

Soft computing



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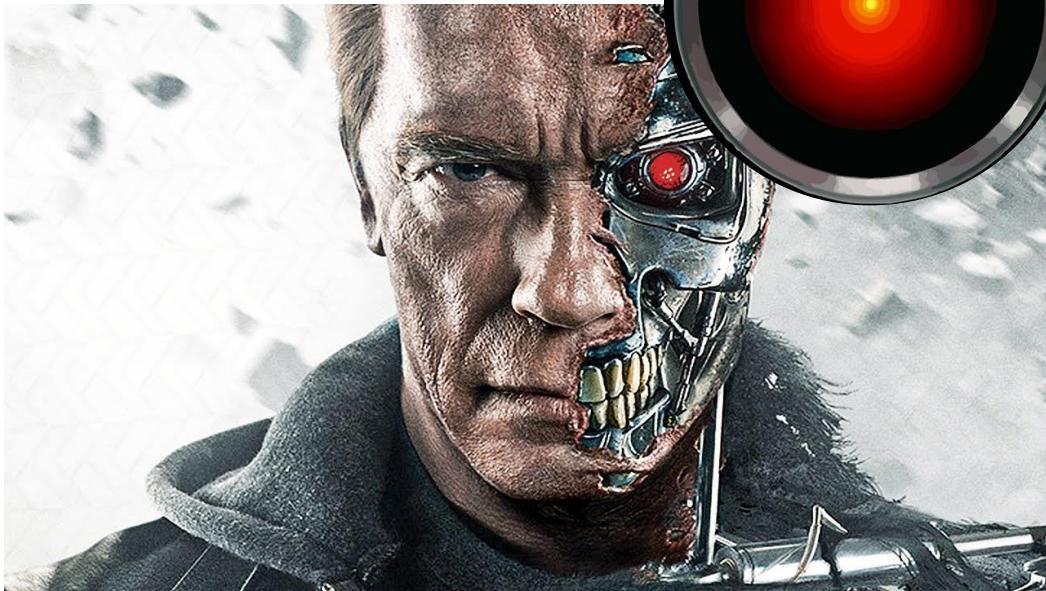
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Veštačka inteligencija

Strong AI



Mašine sposobne za
inteligentno
ponašanje



Nedostatak
ljudske svesti

Usko
specijalizovani

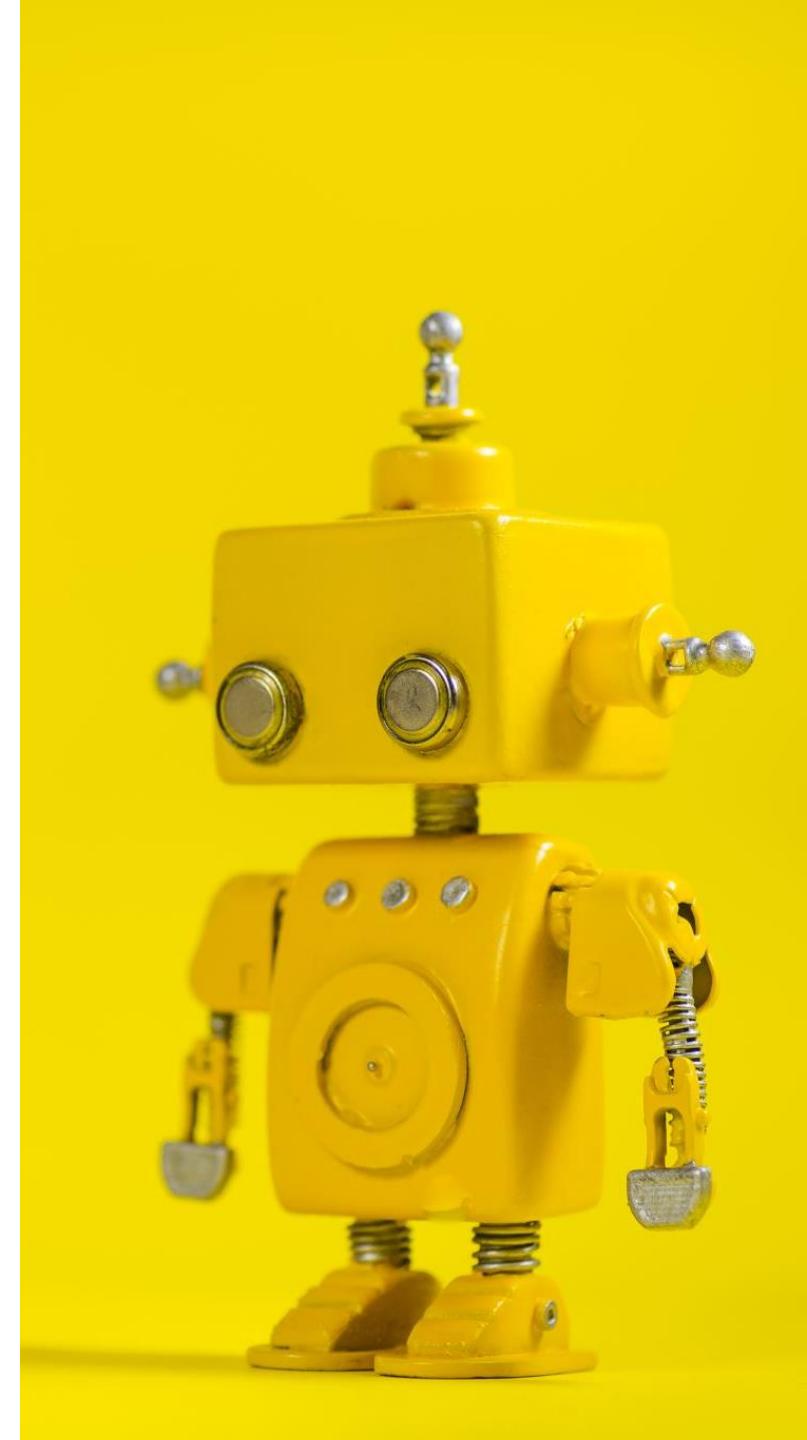
Koristiti sa
oprezom

Weak AI

Da li nam je AI prijatelj ili neprijatelj?

Na koji način možemo zloupotrebiti AI?

Da li vidite neke etičke probleme koji proizilaze iz upotrebe AI?



Veštačka inteligencija

Hard computing

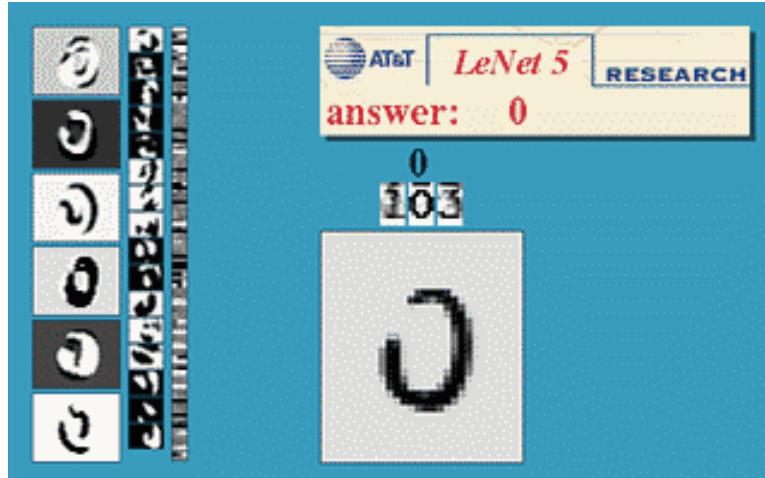
- Ekspertski sistemi, formalna logika, dokazivanje teorema,...
- Problemi intelektualno zahtevni za čoveka
- Formalno izraženi modeli
- Precizna deterministička rešenja

Soft computing

- Razumevanje „iskriviljenog“ govora, lošeg rukopisa, vožnja vozila u gustom saobraćaju,...
- Cilj je modelovanje ljudskog uma koji ima toleranciju na nepreciznost
- Pragmatična rešenja

Optical Character Recognition (OCR)

- Tehnologija kojom možemo konvertovati skenirane dokumente u tekst
- Skeneri sadrže OCR softver



Digit recognition, AT&T labs
<http://www.research.att.com/~yann/>

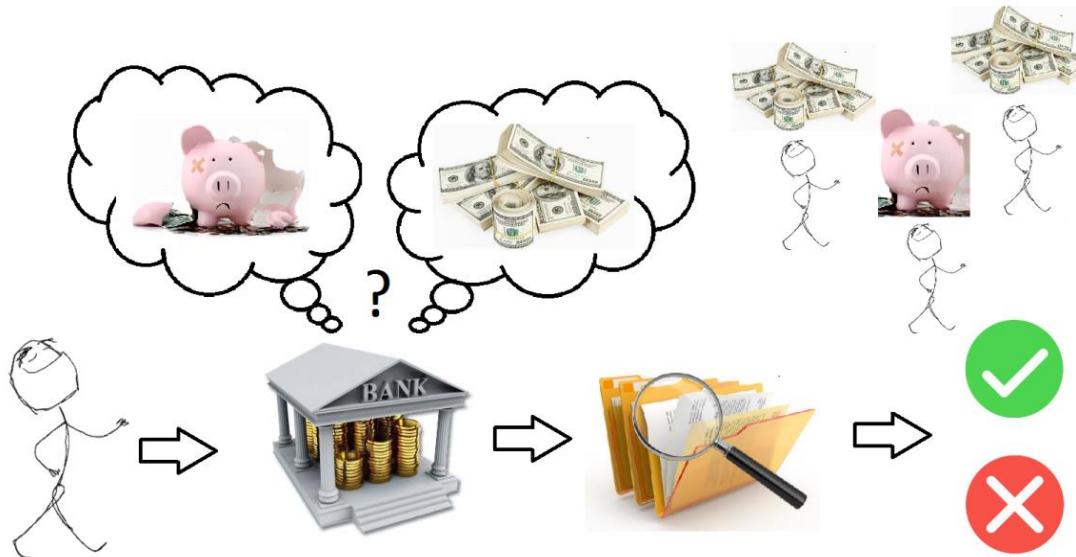


License plate readers
http://en.wikipedia.org/wiki/Automatic_number_plate_recognition

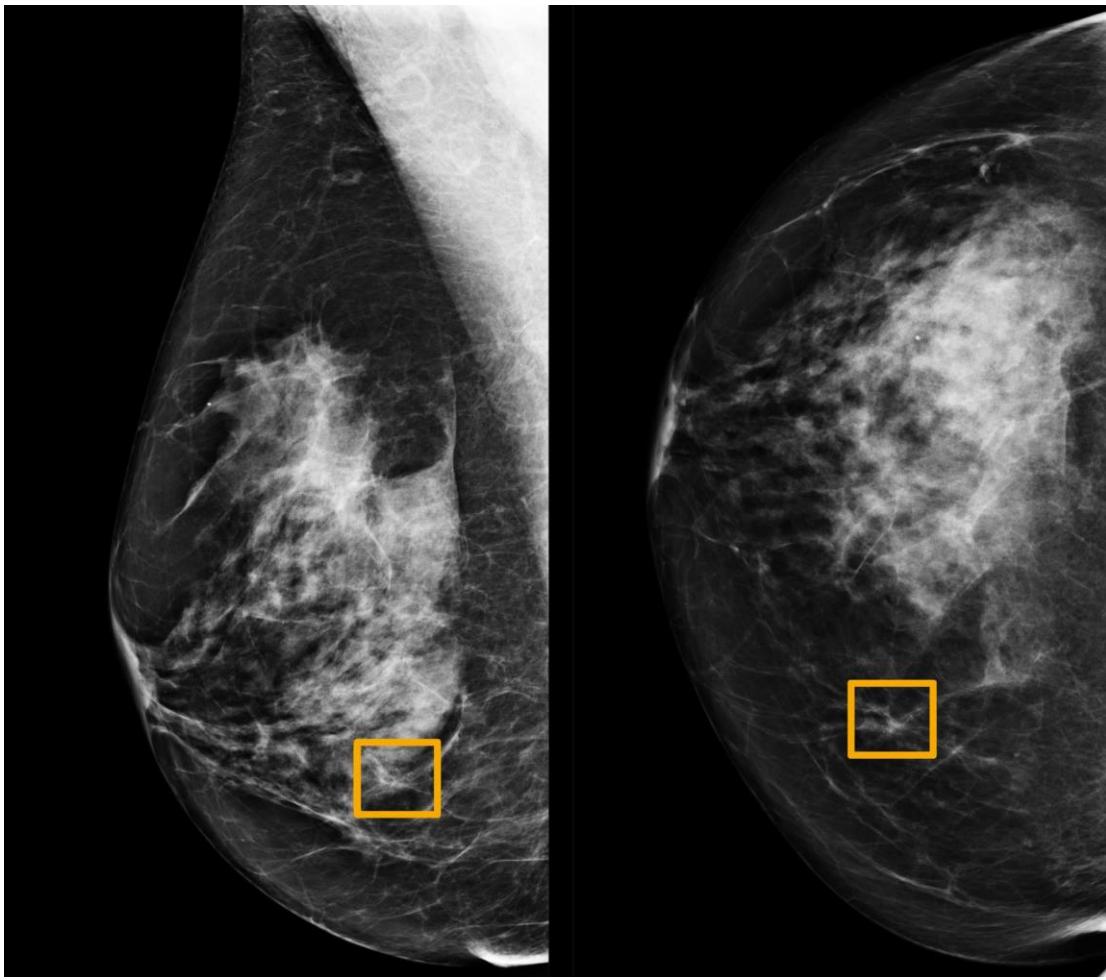
Trebaju nam informacije o aplikantu:

(različita polja za koja se veruje da su u vezi sa time da li je neko pogodan za kredit ili nije)

starost	23 godine
Godišnja zarada	\$30 000
Trenutni dug	\$15 000
Poseduje nekretninu	Da



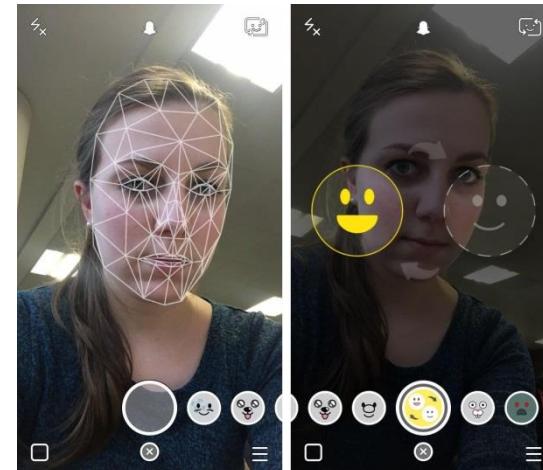
Odobravanje kredita



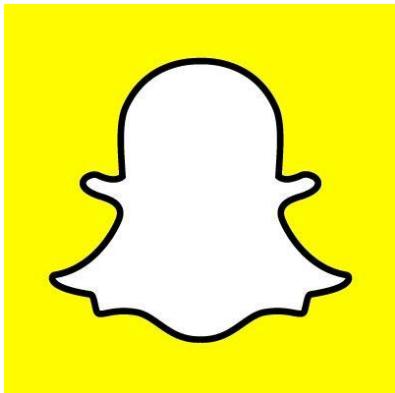
Medicinske dijagnoze

Face Detection

- Gotovo sve digitalne kamere vrše detekciju lica
 - Glavni razlog je fokus, ali je zgodno i za „smart cropping“



Snapchat



<https://pleated-jeans.com/2016/03/02/21-snapchat-face-swaps-that-went-horribly-wrong/>

Object recognition (in supermarkets)

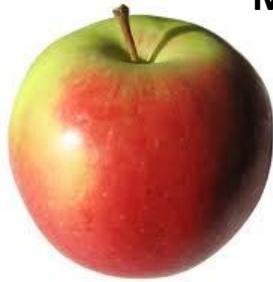
<https://www.amazon.com/b?ie=UTF8&node=16008589011>



Hard Computing ↔ Soft Computing

Realan svet:

- Zašumljen
- Kontinualne vrednosti



Model

```
class Apple{  
    public double weight;  
    public Color color;  
}
```

```
Apple a = new Apple();  
a.weight = 3.5678;  
a.color = ?
```

Računarstvo:

- Binarni princip
True/false
- Precizno i određeno

Želimo da применимо računarsko rezonovanje na realan svet

Veštačka inteligencija

Hard computing

- Zahtevaju eksplisitno programiranje
- Rezultuje preciznim rešenjima
- Determinističko
- Zahteva tačno definisan ulaz

Soft computing

- Programi evoluiraju sa iskustvom (podacima)
- Rezultuje približnim rešenjima
- Stohastičko
- Ulaz dvosmislen i zašumljen

Image processing

- Na ovom kursu čemo se baviti obradom digitalne slike

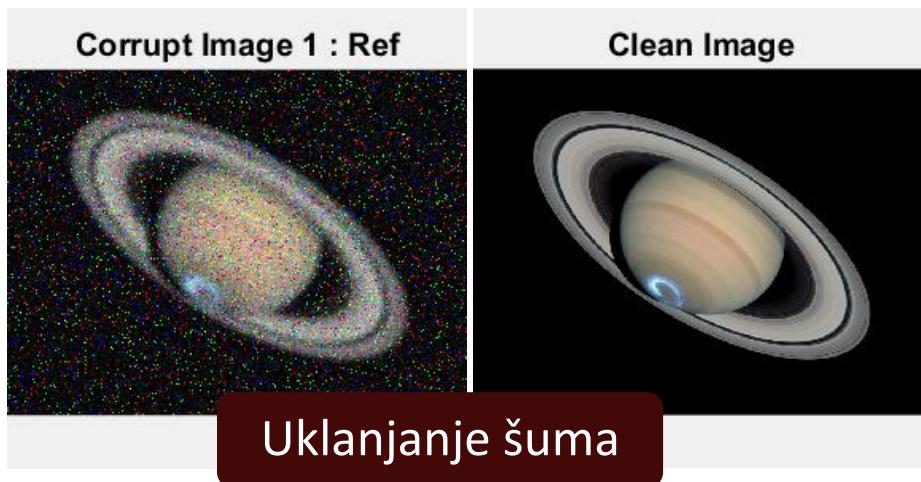
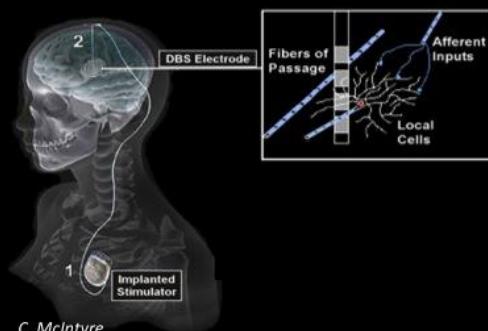
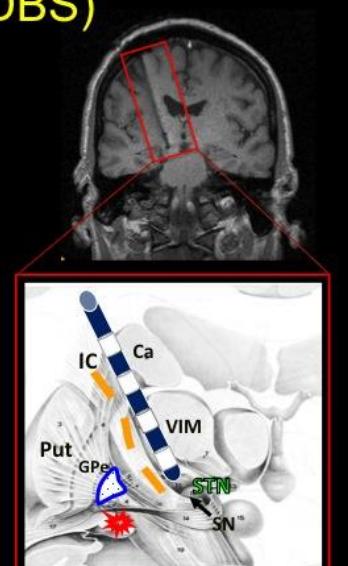


Image processing

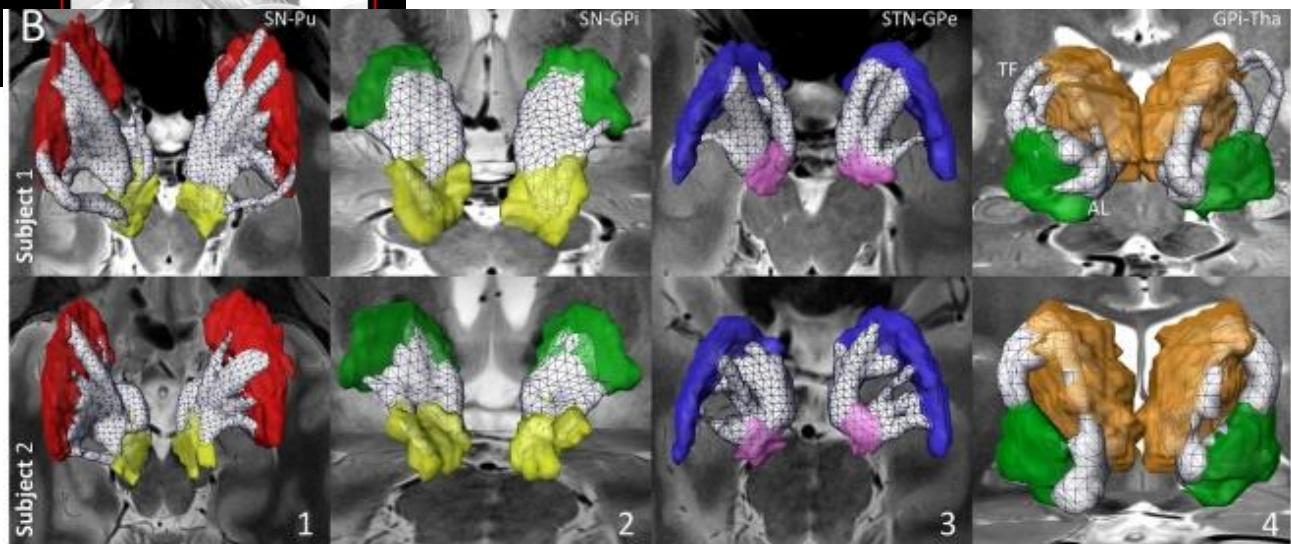
Deep Brain Stimulation (DBS)



Successful DBS surgery is critically dependent on precise placement of DBS electrodes into target structures

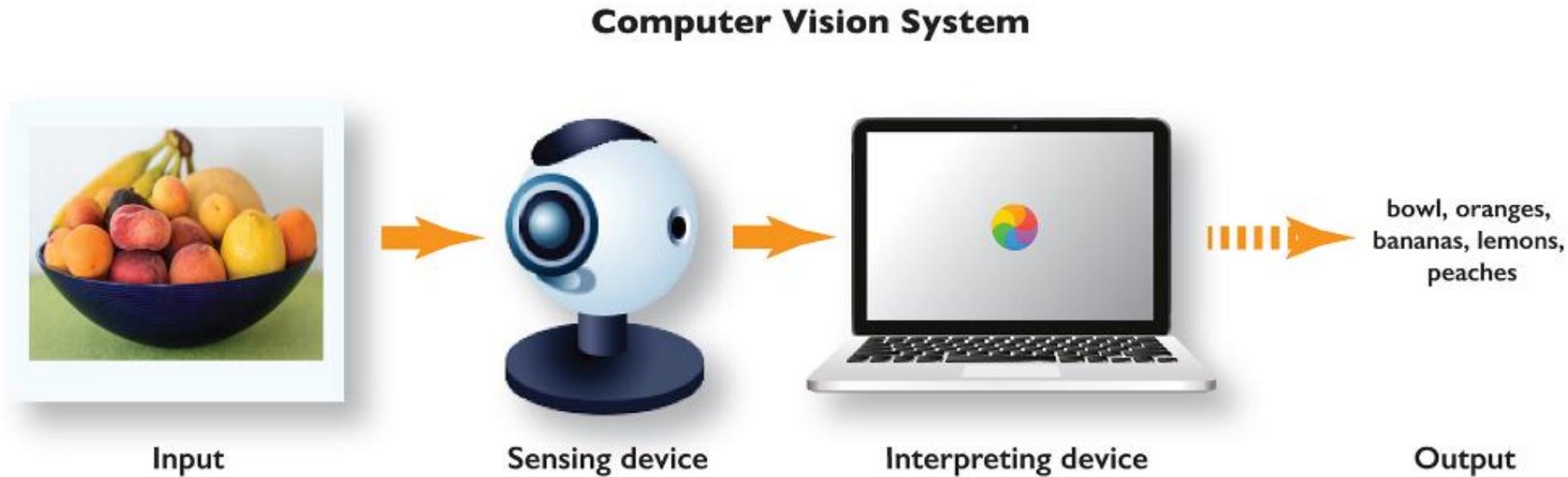


Obrada medicinskih slika



Computer Vision (CV)

- Takođe, bavićemo se računarskom vizijom
- Računarsko razumevanje i interpretacija vizuelnih podataka



Computer Vision – neki od problema

Klasifikacija slika

Cat? (0/1)



Detekcija objekata



Person

Hammer

Neural style transfer



Computer Vision – neki od problema

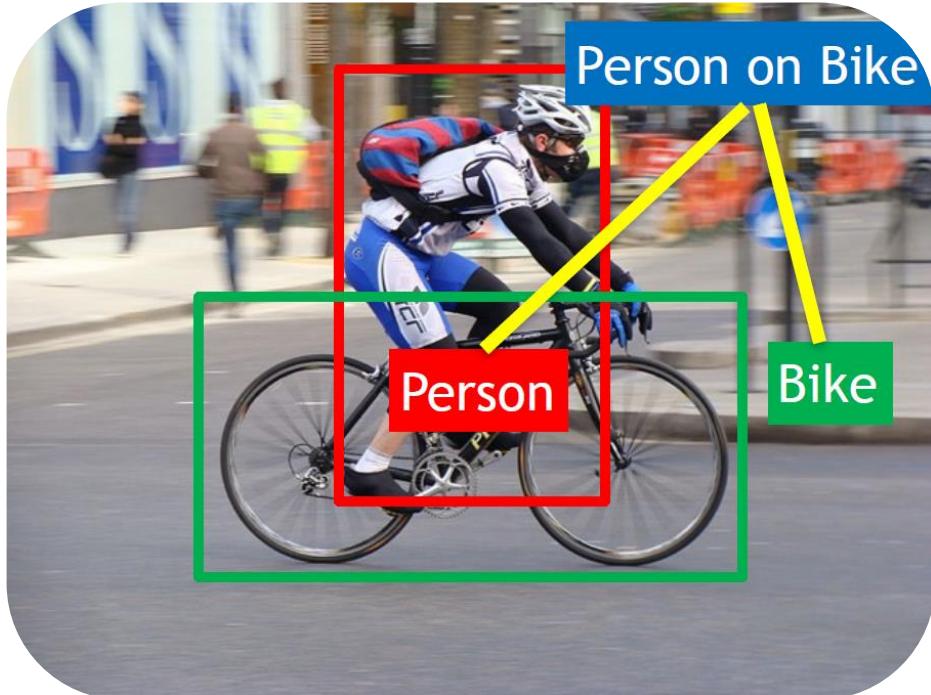
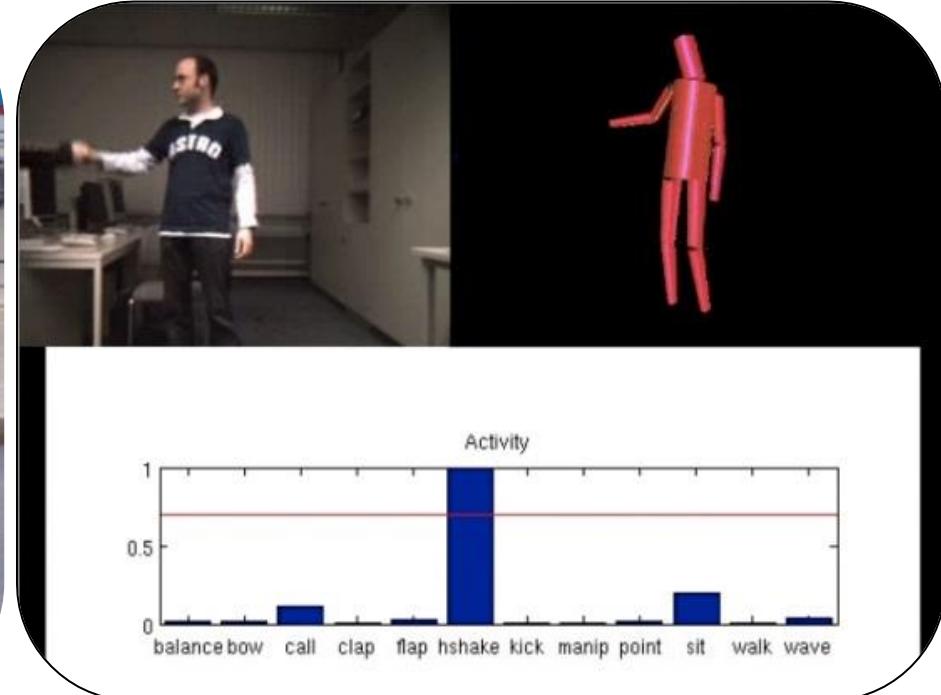


Image captioning



Prepoznavanje aktivnosti

Motivacija: eksplozija vizuelnih podataka

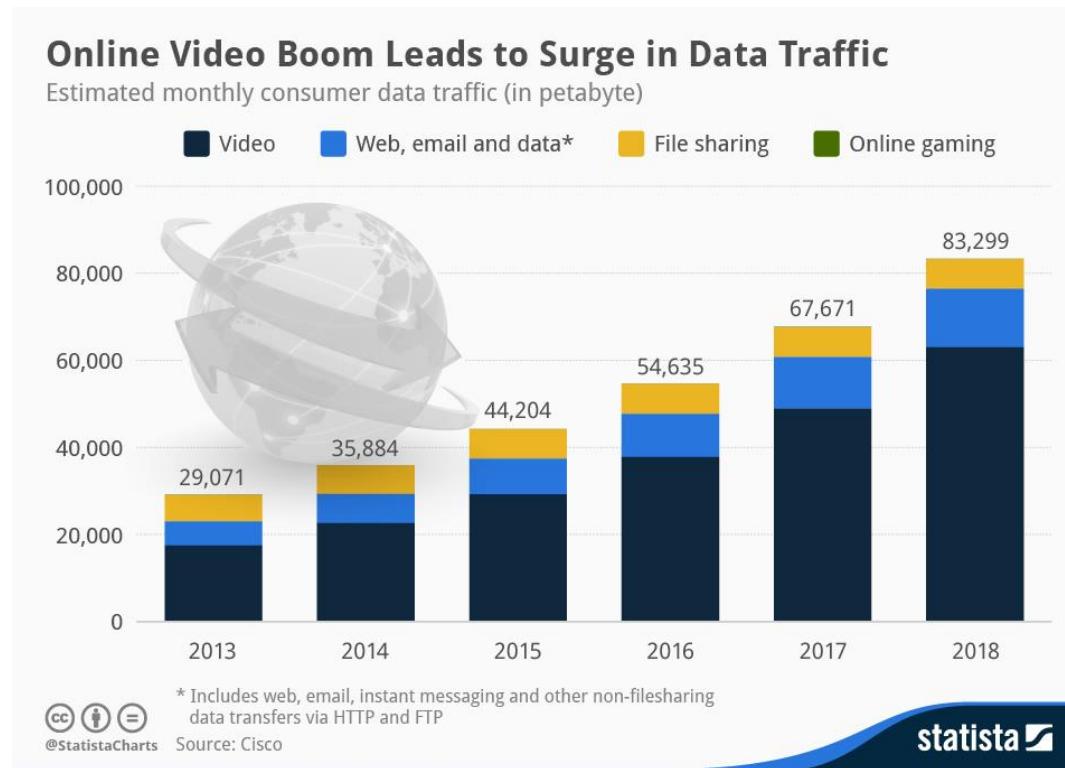
- Svakog dana kreira se neverovatna količina vizuelnih podataka



1 h podele slika =
10 godina pregledanja

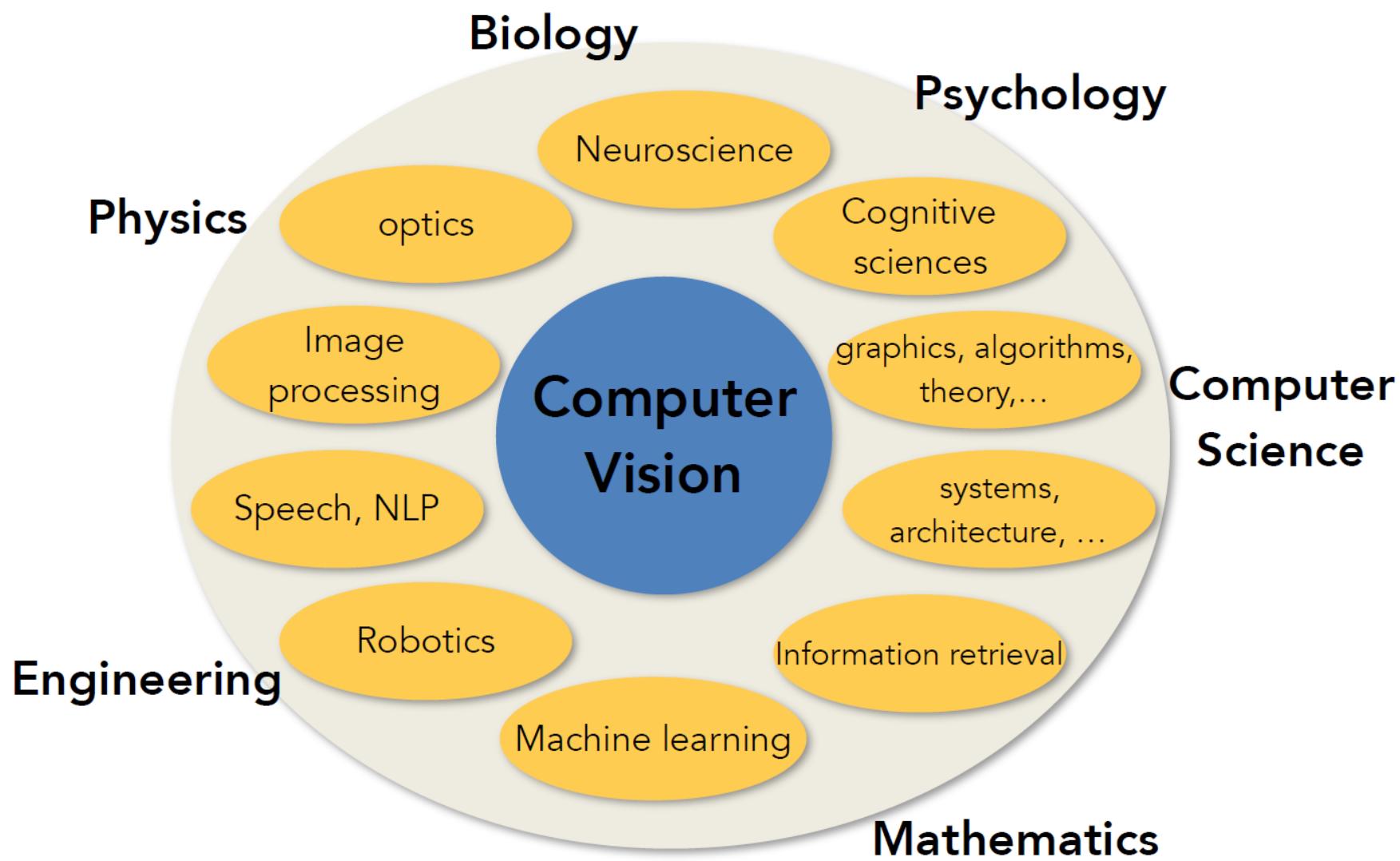


1 s = 5 h videa



- Većina informacija koja danas cirkuliše su zapravo vizuelni podaci
- Ljudske mogućnosti su odavno premašene!
- Od kritične je važnosti da razvijemo algoritme koji mogu da koriste i razumeju vizuelne podatke

Odnos sa ostalim oblastima



Istoriја биолошке визије

Evolution's Big Bang



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543 million years, B.C.

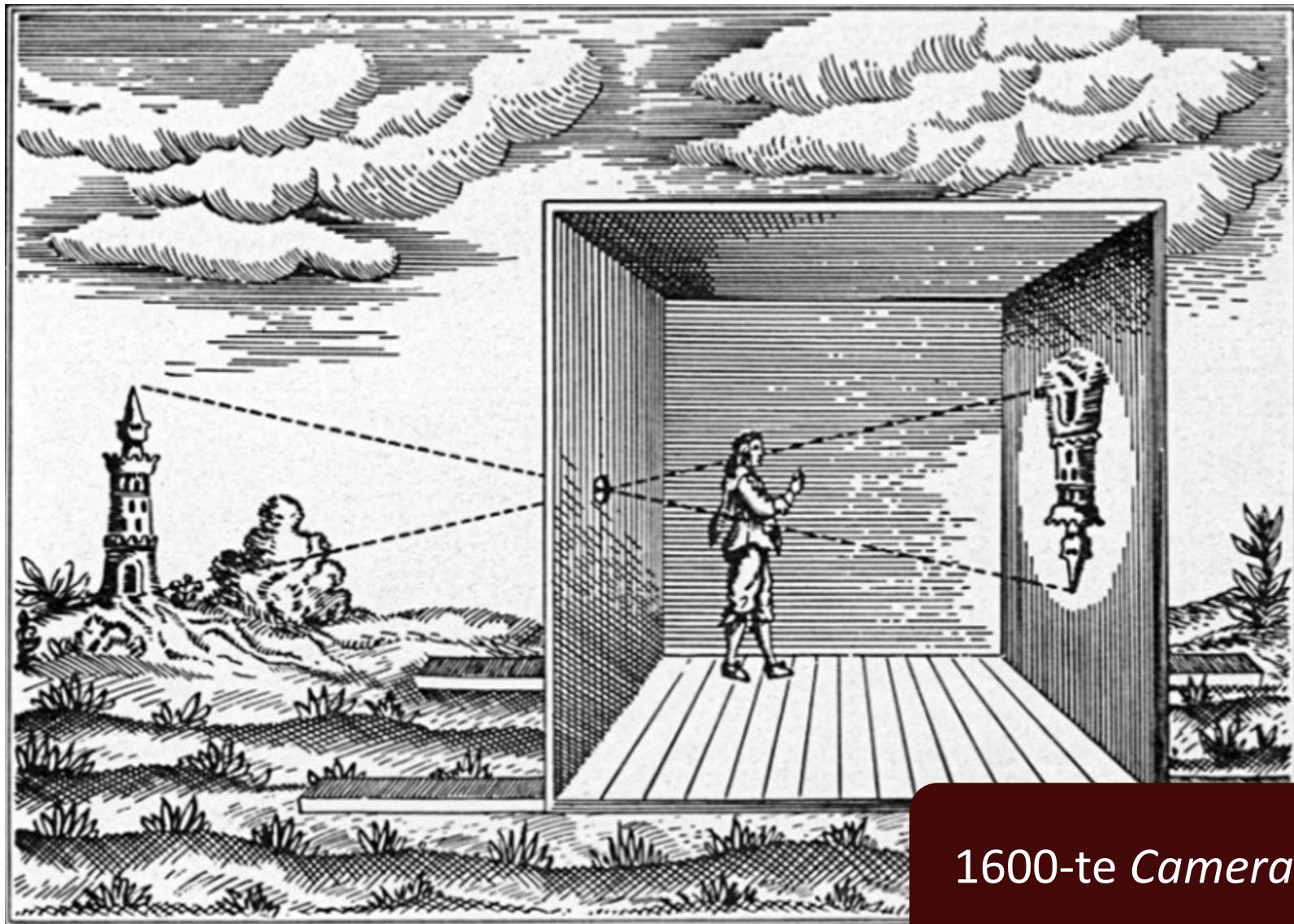
U veoma kratkom vremenskom periodu (10 miliona godina) broj životinjskih vrsta je eksplodirao

Andrew Parker: u to vreme fosili razvijaju oči

Danas...

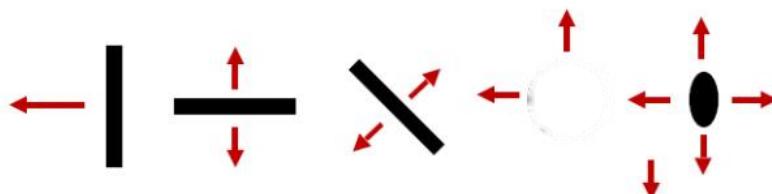
- Vid je највећи сензорни систем код готово свих животинских врста
- Kod ljudi је 50% neurona kortекса посвећено процесирању визуелних података

Istoriја мешаничке визије



1600-te *Camera obscura*

Mehanizam vida



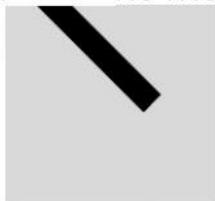
Simple cells:
Response to light orientation

Complex cells:
Response to light orientation and movement

Hypercomplex cells:
Response to movement with end point

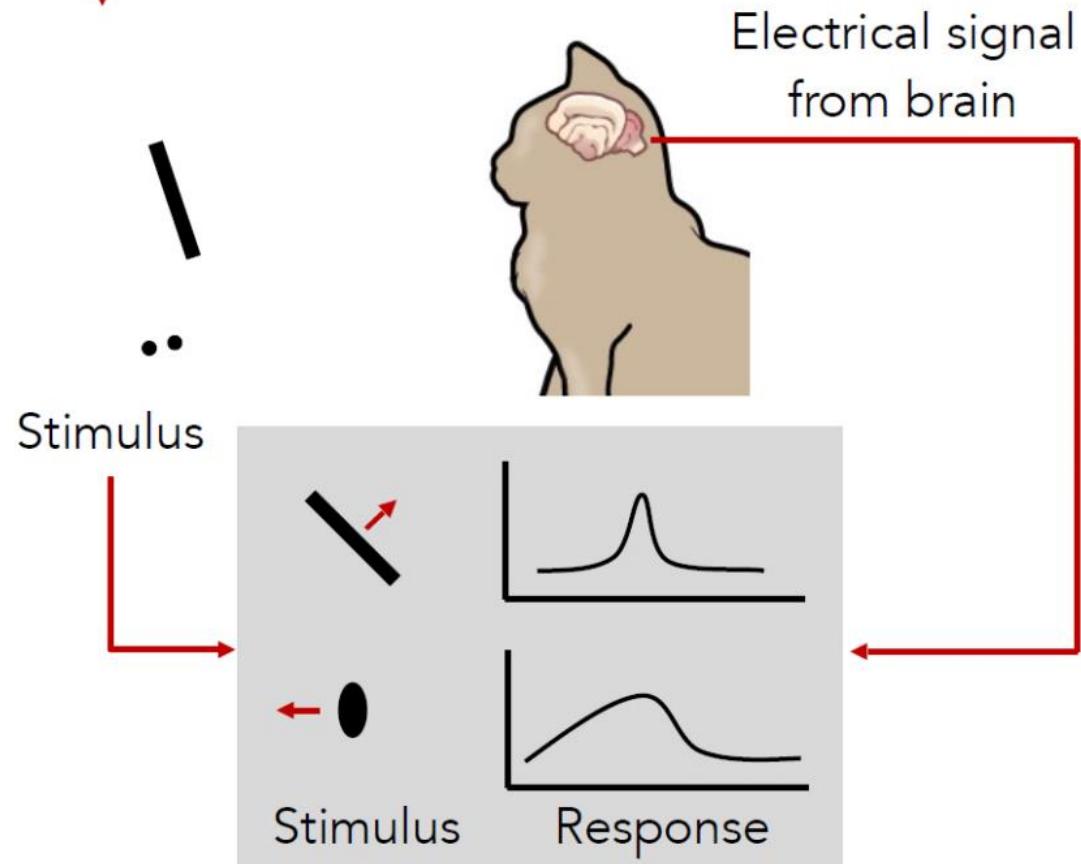


No response



Response
(end point)

Hubel & Wiesel, 1959

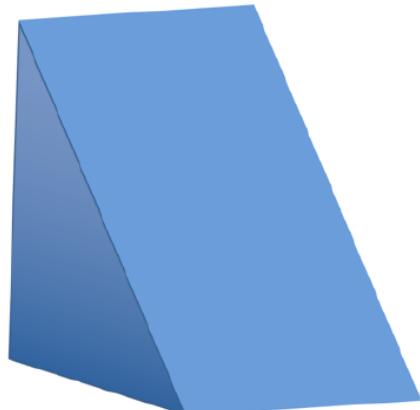


Istorijska računarska vizija

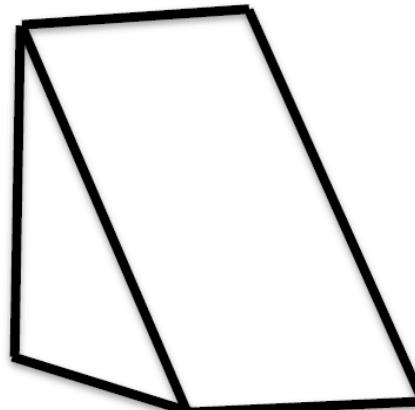
Block world

Larry Roberts, 1963

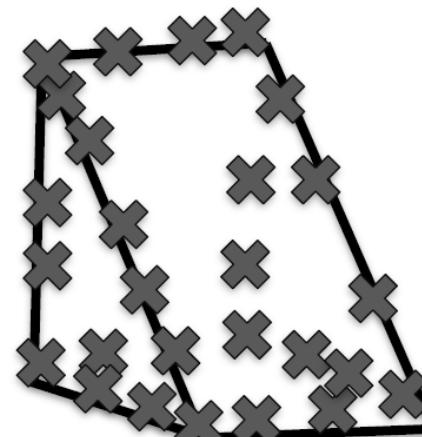
- Prva doktorska disertacija u oblasti računarske vizije
- Simplifikacija sveta pomoću jednostavnih geometrijskih oblika
- Cilj: prepoznavanje oblika i rekonstrukcija scene



(a) Original picture



(b) Differentiated picture



(c) Feature points selected

Istoriја računarske vizije

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
PROJECT MAC

Artificial Intelligence Group
Vision Memo. No. 100.

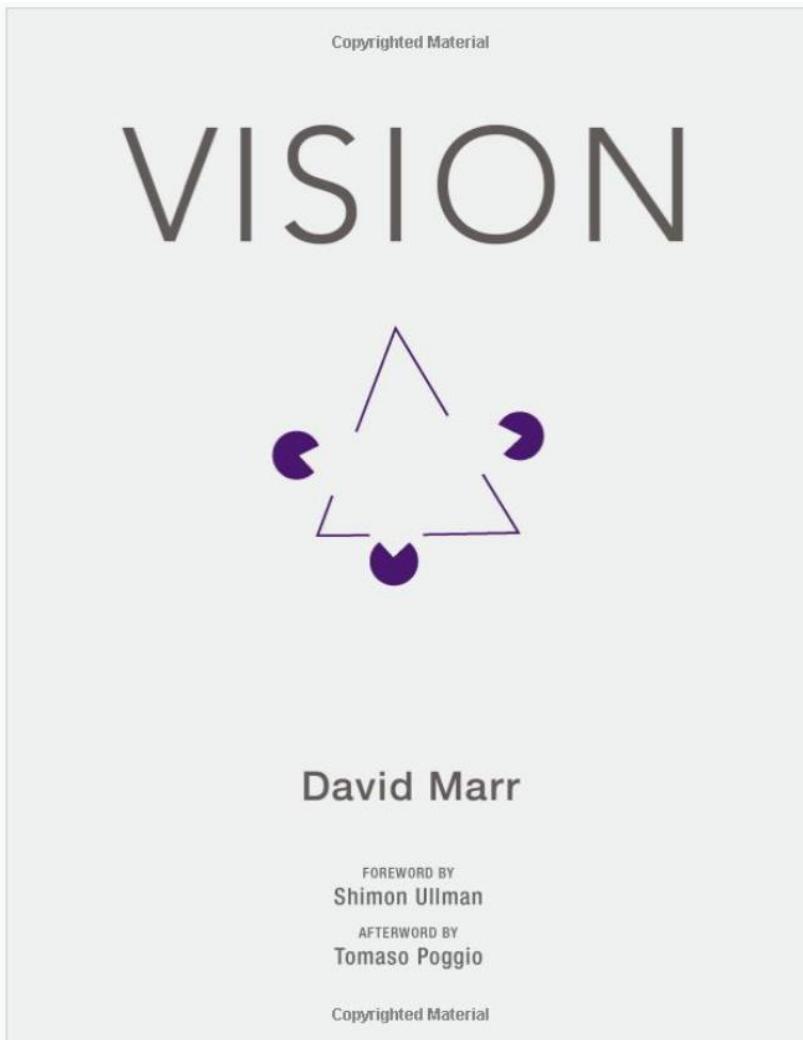
July 7, 1966

THE SUMMER VISION PROJECT

Seymour Papert

The summer vision project is an attempt to use our summer workers effectively in the construction of a significant part of a visual system. The particular task was chosen partly because it can be segmented into sub-problems which will allow individuals to work independently and yet participate in the construction of a system complex enough to be a real landmark in the development of "pattern recognition".

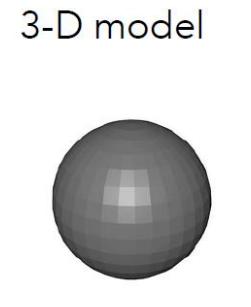
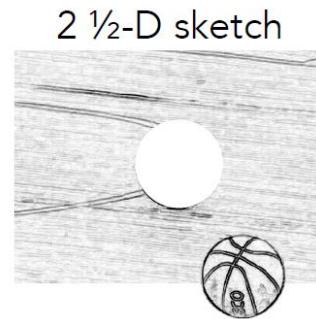
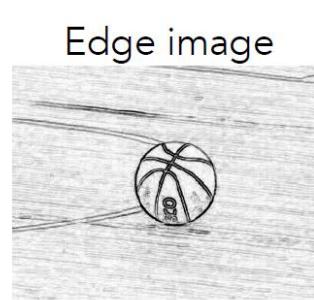
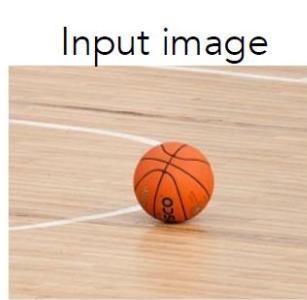
Istorijske teme u računarskoj viziji



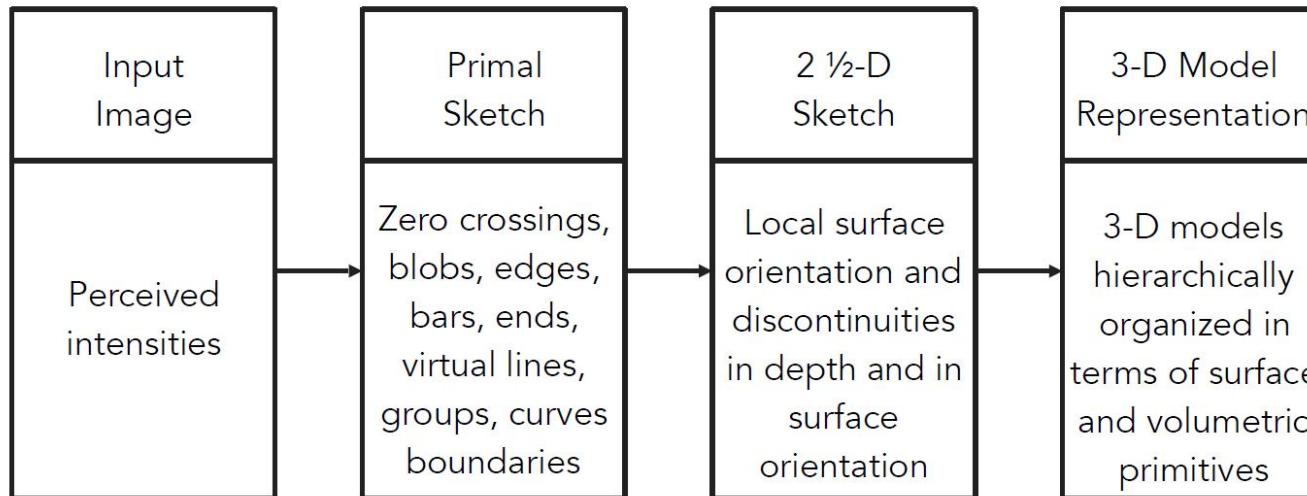
- Jedna od najuticajnijih knjiga iz oblasti računarske vizije
- Šta je vizija?
- Kako možemo razvijati algoritme koje su u mogućnosti da razumeju vizuelni svet?

David Marr, 1970s

Istoriјa računarske vizije



- Ulaz: slika
- Izlaz: potpuna 3D reprezenzacija
- Metod: niz procesa
- Ovaj način razmišljanja je dominirao računarskom vizijom nekoliko decenija

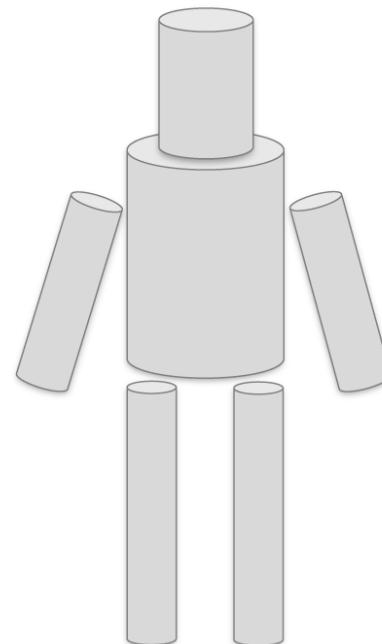


Istorijska računarska vizija

Kako reprezenovati stvarne objekte pomoću jednostavnih geometrijskih primitiva?

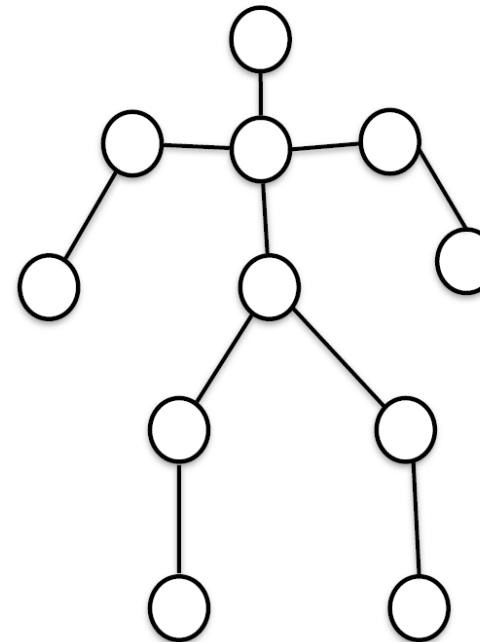
- Generalized Cylinder

Brooks & Binford, 1979



- Pictorial Structure

Fischler and Elschlager, 1973



Istorijska računarska vizija



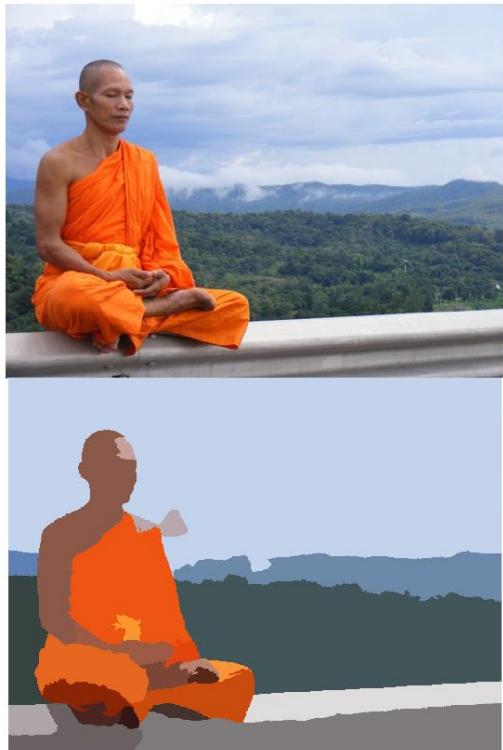
David Lowe, 1987

- Pokušaj da se detektuju ivice i da se ova informacija koristi u cilju prepoznavanja objekata
- Mnogo truda uloženo u razmatranje samih zadataka računarske vizije
- Izdvojio se veoma težak problem prepoznavanja objekata
- Predložena rešenja su uglavnom *toy examples*

Istoriја računarske vizije

Normalized Cut (Shi & Malik, 1997)

[Image is CC BY 3.0](#)



[Image is public domain](#)

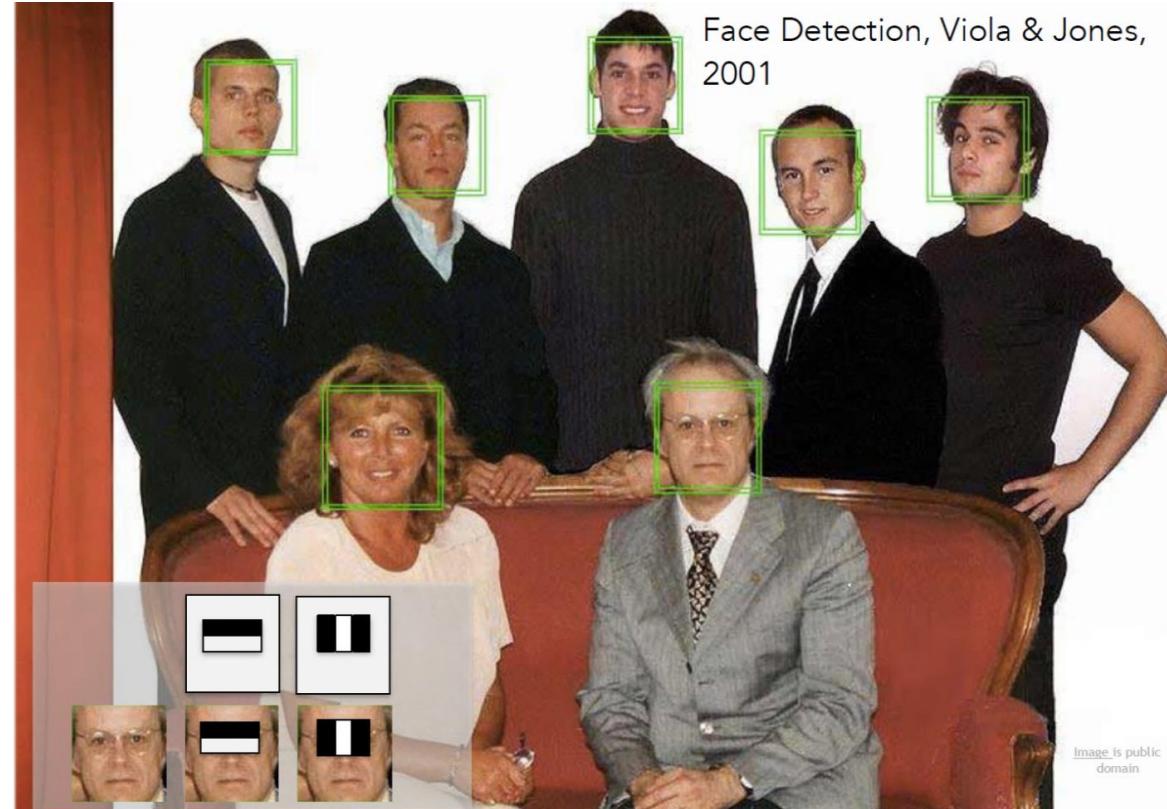


[Image is CC-BY SA 3.0](#)



- Ako je problem prepoznavanja objekata težak, možda treba krenuti od segmentacije
- Krećemo od slike i grupišemo piksele u smislene celine
- Ovde je prikazan jedan od najranijih radova gde se koristi algoritam baziran na teoriji grafova za segmentaciju slike

Istorijska računarska vizija



Eksplozija tehnika mašinskog učenja u 2000-im, pogotovo modela baziranih na statistici (SVM, NN, AdaBoost)

Detekcija lica na slikama u realnom vremenu u vreme kada su računari bili još prilično spori

U 2006 *Fujifilm* izbacuje prvu digitalnu kameru sa ovim softverom – brz prelazak sa istraživanja na realnu primenu

Istorijska računarska vizija



[Image](#) is public domain



[Image](#) is CC BY-SA 2.0

Ugao kamere

Delimično ili potpuno zaklanjanje

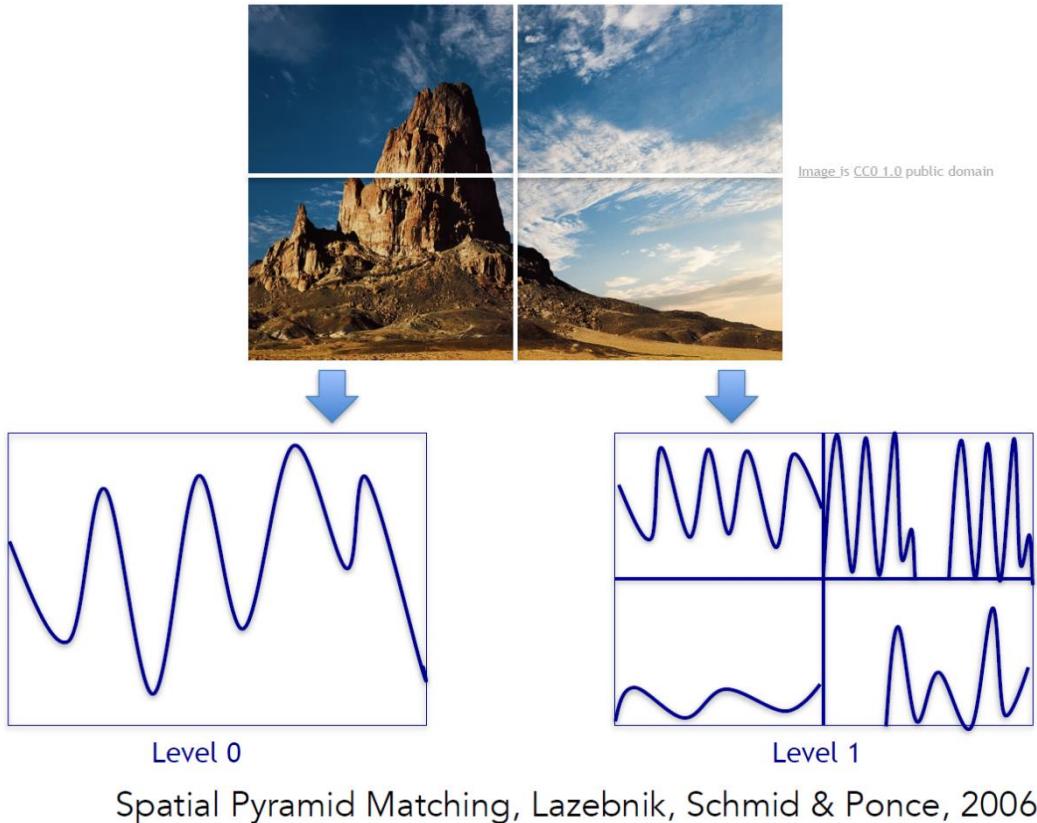
Osvetljenje

Varijacije u izgledu objekta

"SIFT" & Object Recognition, David Lowe, 1999

- Način razmišljanja koji se prožimao kroz 2000-e: prepoznavanje objekata bazirano na obeležjima
- Postoje delovi objekta koji su invarijantni u odnosu na promene u izgledu
- Zadatak prepoznavanja objekta postaje problem identifikacije kritičnih obeležja objekta i preklapanje sa istim obeležjima drugog objekta

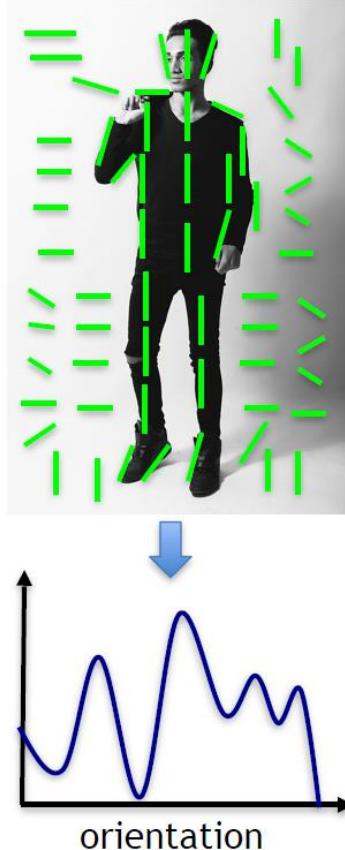
Istoriјa računarske vizije



- Korišćenjem istih gradivnih blokova (obeležja) počelo je prepoznavanje i celih scena
- Tip scene: pejsaž, kuhinja, autoput,...
- Ovaj algoritam ekstrahuje obeležja sa različitih delova objekta i u različitim rezolucijama i konkatenira ih u vektor

Istorijske računarske vizije

[Image is CC0 1.0 public domain](#)



Histogram of Gradients (HoG)
Dalal & Triggs, 2005



Deformable Part Model
Felzenswalb, McAllester, Ramanan, 2009

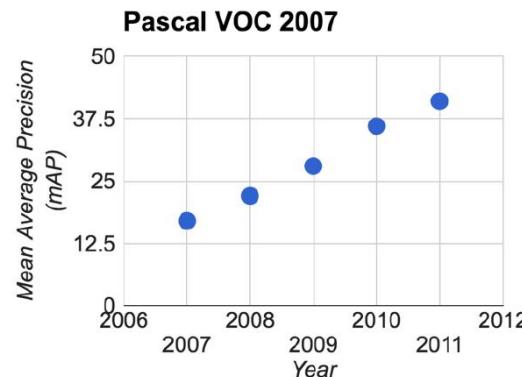
Sličan pristup se pojavio i u domenu
prepoznavanja ljudi

Istoriјa računarske vizije

Identifikovan je važan gradivni blok problema računarske vizije: prepoznavanje objekata

PASCAL Visual Object Challenge (20 object categories)

[Everingham et al. 2006-2012]



- Povećava se kvalitet slike zahvaljujući unapređenju digitalnih kamera i interneta
- Pojavljuje se *benchmark* skup podataka koji nam omogućava da merimo progres u zadatku prepoznavanja objekata
- Performanse detekcije se stalno uvećavaju

Nekoliko hiljada do desetine hiljada slika po kategoriji

Istoriјa računarske vizije

Da li smo spremni da prepoznajemo sve objekte na svetu?



IMAGENET

22K categories and **14M** images

- Animals
 - Bird
 - Fish
 - Mammal
 - Invertebrate
- Plants
 - Tree
 - Flower
- Food
- Materials
- Structures
- Artifact
 - Tools
 - Appliances
 - Structures
- Person
- Scenes
 - Indoor
 - Geological Formations
- Sport Activities

www.image-net.org

Problem svih
modela
mašinskog učenja
je
preprilagođavanje
(overfitting)

Da bismo ovo
izbegli, potreban
nam je velik skup
podataka

Istoriја računarske vizije

IMAGENET Large Scale Visual Recognition Challenge

Steel drum

The Image Classification Challenge:

1,000 object classes

1,431,167 images

Output:

- Scale
- T-shirt
- Steel drum
- Drumstick
- Mud turtle

Output:

- Scale
- T-shirt
- Giant panda
- Drumstick
- Mud turtle

Russakovsky et al. arXiv, 2014

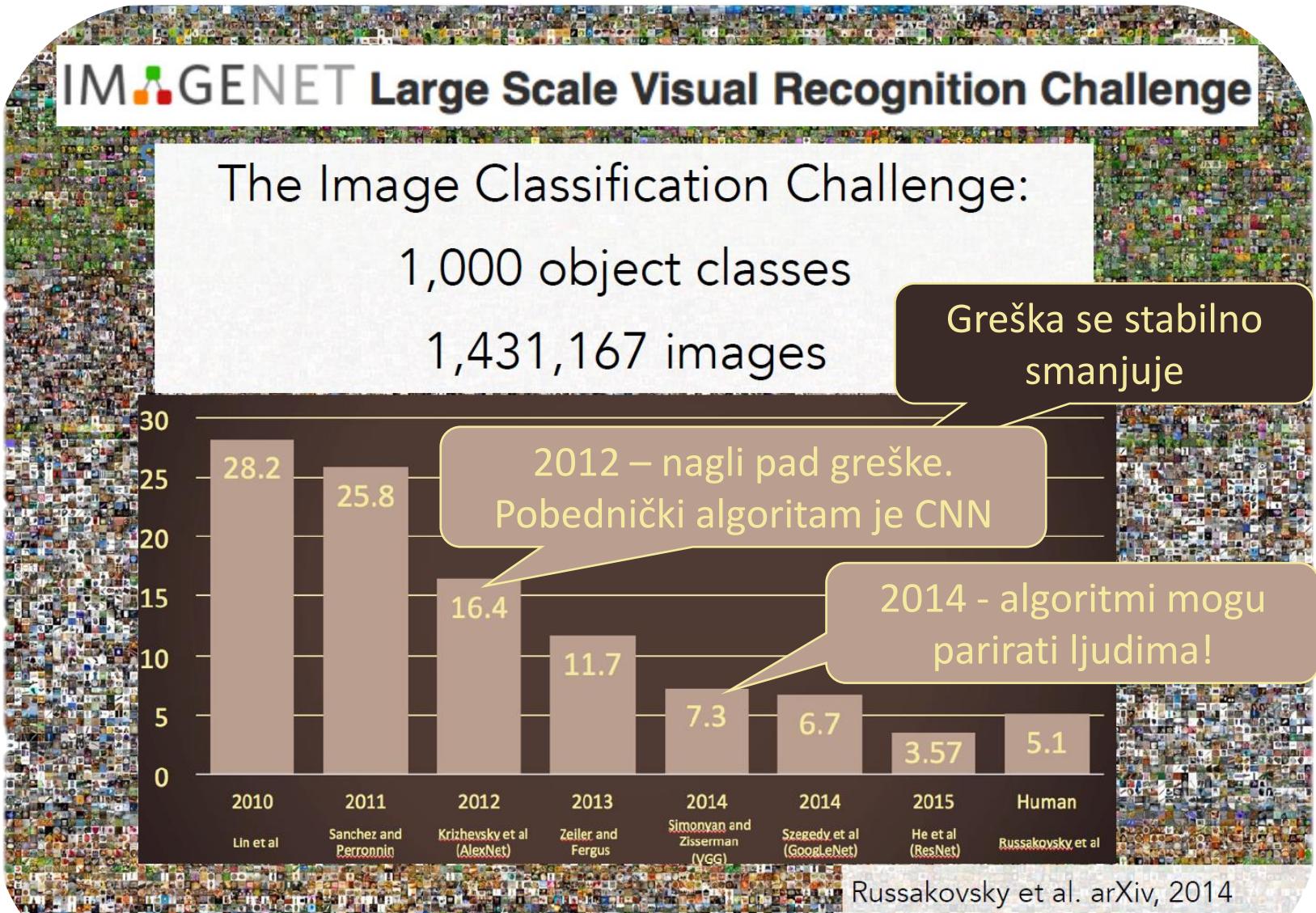
i-Fei Li & Justin Johnson & Serena Yeung

Lecture 1 - 23

4/4/2017

- Od velike je važnosti kako meriti progres
- 2009 godine *Image Net* izbacuje takmičenje
- Strožiji test skup od 1000 klasa objekata
- Ako algoritam može da izbaci top 5 labela koje obuhvataju tačnu labelu, onda to nazivamo uspehom

Istoriја računarske vizije

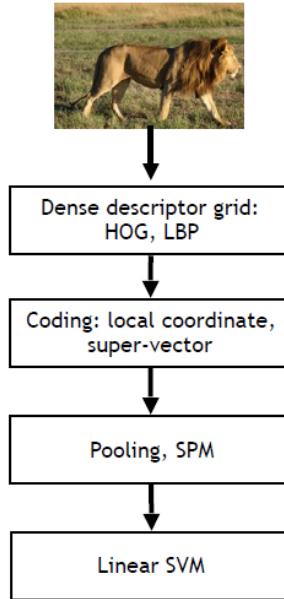


Konvolucione neuronske mreže

IMAGENET Large Scale Visual Recognition Challenge

Year 2010

NEC-UIUC

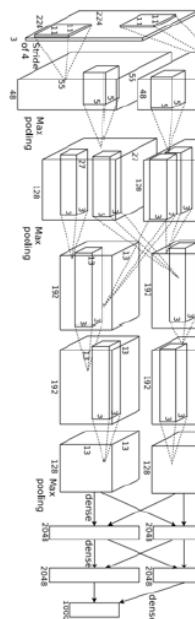


[Lin CVPR 2011]

Lion image by Swissfrog is licensed under CC BY 3.0

Year 2012

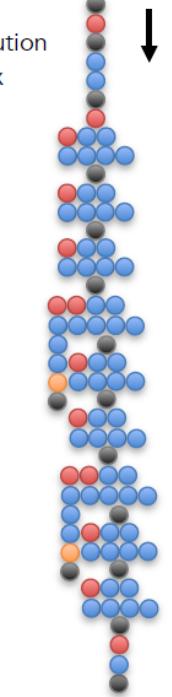
SuperVision



AlexNet
7 slojeva

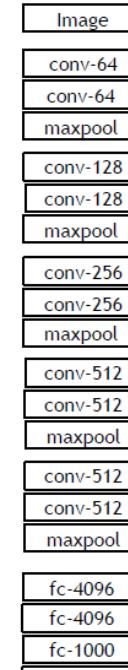
Year 2014

GoogLeNet



[Szegedy arxiv 2014]

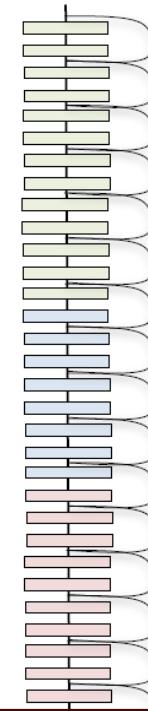
VGG



VGG19
19 slojeva

Year 2015

MSRA



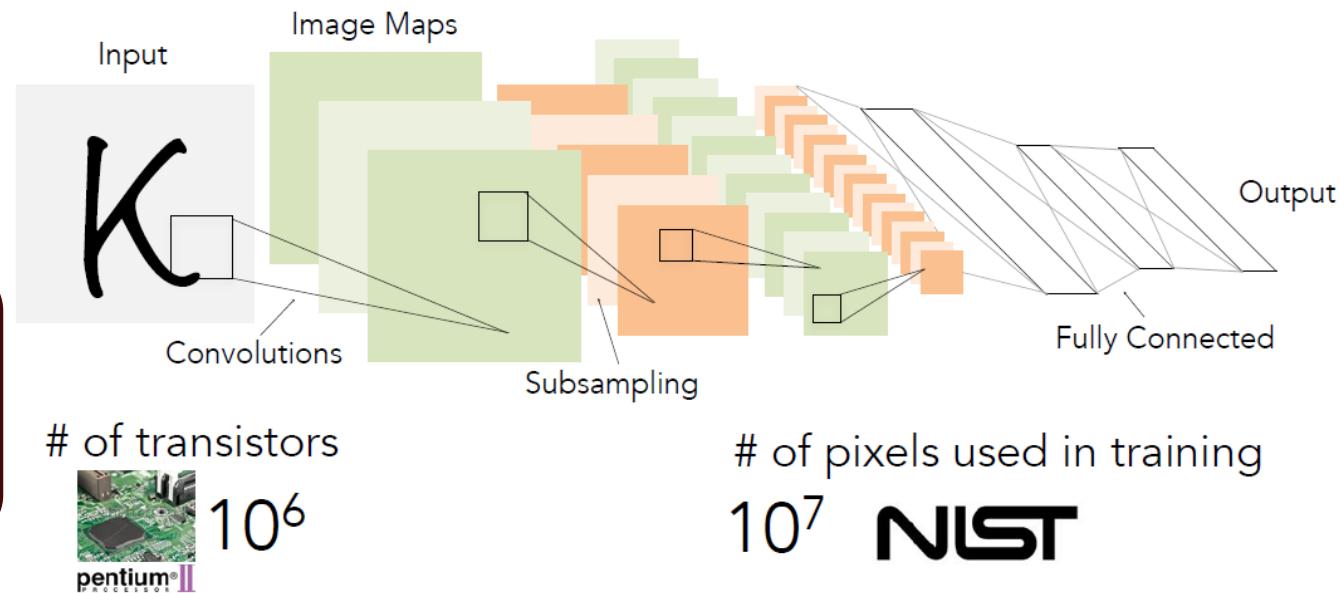
Residual Networks
152 sloja

Konvolucione neuronske mreže

1998

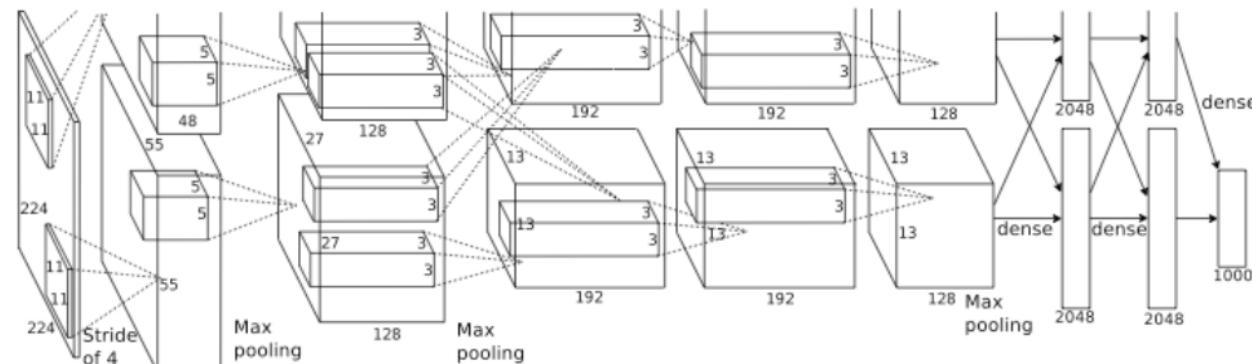
LeCun et al.

Struktura
mreže iz 1998
je slična onoj iz
2012



2012

Krizhevsky et al.



of transistors



10^9

GPUs



of pixels used in training

10^{14}

IMAGENET

Zašto su CNN popularne tek od 2012?

Brzina računara i
mogućnost paralelizacije

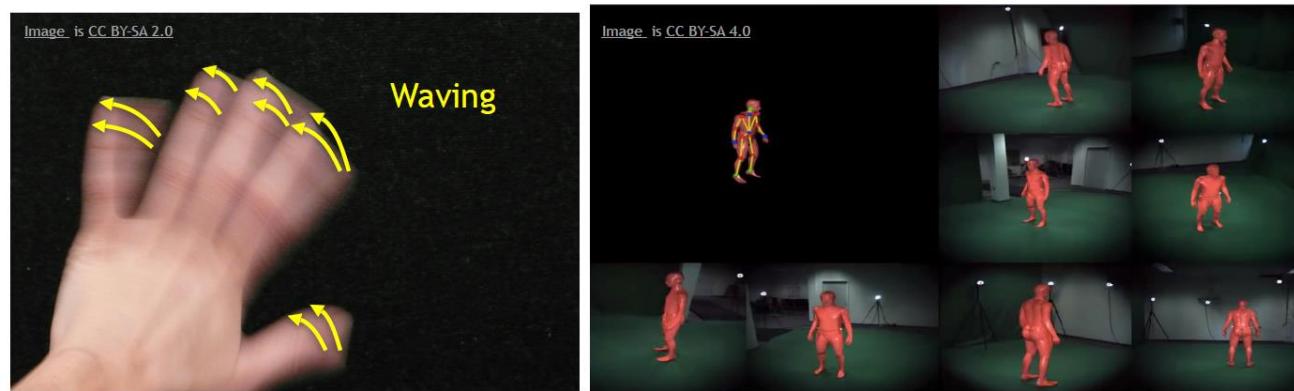
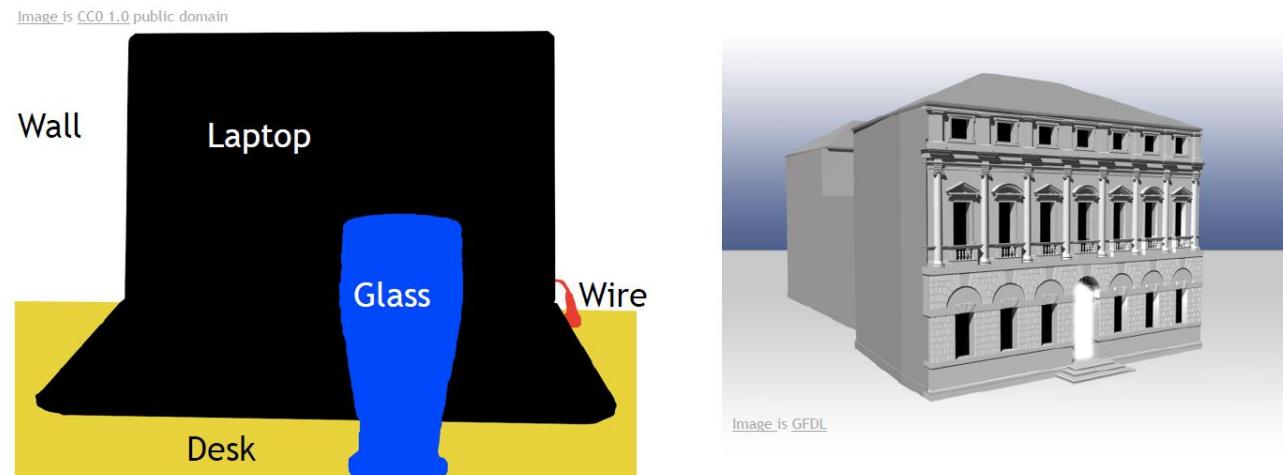
Količina labeliranih
podataka

Po Murovom zakonu, dobijali smo sve
brže i brže računare svake godine: broj
tranzistora na čipovima je nekoliko
redova veličine veći nego u 90-im

Razvoj GPU-ova koji se mogu
maksimalno paralelizovati

Veštačka inteligencija

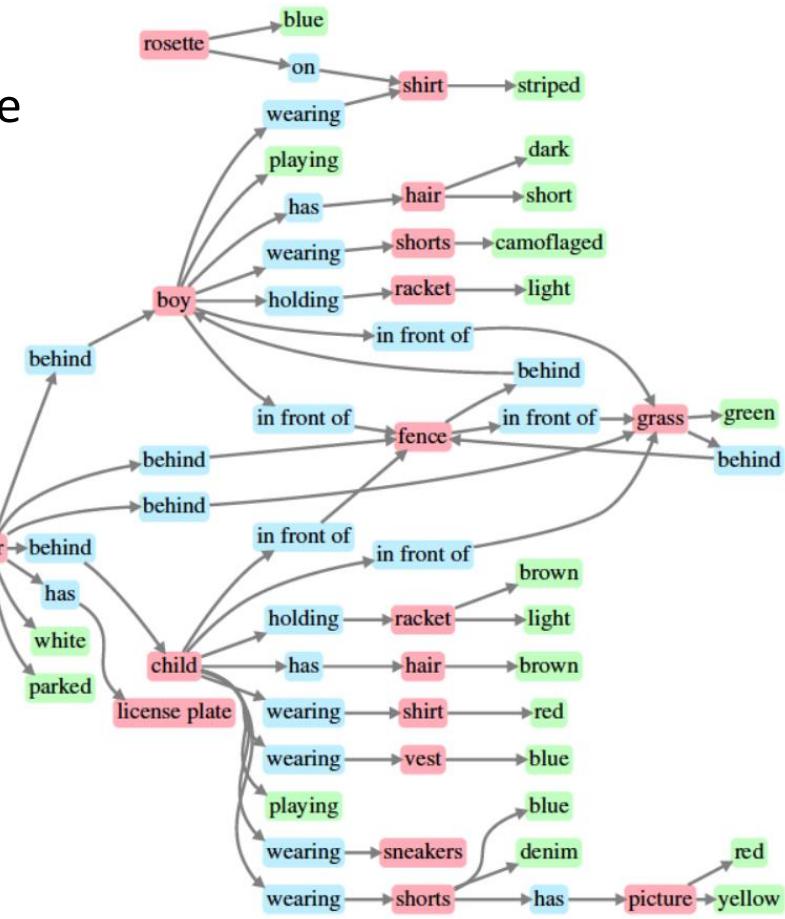
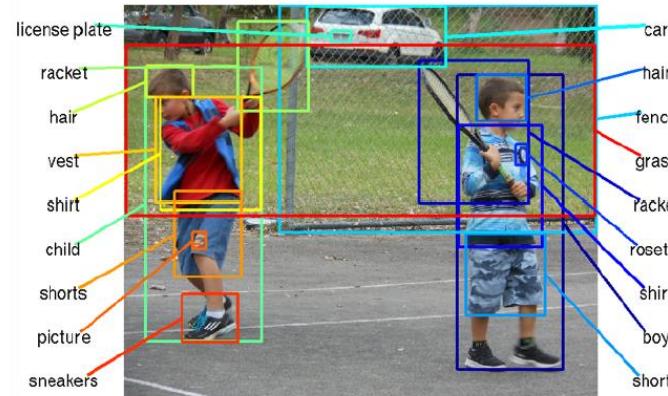
Zadatak veštačke inteligencije je mnogo veći od prepoznavanja objekata...



Visual genome

Ideja je da se slike predstave kao veliki grafovi semantički povezanih koncepta

Ovo ne obuhvata samo identitet objekata već relacije između objekata, njihove atribute, akcije koje se dešavaju na sceni,...



PT = 500ms



Some kind of game or fight. Two groups of two men? The man on the left is throwing something. Outdoors seemed like because i have an impression of grass and maybe lines on the grass? That would be why I think perhaps a game, rough game though, more like rugby than football because they pairs weren't in pads and helmets, though I did get the impression of similar clothing. maybe some trees? in the background. (Subject: SM)

Slika je pokazana ljudima veoma kratak vremenski rok (1/2 sekunde)

Ljudi su uspevali da daju opširne opise

Fei-Fei, Iyer, Koch, Perona, JoV, 2007

Ovo je u nekom smislu sveti gral računarske vizije – da se razume priča na slici na bogat i dubok način

Zašto je ova slika smešna?



This image is copyright-free [United States government work](#)

Example credit: [Andrej Karpathy](#)

Način polaganja

Praktični deo

70 poena

Predispitne obaveze

Striktno definisani rokovi kada
možete braniti

Ukoliko ponovo polažete
određeni deo ispita,
prethodni bodovi tog dela
vam se poništavaju

Teorija

30 poena

Nije neophodna za polaganje
predmeta. Minimum 11 bodova da bi
se teorija položila
(bodovi iz teorije računali)

Način polaganja

Pismeno, u rokovima koje
propisuje FTN

Preporučena literatura – kursevi



Stanford University

Stanford: „Convolutional Neural Networks for Visual Recognition“
<http://cs231n.stanford.edu/>

video materijali:

<https://www.youtube.com/playlist?list=PL3FW7Lu3i5JvHM8ljYj-zLfQRF3EO8sYv>

Duke UNIVERSITY

★★★★★ 4.7 (904) | 44K Students

Image and Video Processing: From Mars to Hollywood with a Stop at the Hospital

coursera

<https://www.coursera.org/learn/image-processing/>

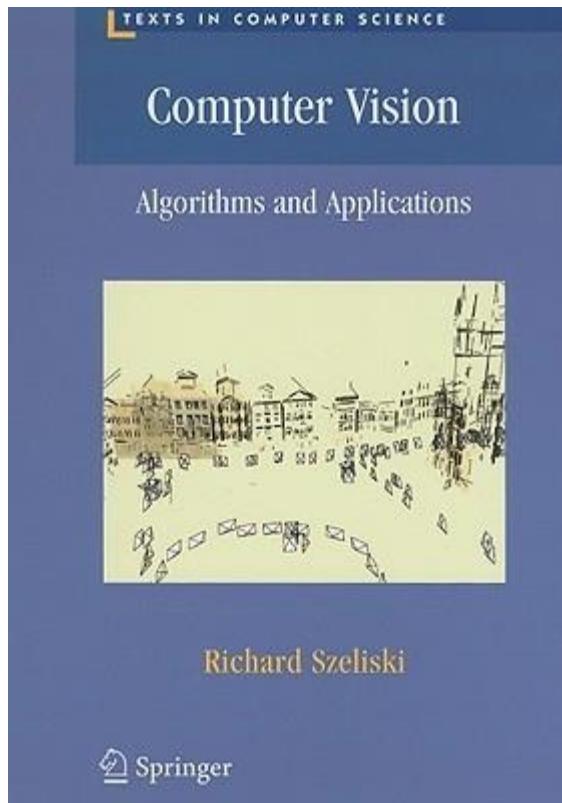


Convolutional
Neural Networks

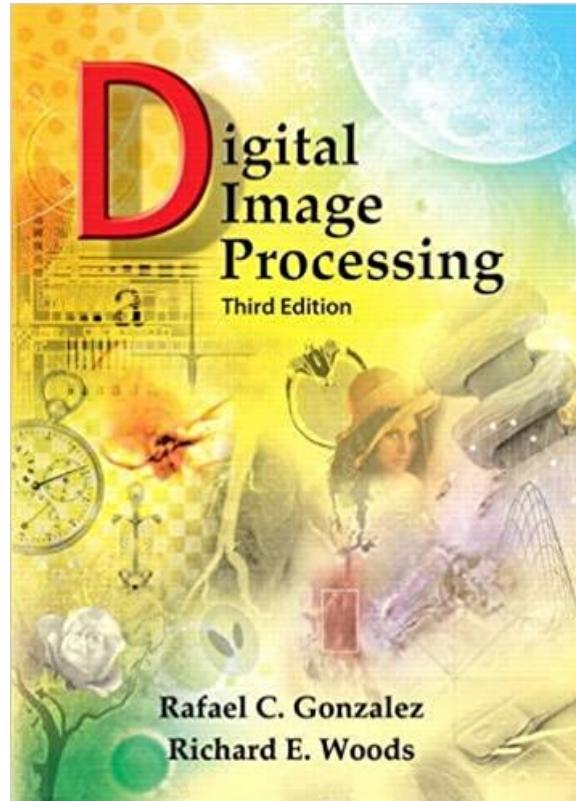
Computer vision

<https://www.coursera.org/learn/convolutional-neural-networks>

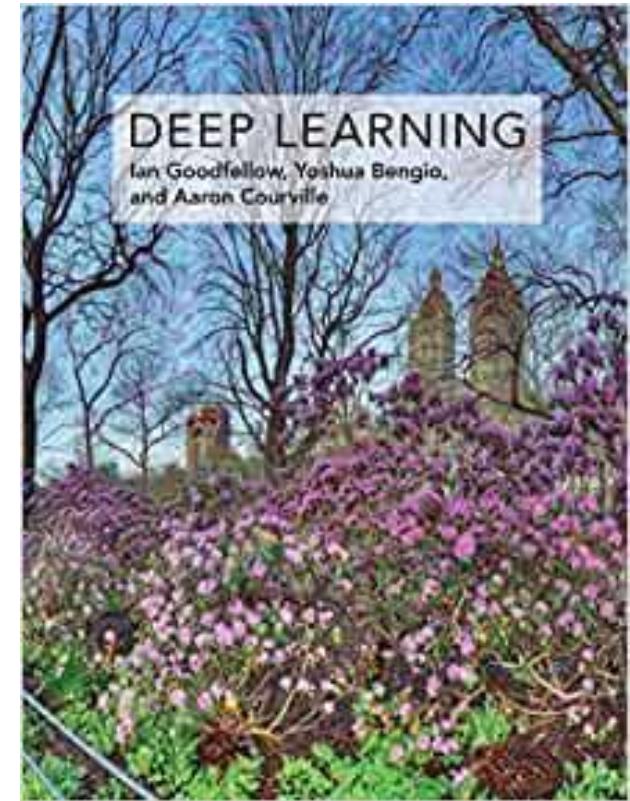
Literatura – knjige



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applications*. Springer
Science & Business Media.
<http://szeliski.org/Book/>



Rafael C. Gonzalez and
Richard E. Woods.
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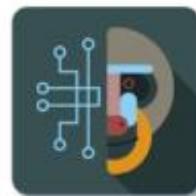
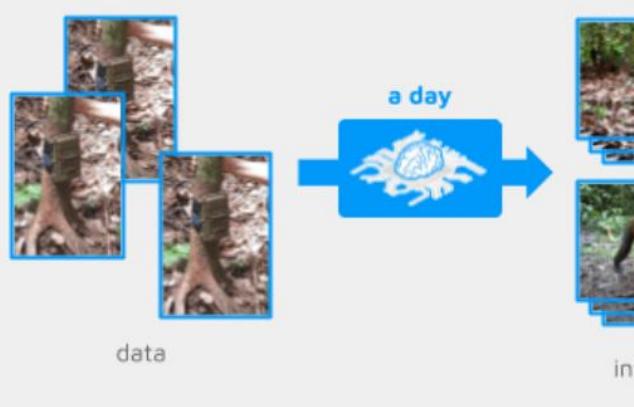
Goodfellow, I., Bengio, Y.,
Courville, A. and Bengio, Y.,
2016. *Deep learning* (Vol. 1).
Cambridge: MIT press

SUSTAINABLE DEVELOPMENT GOALS



<https://sdgs.un.org/goals>

13 CLIMATE ACTION



Mbaza AI

AI-Powered Wildlife Camera
Trap Image Classification



The Actuary

Caught On Camera: How Data Can Preserve Biodiversity

Source: www.theactuary.com

[Learn more](#)



The Guardian

Five ways AI is saving wildlife – from counting chimps to locating whales

Source: www.theguardian.com

[Learn more](#)



euronews.

From the polar bear capital of the world to tropical Gabon, AI is helping to fight biodiversity loss

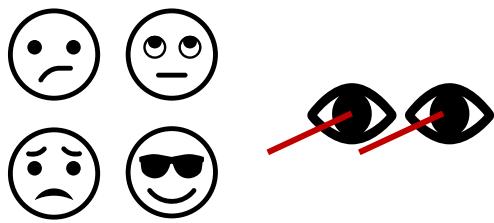


INDEPENDENT

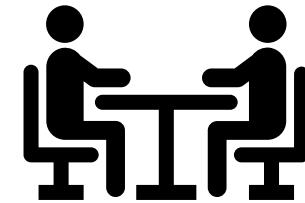
Stop the Illegal Wildlife Trade: How artificial intelligence has become the latest conservation tool

15 LIFE ON LAND





Praćenje angažovanja i usmerenja pažnje



Praćenje međusobnih interakcija studenata i učešća u aktivnostima na času



Automatsko ocenjivanje



Automatsko generisanje edukativnih materijala



Interaktivna okruženja za učenje

Domaći zadatak

Kako bi ti iskoristio
kompjutersku viziju da
unaprediš
čovečanstvo?

<https://docs.google.com/forms/d/e/1FAIpQLSdlzMGPaAODBFWzJiERhNW3ZoEke7xecyZVeAuAYXTiyetrw/viewform>