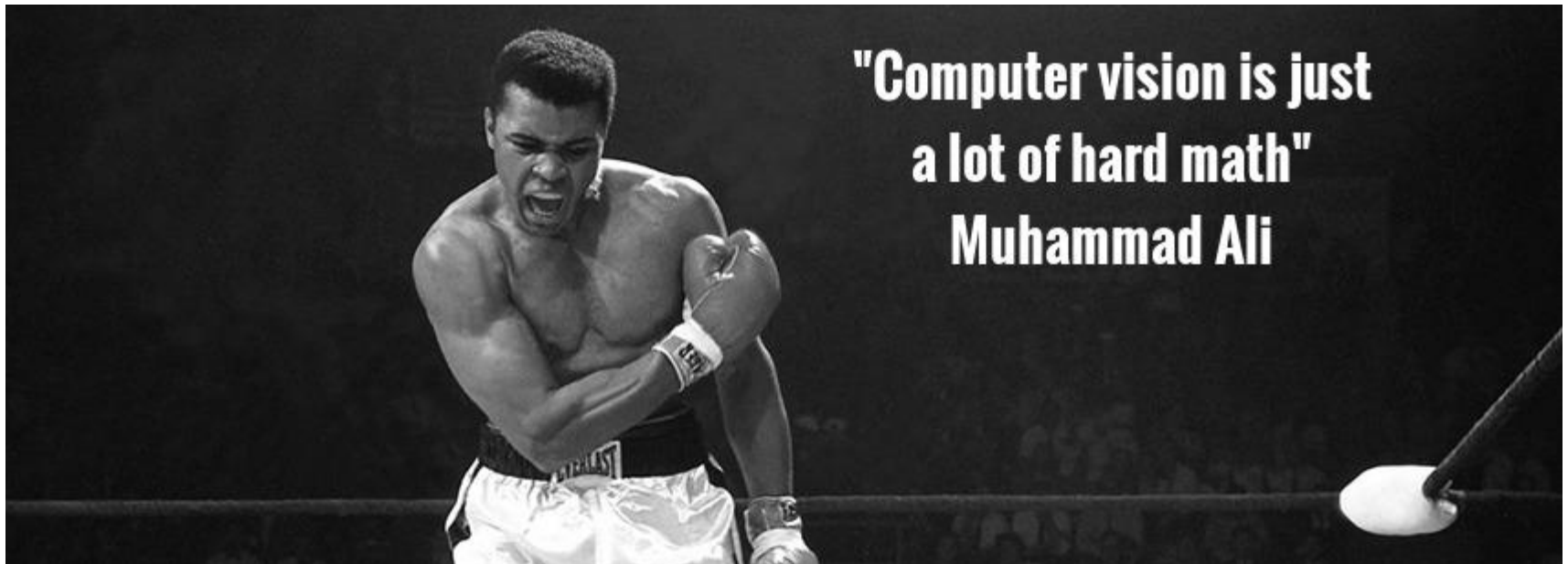
- **Course details**
- What is computer vision (CV)?
- Course outline
- Intro to Python

# Course details

- Lecturer: Yoni Chechik
  - Mail: #####
- Lecture time: #####
- Lecture place: #####
- Lectures Based on the book: **Computer Vision: Algorithms and Applications**, 2010, Richard Szeliski  
(<http://szeliski.org/Book/>)
- Grading: ####
- Website: #####

# Prerequisites

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

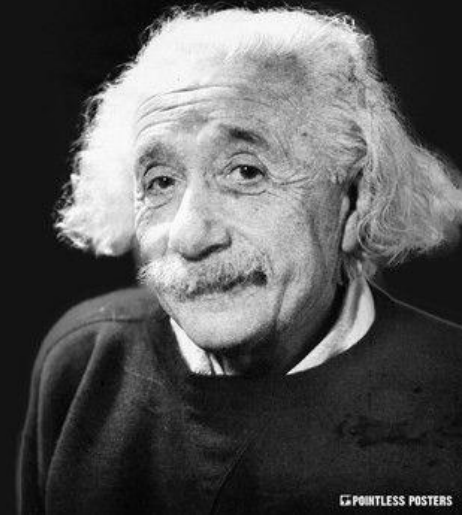


# contents

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

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

ALBERT EINSTEIN

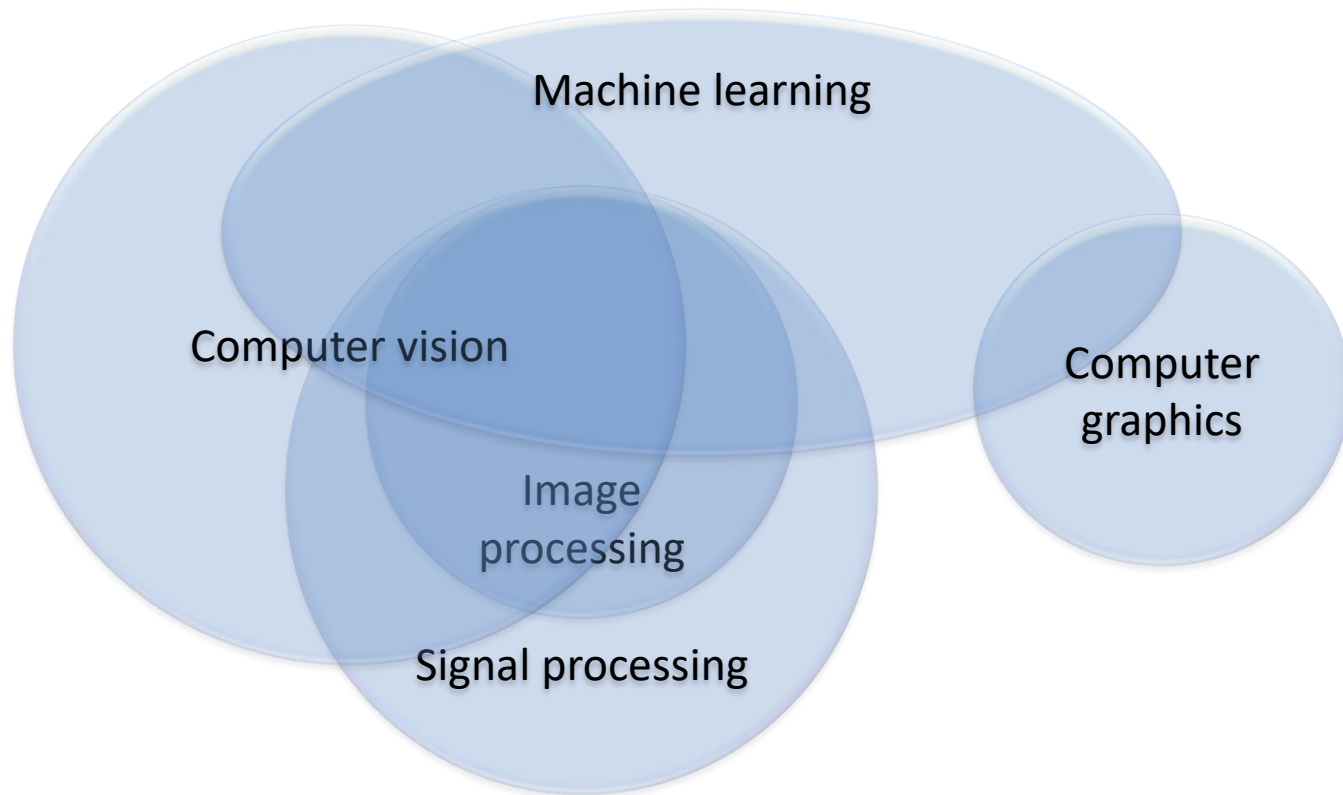


# What is CV?

- **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
	Signal processing	Computer graphics
Data	Signal processing	Computer graphics
Image	Computer vision	Image processing



# Why CV?

IT'S  
F\*\*\*ING  
COOL



# 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>



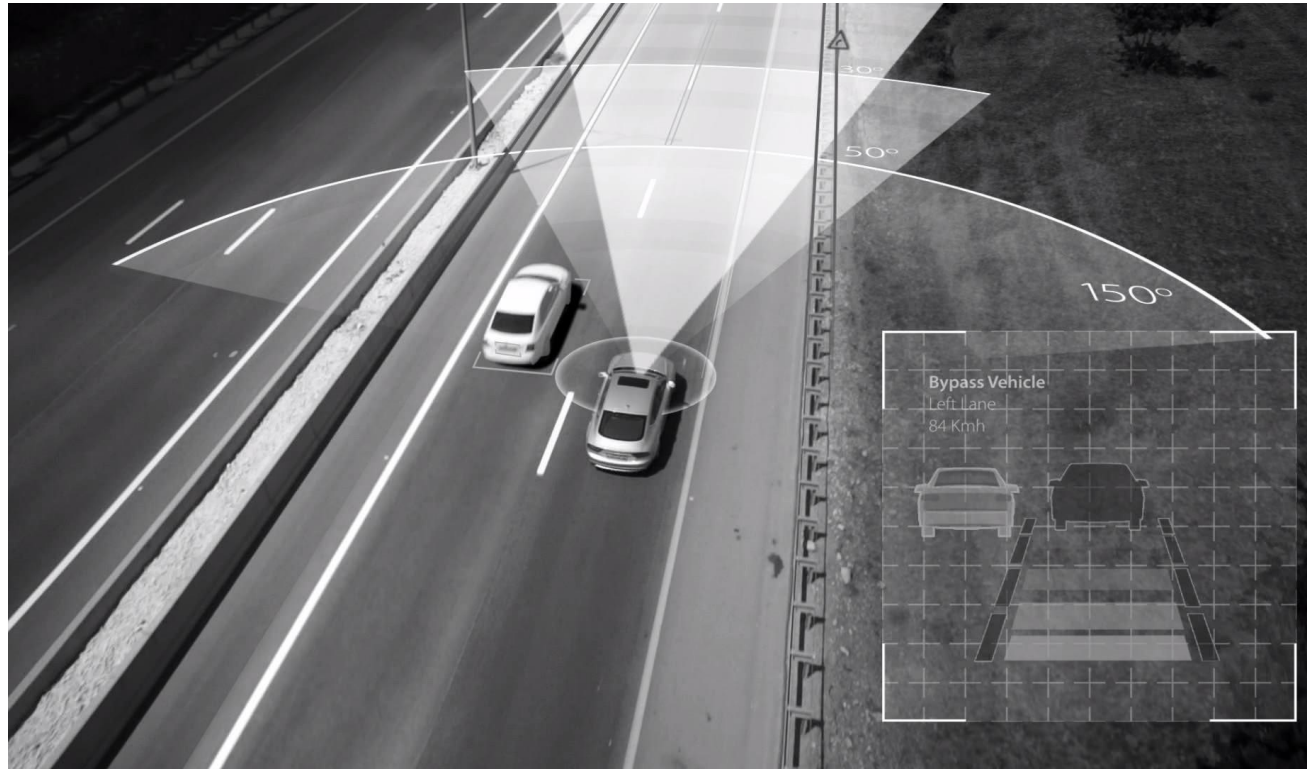
# Why CV?

## Top Public Company Acquirors

Company	Embedded Vision/Computer Vision M&A			
	 October – 2012 \$45.0M	 March – 2013 NA	 July – 2016 NA	 October – 2016 NA
	 November – 2013 \$360.0M	 January – 2016 NA	 January – 2016 NA	 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	

# 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=39QMYkx89j0>





# Why CV?

StartupHub.ai

## ISRAEL'S COMPUTER VISION STARTUPS

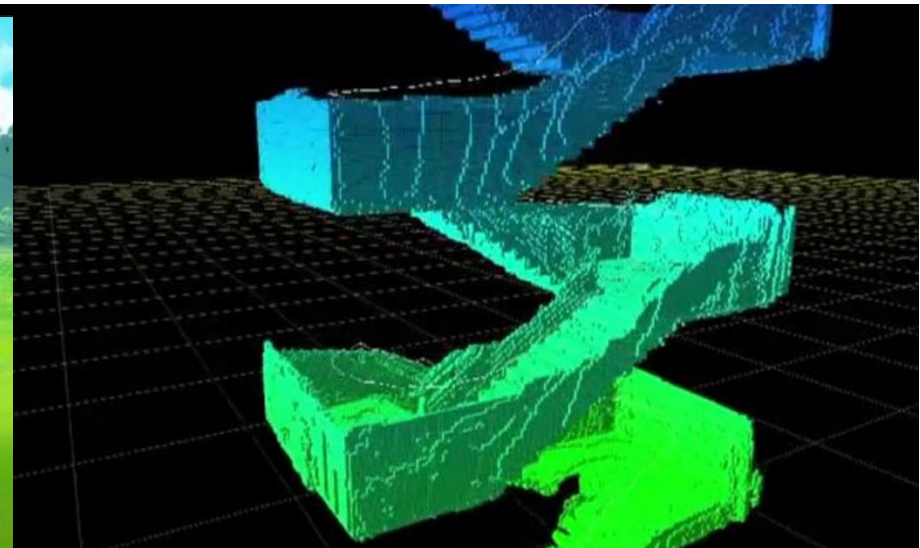


COMPUTER VISION TECHNOLOGY		HEALTHCARE	AUTOMOTIVE	AGRICULTURE	INDUSTRIAL	RETAIL	SECTORS
CHIPS	VIDEO INTELLIGENCE	MEDICAL IMAGING	AUTONOMOUS	CROP MANAGEMENT	ROBOTICS & UTILITIES	MONITORING & ANALYTICS	SMART CITY
Hailo INUVIS	AGENT2 EyeSafe	zebra iz.ai	arbe Imagry	TARANIS prospera	Planet Watchers KITOV SYSTEMS	trax trigo	ZC ZENCITY
Brodmann Edgify REDFALCON	QUANTUM RGB D Vision viisights GETALERT VIDEOinFORM SENSORITY videocites ZyroBot XRvision anyvision.1702ai	Healthy.io aidoc BODY VISION DIA MobileODT maxQ sight Biomedical FDNA innoging HT DeePathology.ai ORCA PerSimoO	i4drive ADASXY oryx Vectoraic RIDEVISION RAM StreetLight.ai CRadar.AI BWV RFISSE IONTERRA VAYAVISION VOYAGE 81	See Tree SKYX fieldin AgroScout sailing arugga GemmaCert SeedX VIBBE HiGrade	DLR COGNITEAM Movi SKYLINE ROBOTICS IPV ORCA AI pzartech BladeRanger	eyezon WISE SHELF memomi MYSTOR-E X	SPATIAL LOGIC UTILIS syte clonde
vayyar KAYA INSTRUMENTS TRIEYE NEWSIGHT IMAGING unispectral	D-ID FACEPTION VIKI sense IS IT YOU ONLINE verifioo Facetrom FAB BrighterAI IDENTYTECH edgecase.ai	RADLogics TECHMED IBEX XPRINT XRAY MAGENTIQ IMedis Deep Oncology nucleai SCOPIO MedHub-AI	MDGO eyesight neteera CLAIR LABS GUARDIAN JUNGO SAVERONE CAARESYS	METOMOTION meshek (76)	XTEND AerialGuard AIROBOTICS skywatch.ai EDGY BEES ClearVuze Sightec HIGH LANDER thirdeye CIVDRONE vHive PERCEPTO	playsight TRACK160 WSC Sports PhysiMax Pixellot SenSwim Zone7 LVISION Baseline VISION	nanit intuition robotics temi RES SCIO FITSCANNER MyselfFit
missinglink.ai allegro.ai dataloop Clay Sciences	D-ID FACEPTION VIKI sense IS IT YOU ONLINE verifioo Facetrom FAB BrighterAI IDENTYTECH edgecase.ai	RADLogics TECHMED IBEX XPRINT XRAY MAGENTIQ IMedis Deep Oncology nucleai SCOPIO MedHub-AI	MDGO eyesight neteera CLAIR LABS GUARDIAN JUNGO SAVERONE CAARESYS	METOMOTION meshek (76)	XTEND AerialGuard AIROBOTICS skywatch.ai EDGY BEES ClearVuze Sightec HIGH LANDER thirdeye CIVDRONE vHive PERCEPTO	playsight TRACK160 WSC Sports PhysiMax Pixellot SenSwim Zone7 LVISION Baseline VISION	nanit intuition robotics temi RES SCIO FITSCANNER MyselfFit
INNEREYE DataGen Technologies edgecase.ai	D-ID FACEPTION VIKI sense IS IT YOU ONLINE verifioo Facetrom FAB BrighterAI IDENTYTECH edgecase.ai	RADLogics TECHMED IBEX XPRINT XRAY MAGENTIQ IMedis Deep Oncology nucleai SCOPIO MedHub-AI	MDGO eyesight neteera CLAIR LABS GUARDIAN JUNGO SAVERONE CAARESYS	METOMOTION meshek (76)	XTEND AerialGuard AIROBOTICS skywatch.ai EDGY BEES ClearVuze Sightec HIGH LANDER thirdeye CIVDRONE vHive PERCEPTO	playsight TRACK160 WSC Sports PhysiMax Pixellot SenSwim Zone7 LVISION Baseline VISION	nanit intuition robotics temi RES SCIO FITSCANNER MyselfFit
INNEREYE DataGen Technologies edgecase.ai	D-ID FACEPTION VIKI sense IS IT YOU ONLINE verifioo Facetrom FAB BrighterAI IDENTYTECH edgecase.ai	RADLogics TECHMED IBEX XPRINT XRAY MAGENTIQ IMedis Deep Oncology nucleai SCOPIO MedHub-AI	MDGO eyesight neteera CLAIR LABS GUARDIAN JUNGO SAVERONE CAARESYS	METOMOTION meshek (76)	XTEND AerialGuard AIROBOTICS skywatch.ai EDGY BEES ClearVuze Sightec HIGH LANDER thirdeye CIVDRONE vHive PERCEPTO	playsight TRACK160 WSC Sports PhysiMax Pixellot SenSwim Zone7 LVISION Baseline VISION	nanit intuition robotics temi RES SCIO FITSCANNER MyselfFit
INNEREYE DataGen Technologies edgecase.ai	D-ID FACEPTION VIKI sense IS IT YOU ONLINE verifioo Facetrom FAB BrighterAI IDENTYTECH edgecase.ai	RADLogics TECHMED IBEX XPRINT XRAY MAGENTIQ IMedis Deep Oncology nucleai SCOPIO MedHub-AI	MDGO eyesight neteera CLAIR LABS GUARDIAN JUNGO SAVERONE CAARESYS	METOMOTION meshek (76)	XTEND AerialGuard AIROBOTICS skywatch.ai EDGY BEES ClearVuze Sightec HIGH LANDER thirdeye CIVDRONE vHive PERCEPTO	playsight TRACK160 WSC Sports PhysiMax Pixellot SenSwim Zone7 LVISION Baseline VISION	nanit intuition robotics temi RES SCIO FITSCANNER MyselfFit
INNEREYE DataGen Technologies edgecase.ai	D-ID FACEPTION VIKI sense IS IT YOU ONLINE verifioo Facetrom FAB BrighterAI IDENTYTECH edgecase.ai	RADLogics TECHMED IBEX XPRINT XRAY MAGENTIQ IMedis Deep Oncology nucleai SCOPIO MedHub-AI	MDGO eyesight neteera CLAIR LABS GUARDIAN JUNGO SAVERONE CAARESYS	METOMOTION meshek (76)	XTEND AerialGuard AIROBOTICS skywatch.ai EDGY BEES ClearVuze Sightec HIGH LANDER thirdeye CIVDRONE vHive PERCEPTO	playsight TRACK160 WSC Sports PhysiMax Pixellot SenSwim Zone7 LVISION Baseline VISION	nanit intuition robotics temi RES SCIO FITSCANNER MyselfFit
INNEREYE DataGen Technologies edgecase.ai	D-ID FACEPTION VIKI sense IS IT YOU ONLINE verifioo Facetrom FAB BrighterAI IDENTYTECH edgecase.ai	RADLogics TECHMED IBEX XPRINT XRAY MAGENTIQ IMedis Deep Oncology nucleai SCOPIO MedHub-AI	MDGO eyesight neteera CLAIR LABS GUARDIAN JUNGO SAVERONE CAARESYS	METOMOTION meshek (76)	XTEND AerialGuard AIROBOTICS skywatch.ai EDGY BEES ClearVuze Sightec HIGH LANDER thirdeye CIVDRONE vHive PERCEPTO	playsight TRACK160 WSC Sports PhysiMax Pixellot SenSwim Zone7 LVISION Baseline VISION	nanit intuition robotics temi RES SCIO FITSCANNER MyselfFit
INNEREYE DataGen Technologies edgecase.ai	D-ID FACEPTION VIKI sense IS IT YOU ONLINE verifioo Facetrom FAB BrighterAI IDENTYTECH edgecase.ai	RADLogics TECHMED IBEX XPRINT XRAY MAGENTIQ IMedis Deep Oncology nucleai SCOPIO MedHub-AI	MDGO eyesight neteera CLAIR LABS GUARDIAN JUNGO SAVERONE CAARESYS	METOMOTION meshek (76)	XTEND AerialGuard AIROBOTICS skywatch.ai EDGY BEES ClearVuze Sightec HIGH LANDER thirdeye CIVDRONE vHive PERCEPTO	playsight TRACK160 WSC Sports PhysiMax Pixellot SenSwim Zone7 LVISION Baseline VISION	nanit intuition robotics temi RES SCIO FITSCANNER MyselfFit
INNEREYE DataGen Technologies edgecase.ai	D-ID FACEPTION VIKI sense IS IT YOU ONLINE verifioo Facetrom FAB BrighterAI IDENTYTECH edgecase.ai	RADLogics TECHMED IBEX XPRINT XRAY MAGENTIQ IMedis Deep Oncology nucleai SCOPIO MedHub-AI	MDGO eyesight neteera CLAIR LABS GUARDIAN JUNGO SAVERONE CAARESYS	METOMOTION meshek (76)	XTEND AerialGuard AIROBOTICS skywatch.ai EDGY BEES ClearVuze Sightec HIGH LANDER thirdeye CIVDRONE vHive PERCEPTO	playsight TRACK160 WSC Sports PhysiMax Pixellot SenSwim Zone7 LVISION Baseline VISION	nanit intuition robotics temi RES SCIO FITSCANNER MyselfFit
INNEREYE DataGen Technologies edgecase.ai	D-ID FACEPTION VIKI sense IS IT YOU ONLINE verifioo Facetrom FAB BrighterAI IDENTYTECH edgecase.ai	RADLogics TECHMED IBEX XPRINT XRAY MAGENTIQ IMedis Deep Oncology nucleai SCOPIO MedHub-AI	MDGO eyesight neteera CLAIR LABS GUARDIAN JUNGO SAVERONE CAARESYS	METOMOTION meshek (76)	XTEND AerialGuard AIROBOTICS skywatch.ai EDGY BEES ClearVuze Sightec HIGH LANDER thirdeye CIVDRONE vHive PERCEPTO	playsight TRACK160 WSC Sports PhysiMax Pixellot SenSwim Zone7 LVISION Baseline VISION	nanit intuition robotics temi RES SCIO FITSCANNER MyselfFit
INNEREYE DataGen Technologies edgecase.ai	D-ID FACEPTION VIKI sense IS IT YOU ONLINE verifioo Facetrom FAB BrighterAI IDENTYTECH edgecase.ai	RADLogics TECHMED IBEX XPRINT XRAY MAGENTIQ IMedis Deep Oncology nucleai SCOPIO MedHub-AI	MDGO eyesight neteera CLAIR LABS GUARDIAN JUNGO SAVERONE CAARESYS	METOMOTION meshek (76)	XTEND AerialGuard AIROBOTICS skywatch.ai EDGY BEES ClearVuze Sightec HIGH LANDER thirdeye CIVDRONE vHive PERCEPTO	playsight TRACK160 WSC Sports PhysiMax Pixellot SenSwim Zone7 LVISION Baseline VISION	nanit intuition robotics temi RES SCIO FITSCANNER MyselfFit
INNEREYE DataGen Technologies edgecase.ai	D-ID FACEPTION VIKI sense IS IT YOU ONLINE verifioo Facetrom FAB BrighterAI IDENTYTECH edgecase.ai	RADLogics TECHMED IBEX XPRINT XRAY MAGENTIQ IMedis Deep Oncology nucleai SCOPIO MedHub-AI	MDGO eyesight neteera CLAIR LABS GUARDIAN JUNGO SAVERONE CAARESYS	METOMOTION meshek (76)	XTEND AerialGuard AIROBOTICS skywatch.ai EDGY BEES ClearVuze Sightec HIGH LANDER thirdeye CIVDRONE vHive PERCEPTO	playsight TRACK160 WSC Sports PhysiMax Pixellot SenSwim Zone7 LVISION Baseline VISION	nanit intuition robotics temi RES SCIO FITSCANNER MyselfFit
INNEREYE DataGen Technologies edgecase.ai	D-ID FACEPTION VIKI sense IS IT YOU ONLINE verifioo Facetrom FAB BrighterAI IDENTYTECH edgecase.ai	RADLogics TECHMED IBEX XPRINT XRAY MAGENTIQ IMedis Deep Oncology nucleai SCOPIO MedHub-AI	MDGO eyesight neteera CLAIR LABS GUARDIAN JUNGO SAVERONE CAARESYS	METOMOTION meshek (76)	XTEND AerialGuard AIROBOTICS skywatch.ai EDGY BEES ClearVuze Sightec HIGH LANDER thirdeye CIVDRONE vHive PERCEPTO	playsight TRACK160 WSC Sports PhysiMax Pixellot SenSwim Zone7 LVISION Baseline VISION	nanit intuition robotics temi RES SCIO FITSCANNER MyselfFit
INNEREYE DataGen Technologies edgecase.ai	D-ID FACEPTION VIKI sense IS IT YOU ONLINE verifioo Facetrom FAB BrighterAI IDENTYTECH edgecase.ai	RADLogics TECHMED IBEX XPRINT XRAY MAGENTIQ IMedis Deep Oncology nucleai SCOPIO MedHub-AI	MDGO eyesight neteera CLAIR LABS GUARDIAN JUNGO SAVERONE CAARESYS	METOMOTION meshek (76)	XTEND AerialGuard AIROBOTICS skywatch.ai EDGY BEES ClearVuze Sightec HIGH LANDER thirdeye CIVDRONE vHive PERCEPTO	playsight TRACK160 WSC Sports PhysiMax Pixellot SenSwim Zone7 LVISION Baseline VISION	

# More CV related topics

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

Segmentation Results



# contents

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

# Course outline

#	subject
1	Introduction to CV + Python: numpy, matplotlib.
2	Image processing recap: convolutions, LPF, HPF, morphology, connected components, gamma correction, histogram equalization.
3	Edge detection: gradient (roberts, prewitt, sobel), Laplacian, DoG (derivative of Gaussian), canny edge detector.
4	Shape detection: template matching, Hough transform.
5	Digital cameras: image formation, transformation, interpolation.
6	Camera calibration: extrinsic, intrinsic, radial distortion.
7	Stereo vision :dual camera rectification, triangulation.
8	3D cameras: LIDAR, KINECT, structured light, planoptic
9	Line fit: least squares, total least squares, RANSAC,
10	Feature extraction: SIFT, image stitching (scale space).
11	Neural networks: intro, CNN, MNIST, Alexnet.
12	Final project 1
13	Final project 2



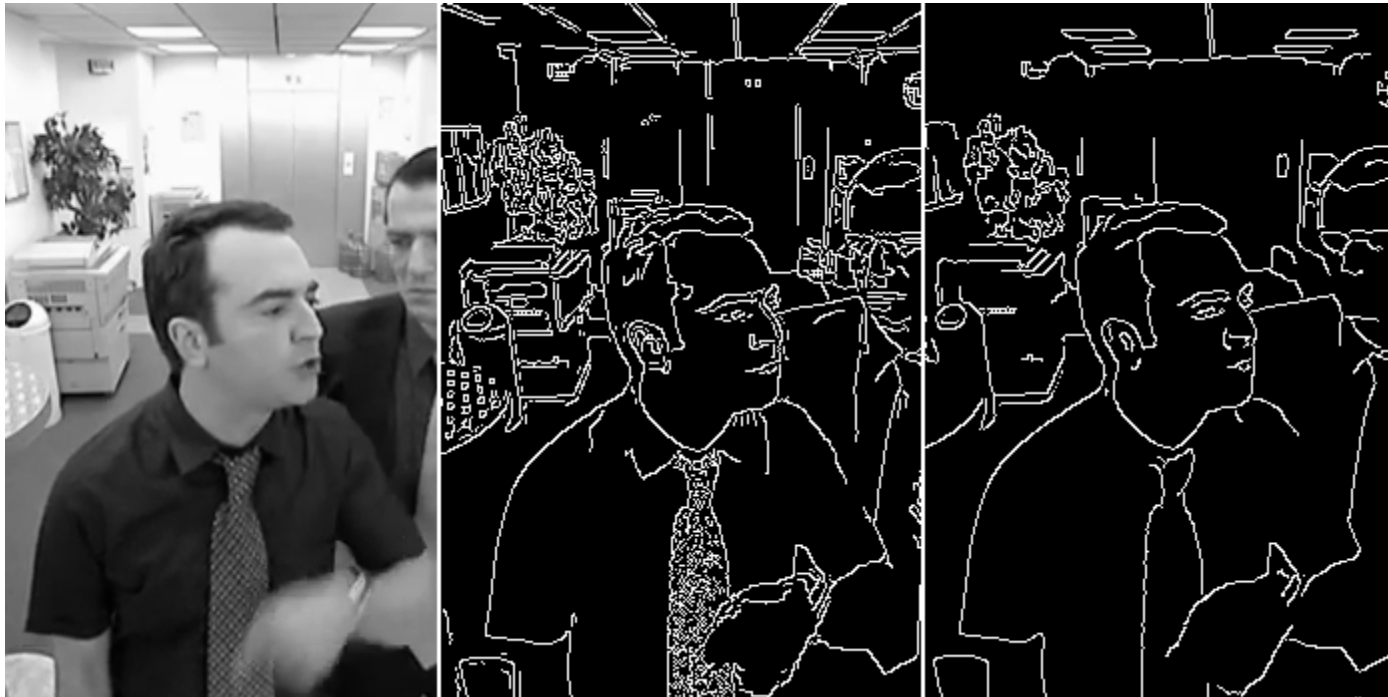
# Image processing

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

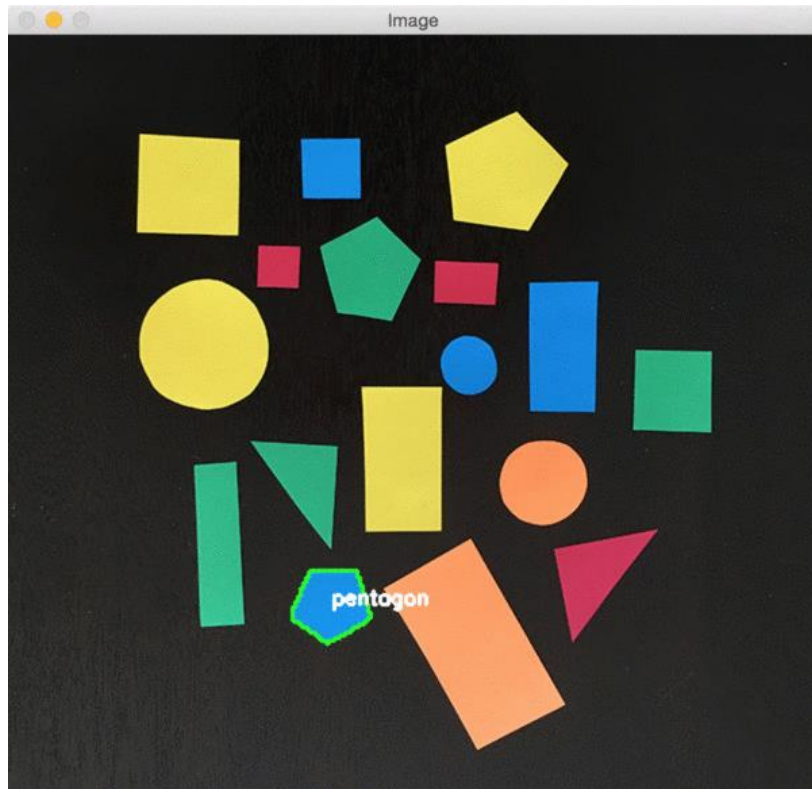


# Edge Detection

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



# Shape detection



# Digital cameras

- Image formation:  
<https://www.youtube.com/watch?v=dY0K65eXhkA>
- Transformation and interpolation.





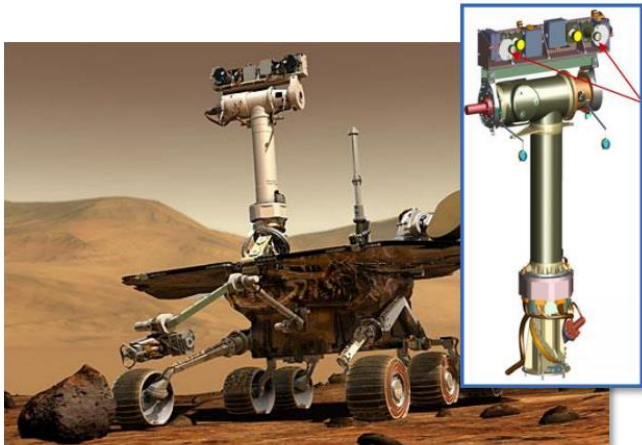
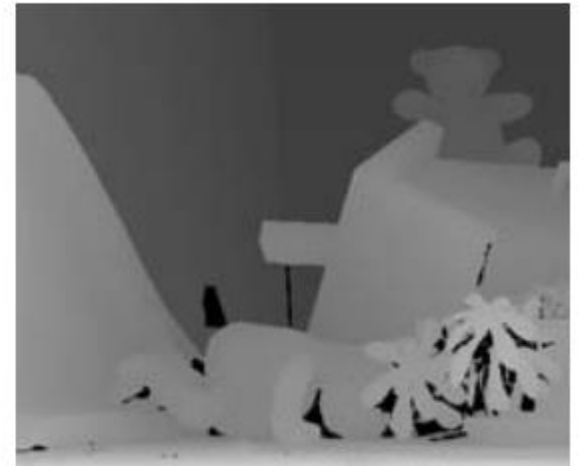
# Image calibration

- Fisheye correction from go-pro for example



# Stereo & 3d cameras

- [https://www.youtube.com/watch?v=PySBQ8Q\\_R8k](https://www.youtube.com/watch?v=PySBQ8Q_R8k)



(a)

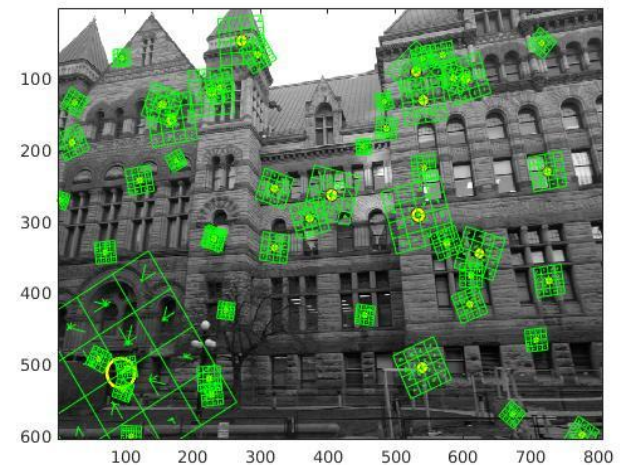


(b)



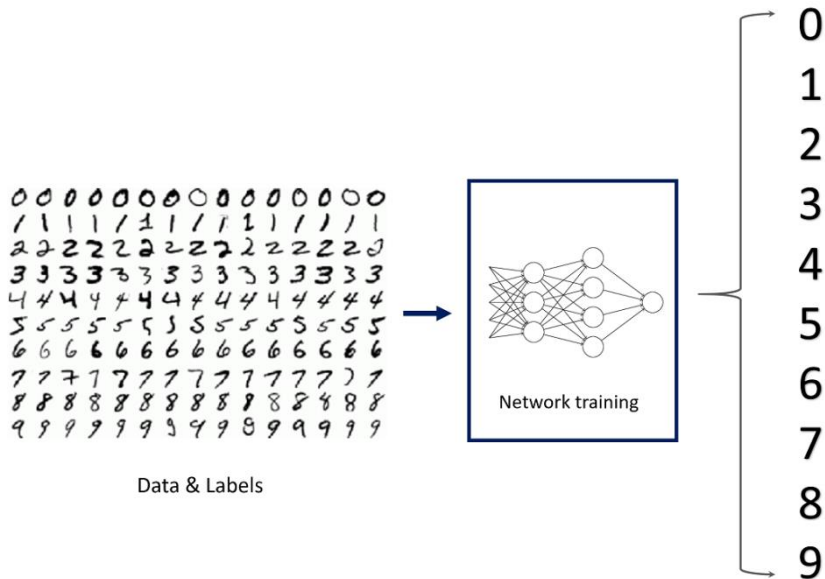
# Fitting & Feature extraction

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



# Neural networks

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





# contents

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