



Uvod u Mašinsko Učenje

Predavač: Aleksandar Kovačević

Slajdovi preuzeti sa CS 4641, Georgia Tech

<https://www.cc.gatech.edu/~zk15/ML2017/>

Šta je Mašinsko Učenje?

“Učenje je proces u kome sistem poboljšava svoje performanse kroz iskustvo.”

-Herbert Simon

Tom Mitchell (1998):

Mašinsko učenje je proučavanje algoritama koji:

- poboljšavaju svoje performanse P
- za neki zadatak T
- kroz iskustvo E .

Dobro definisan zadatak mašinskog učenja dat je sa $\langle P, T, E \rangle$.

Šta je Mašinsko Učenje?

Grana (pod-oblast) veštačke inteligencije, koja se bavi konstrukcijom i proučavanjem sistema koji uče iz podataka.



Šta je Mašinsko Učenje?

Programiranje računara da optimizuju neki kriterijum performansi koristeći primere (podatke) iz prošlosti.

-- Ethem Alpaydin

Cilj mašinskog učenja je razvoj algoritama koji mogu automatski da detektuju šablone u podacima, i onda da iskoristi te šablone za predviđanje budućih vrednosti.

-- Kevin P. Murphy

Šta je Mašinsko Učenje?

Mašinsko Učenje je predikcija budućnosti na osnovu prošlosti.

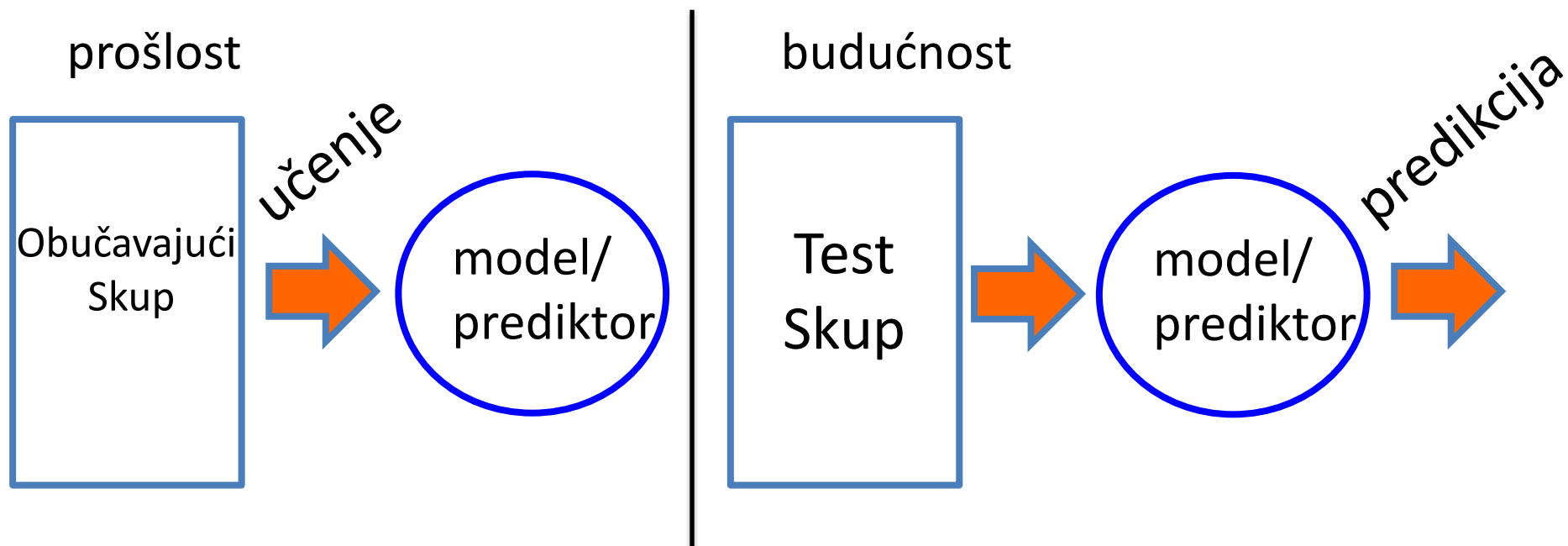
-- Hal Daume III



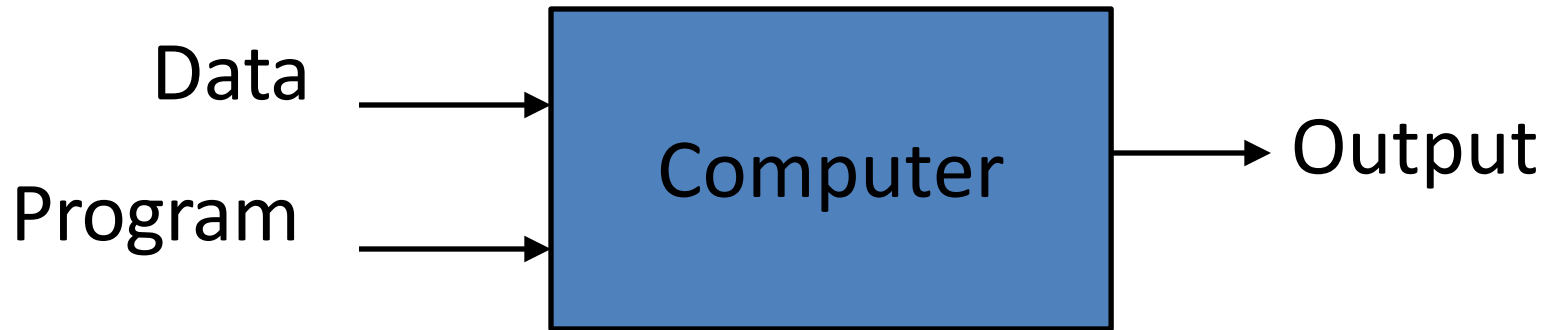
Šta je Mašinsko Učenje?

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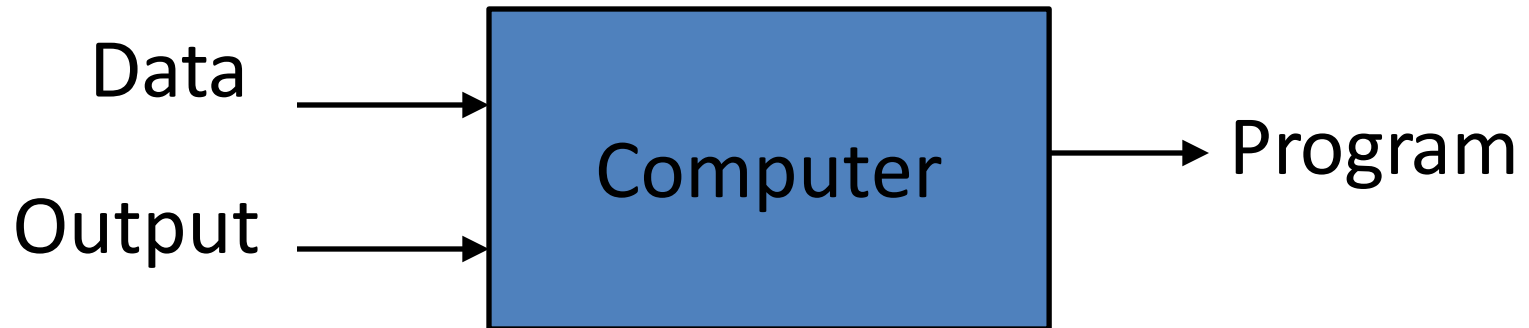
-- Hal Daume III



Tradicionalno programiranje



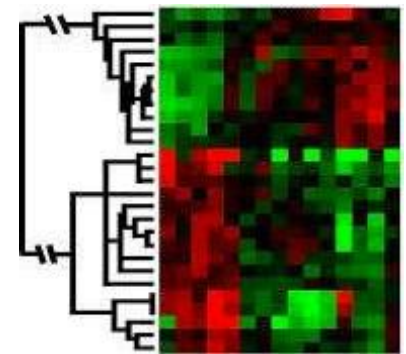
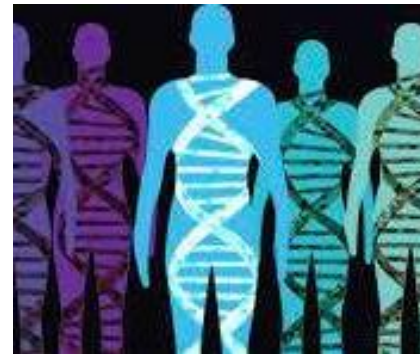
Mašinsko Učenje



Kada nam je potrebno Mašinsko Učenje?

ML se koristi kad:

- Ljudska ekspertiza ne postoji (koji ekspert zna kuda robot treba da ide na Marsu?)
- Ljudi ne mogu da objasne ekspertizu (prepoznavanje lica ili govora)
- Nivo kvaliteta, detaljnosti za koji ljudi nemaju vremena (personalizovana medicina)
- Količine podataka koje ljudi ne mogu da savladaju (bioinformatika - geni)



Mašinsko učenje nije uvek potrebno:

- Npr. ne treba nam ML da izračunamo neto od bruto plate.

Prepoznavanje pisanih cifara (ili slova) je klasičan zadatak za koji je potrebno Mašinsko Učenje

čoveku je jako teško da objasni kako zna da prepozna broj 2

0 0 0 1 1 1 1 1 1 2

2 2 2 2 2 2 2 3 3 3

3 4 4 4 4 4 5 5 5 5

6 6 7 7 7 7 7 8 8 8

9 9 9 9 9 4 9 9 9

Još neki zadaci za koje je prikladna i uspešna primena ML

- Prepoznavanje šablona:
 - Prepoznavanje lica ili određenih izraza lica
 - Prepoznavanje pisanih ili izgovorenih reči
 - Obrada medicinskih slika (npr. da li određeni snimak sadrži tumor ili ne)
- Generisanje šablona:
 - Generisanje slika, teksta, govora ili muzike
- Detekcija anomalija:
 - Neuobičajene transakcije sa kreditnim karticama
 - Neuobičajne vrednosti na senzorima nuklearne elektrane
- Predikcija:
 - Predikcija vrednosti akcija ili kursa valuta

Neki od primera primene

- Web pretraživači (npr. Learn To Rank algoritam)
- Bioinformatika
- Biznis
- Elektronska trgovina
- Istraživanje svemira
- Robotika
- Ekstrakcija informacija
- Analiza društvenih mreža
- Itd.

Jedan od ranih primera: Igranje Mica

“Mašinsko učenje: Naučna disciplina koja omogućava računarima da uče bez eksplicitnog programiranja.”
-Arthur Samuel (1959)



Definisanje zadatka mašinskog učenja kroz primere

Poboljšati performanse za zadatak T , u odnosu na meru performansi P , na osnovu iskustva E

T: Igranje mica

P: procenat pobeda

E: Igranje sam protiv sebe

T: Prepoznavanje napisanih reči

P: Procenat tačno prepoznatih reči

E: Skup slika sa napisanim rečima koje su ljudi označili sa rečima koje sa njima nalaze

T: Autonomna vožnja po auto-putu

P: Prosečan put pređen do prve potrebe čoveka za intervencijom

E: Niz slika puta i poteza na volanu koje je uradio ljudski vozač

T: Kategorizacija e-mailova u spam i normalne

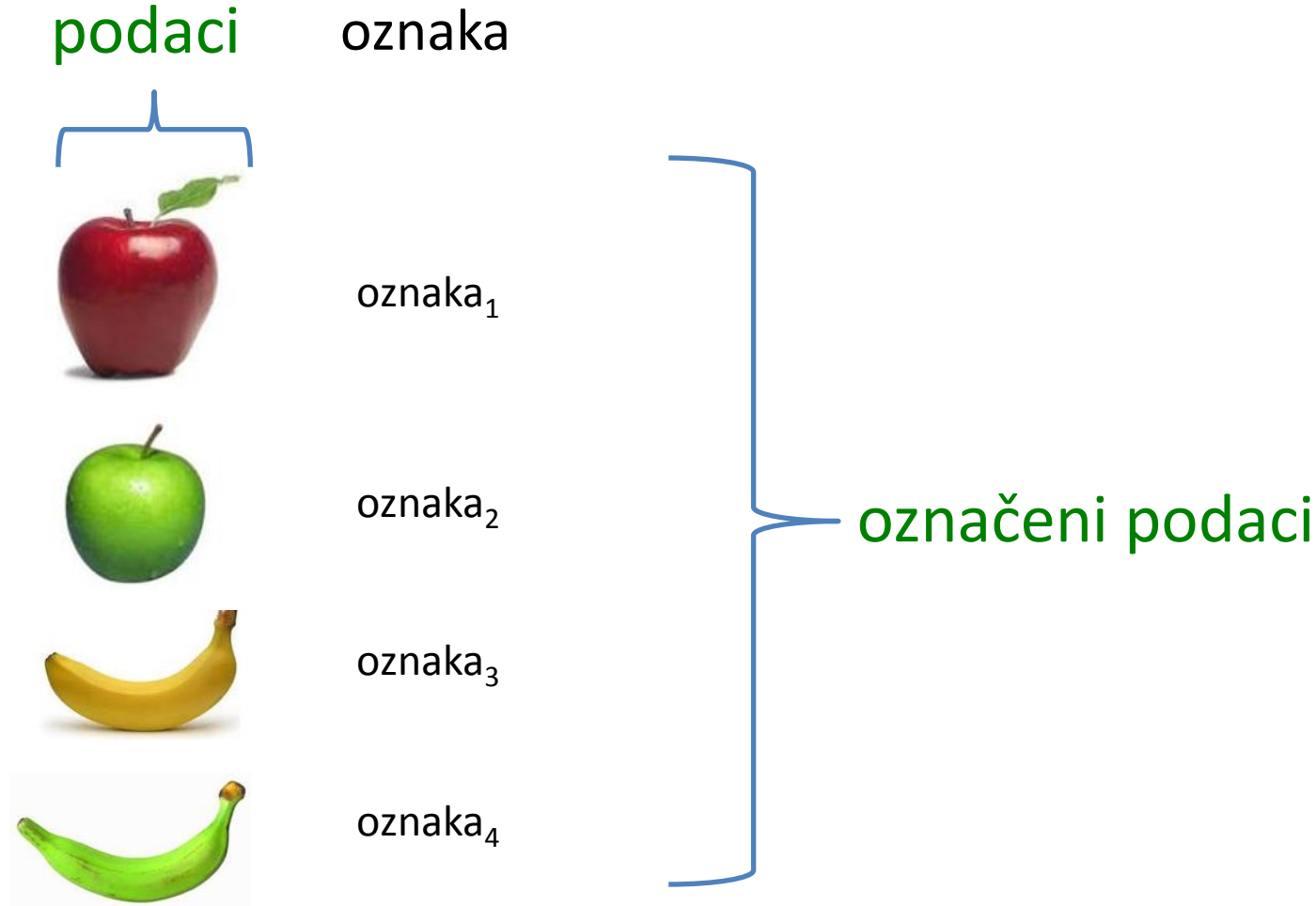
P: Procenata tačno klasifikovanih e-mailova.

E: Skup e-mailova koje su ljudi označili kao spam i normalne

Tipovi Učenja

- Nadgledano (induktivno) učenje
 - Dato: skup podataka + oznake (npr. oznake klasa)
- Nenadgledano učenje
 - Dato: skup podataka (bez oznaka)
- Polu-nadgledano učenje
 - Dato: skup podataka + vrlo malo označenih podataka
- Učenje Uslovljavanjem
 - Nagrade ili kazne nakon niza akcija

Nadgledano Učenje



oznaka₁ – odnosi se na oznaku baš prvog primera tj. brojevi 1-4 su redni brojevi primera.
Primer 1 i 2 mogu imati istu oznaku npr. u smilu da su oba jabuke.

Nadgledano Učenje

podaci

oznaka



oznaka₁



oznaka₂



oznaka₃



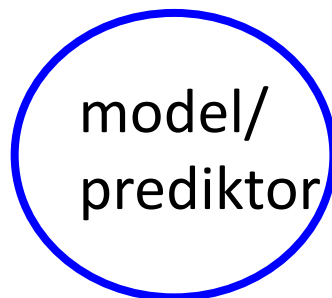
oznaka₄



model/
prediktor

Nadgledano Učenje

Kako označiti novi podataka – koji nema oznaku



predviđena oznaka

Nadgledano učenje: klasifikacija

oznaka



jabuka



jabuka



banana

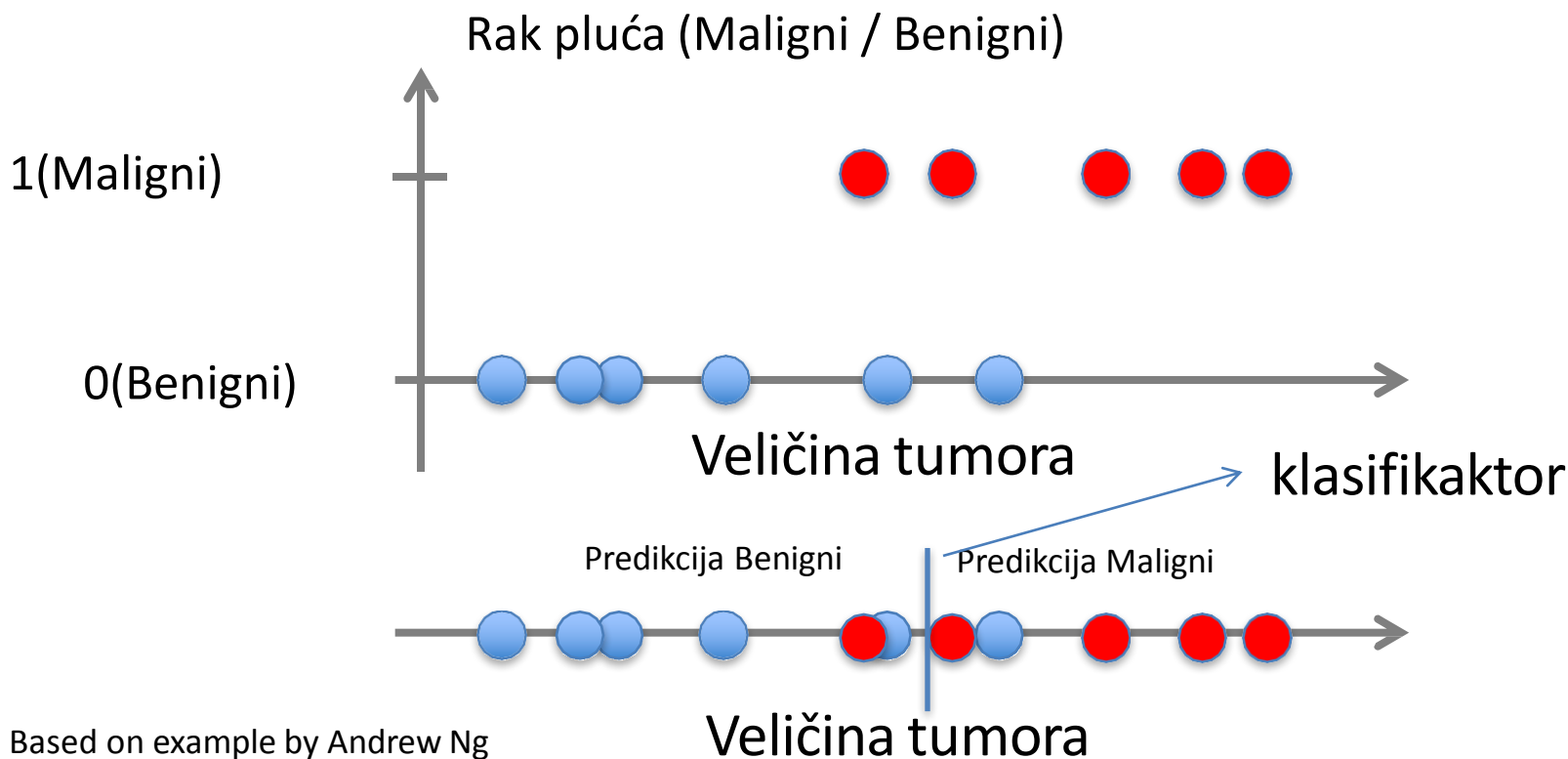


banana

Klasifikacija: konačan skup
diskretnih klasa

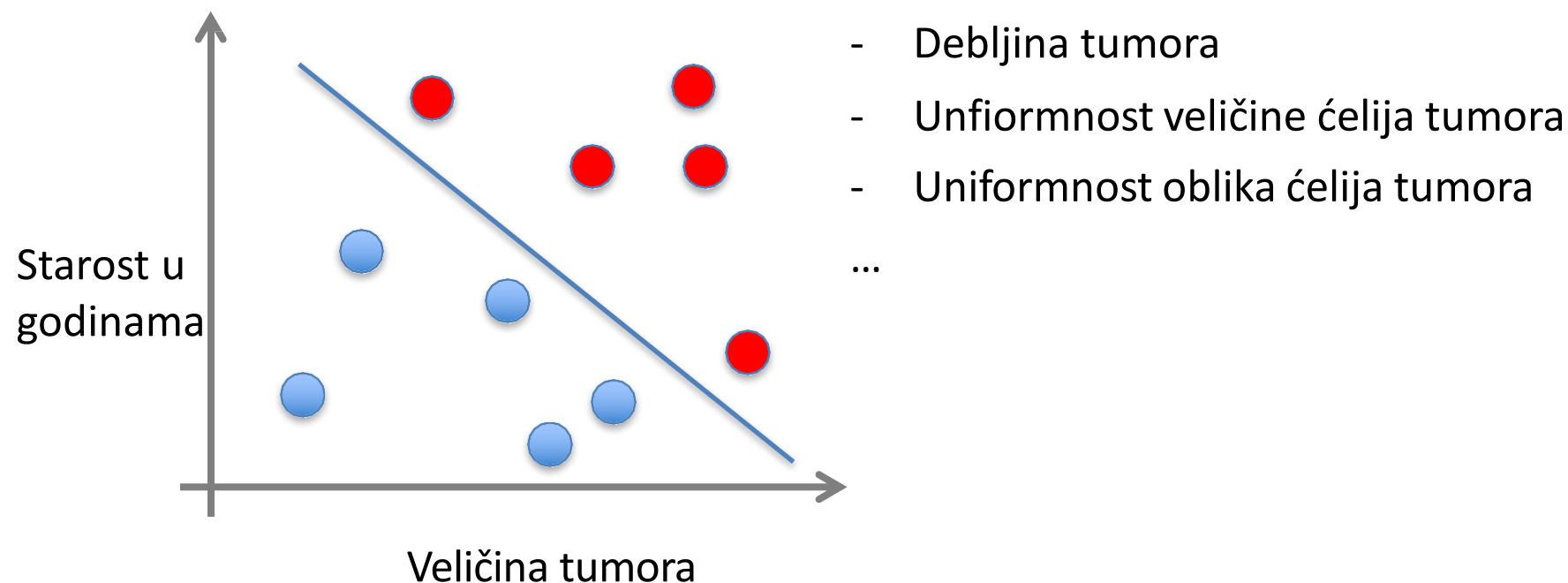
Nadgledano učenje: klasifikacija

- Dato je $(x_1, y_1), (x_2, y_2), \dots, (x_n, y_n)$
- Cilj je naučiti funkciju $f(x)$ koja predviđa y za dato x
 - y je diskretna vrednost



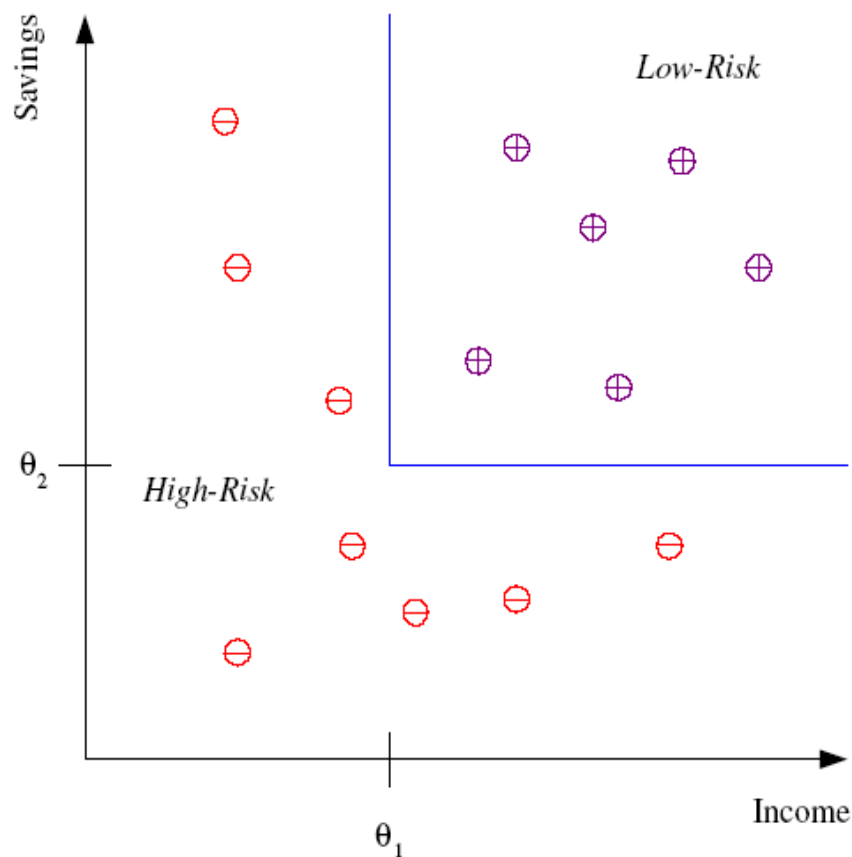
Nadgledano učenje: klasifikacija

- x može biti više-dimezioni
 - Svaka dimenzija je jedan atribut



Klasifikacija – još primera

Klasifikovati aplikante za kredit u **nisko-rizične** i **visoko-rizične** na osnovu prihoda (*income*) i (ušteđevine)



Klasifikacija – primer sa obradom slika

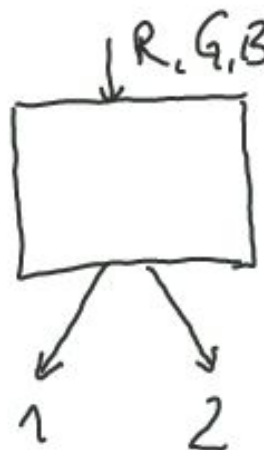
Klasifikacija

Nadgledano učenje

R	G	B	Klasa
153	141	125	K1
151	139	123	?
152	140	124	?
153	140	123	?
154	142	126	K1
154	141	124	?
156	143	126	?
155	142	125	?
151	138	121	?
155	143	127	?
152	139	122	?
150	138	122	?
197	142	23	?
158	145	128	?
201	146	27	K2
199	144	25	K2
149	136	119	?
156	144	128	?
157	144	127	?

Šta se uči?

Pravila po kojima se neoznačeni podaci klasifikuju u kategorije.



Klasifikacija – primer sa obradom slika

Klasifikacija

Nadgledano učenje

R	G	B	Klasa
153	141	125	K1
151	139	123	?
152	140	124	?
153	140	123	?
154	142	126	K1
154	141	124	?
156	143	126	?
155	142	125	?
151	138	121	?
155	143	127	?
152	139	122	?
150	138	122	?
197	142	23	?
158	145	128	?
201	146	27	K2
199	144	25	K2
149	136	119	?
156	144	128	?
157	144	127	?

Šta se uči?

Pravila po kojima se ne označeni podaci klasifikuju u kategorije.

Ako je vrednost obeležja $B < 50$ tada objekat pripada kategoriji K2 u protivnom pripada kategoriji K1

Klasifikacija – primer sa obradom slika

Klasifikacija

Nadgledano učenje

R	G	B	Region
153	141	125	K1
151	139	123	?
152	140	124	?
153	140	123	?
154	142	126	K1
154	141	124	?
156	143	126	?
155	142	125	?
151	138	121	?
155	143	127	?
152	139	122	?
150	138	122	?
197	142	23	?
158	145	128	?
201	146	27	K2
199	144	25	K2
149	136	119	?
156	144	128	?
157	144	127	?

Ako je vrednost obeležja $B < 50$ tada objekat pripada kategoriji K2 u protivnom pripada kategoriji K1

Da li je $B < 50$ jedino pravilo kojim se u ovom primeru može KVALITETNO izvršiti klasifikacija?

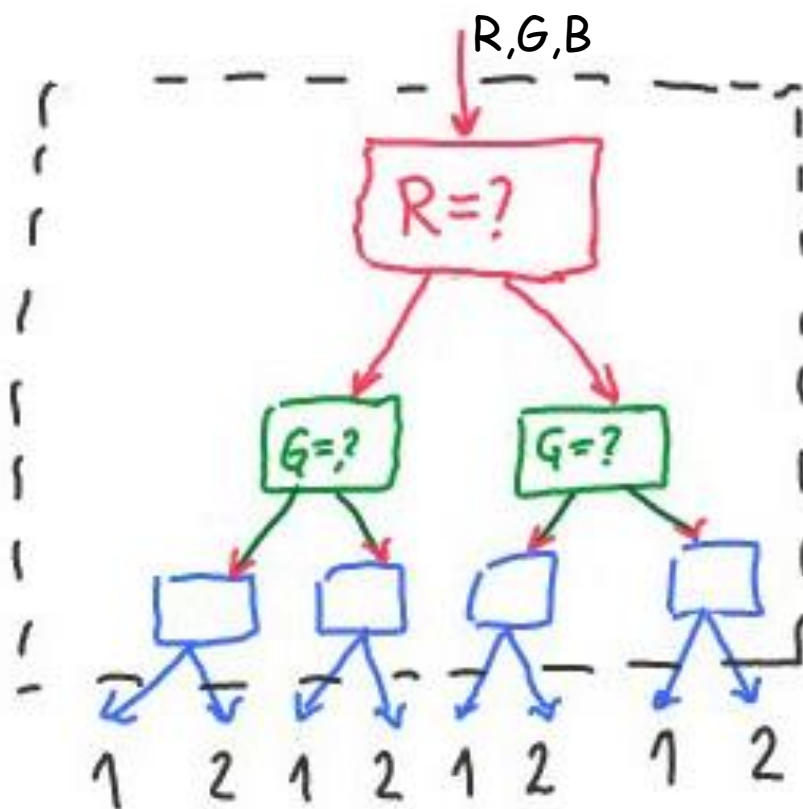
Klasifikacija – primer sa obradom slika

Klasifikacija

Nadgledano učenje

R	G	B	Region
153	141	125	K1
151	139	123	?
152	140	124	?
153	140	123	?
154	142	126	K1
154	141	124	?
156	143	126	?
155	142	125	?
151	138	121	?
155	143	127	?
152	139	122	?
150	138	122	?
197	142	23	?
158	145	128	?
201	146	27	K2
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149	136	119	?
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157	144	127	?

Stabla odlučivanja



Klasifikacija – Probabilističke tehnike

Klasifikacija

Nadgledano učenje

R	G	B	Region
153	141	125	K1
151	139	123	?
152	140	124	?
153	140	123	?
154	142	126	K1
154	141	124	?
156	143	126	?
155	142	125	?
151	138	121	?
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158	145	128	?
201	146	27	K2
199	144	25	K2
149	136	119	?
156	144	128	?
157	144	127	?

Probabilističke tehnike

Običan BAYES klasifikator

Markovljevi skriveni lanci

BAYES mreže

Klasifikacija – Druge tehnike

Klasifikacija

Nadgledano učenje

R	G	B	Region
153	141	125	K1
151	139	123	?
152	140	124	?
153	140	123	?
154	142	126	K1
154	141	124	?
156	143	126	?
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155	143	127	?
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197	142	23	?
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199	144	25	K2
149	136	119	?
156	144	128	?
157	144	127	?

Neuronske mreže

Višeslojni perceptron

SVM Suport Vector Machine

Još neki primeri klasifikacije sa ilustracijama: Spam Filter

podaci

☆ **Osman Khan** to Carlos [show details](#) Jan 7 (6 days ago) [Reply](#) ▼

sounds good
+ok

Carlos Guestrin wrote:
Let's try to chat on Friday a little to coordinate and more on Sunday in person?

Carlos

Welcome to New Media Installation: Art that Learns

☆ **Carlos Guestrin** to 10615-announce, Osman, Miche: [show details](#) 3:15 PM (8 hours ago) [Reply](#) ▼

Hi everyone,

Welcome to New Media Installation:Art that Learns

The class will start tomorrow.
Make sure you attend the first class, even if you are on the Wait List.
The classes are held in Doherty Hall C316, and will be Tue, Thu 01:30-4:20 PM.

By now, you should be subscribed to our course mailing list: 10615-announce@cs.cmu.edu.
You can contact the instructors by emailing: 10615-instructors@cs.cmu.edu

Natural _LoseWeight SuperFood Endorsed by Oprah Winfrey, Free Trial 1 bottle, pay only \$5.95 for shipping mfw rlk [Spam](#) | [X](#)

☆ **Jaquelyn Halley** to nherlein, bcc: thehorney, bcc: ang [show details](#) 9:52 PM (1 hour ago) [Reply](#) ▼

=== Natural WeightLOSS Solution ===

Vital Acai is a natural WeightLOSS product that Enables people to lose wieght and cleansing their bodies faster than most other products on the market.

Here are some of the benefits of Vital Acai that You might not be aware of. These benefits have helped people who have been using Vital Acai daily to Achieve goals and reach new heights in there dieting that they never thought they could.

- * Rapid WeightLOSS
- * Increased metabolism - BurnFat & calories easily!
- * Better Mood and Attitude
- * More Self Confidence
- * Cleanse and Detoxify Your Body
- * Much More Energy
- * BetterSexLife
- * A Natural Colon Cleanse

predikcija

Spam
vs.
Normalan

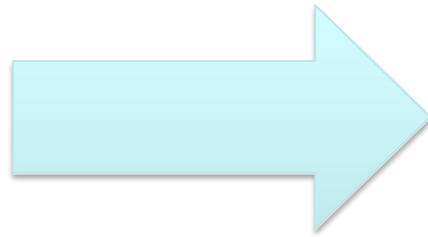
Još neki primeri klasifikacije sa ilustracijama: Prepoznavanje lica



Primer iz obučavajućeg skupa –
isto lice iz različitih uglova



Još neki primeri klasifikacije sa ilustracijama:
Prognoza vremena (u diskretne klase:
oblačno, sunčano, kiša....)



Nadgledano Učenje: Regresija



oznaka

-4.5



10.1



3.2

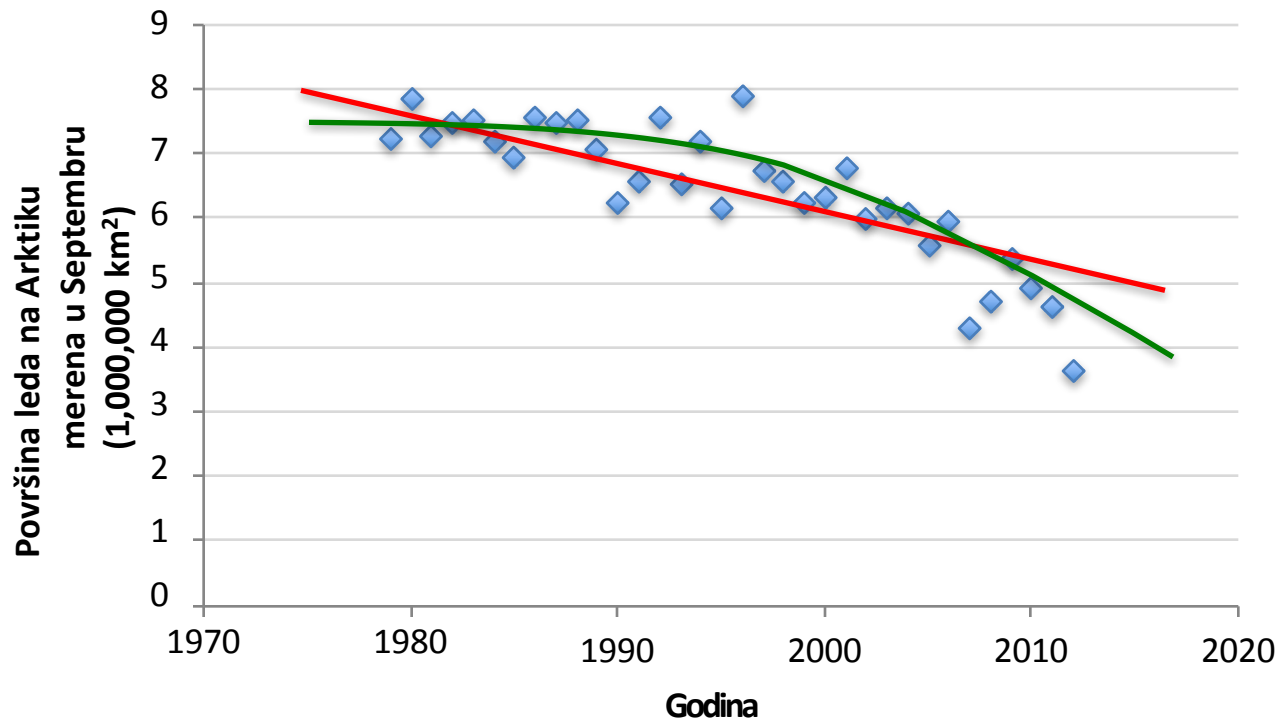


4.3

Regresija: Oznaka tj. cilja vrednot je kontinualna (obično realan broj), a ne diskretna

Nadgledano Učenje: Regresija

- Dato je $(x_1, y_1), (x_2, y_2), \dots, (x_n, y_n)$
- Cilj je naučiti funkciju $f(x)$ koja predviđa y za dato x
 - y je kontinualna vrednost

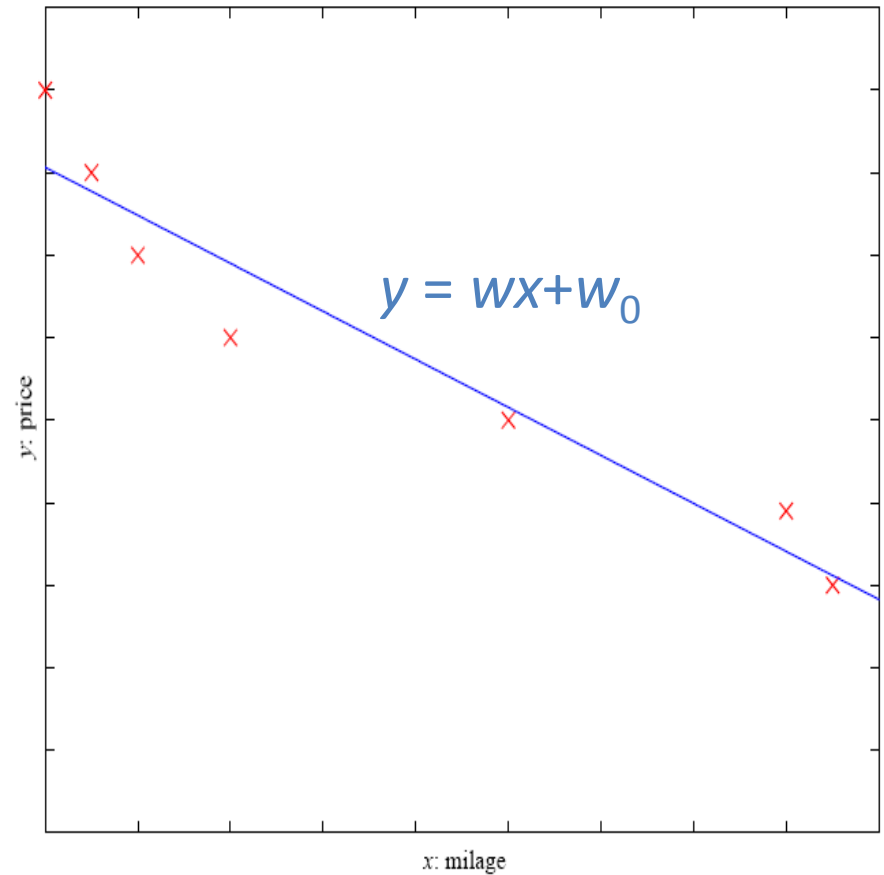


Regresija – još primera

Cena polovnih automobila

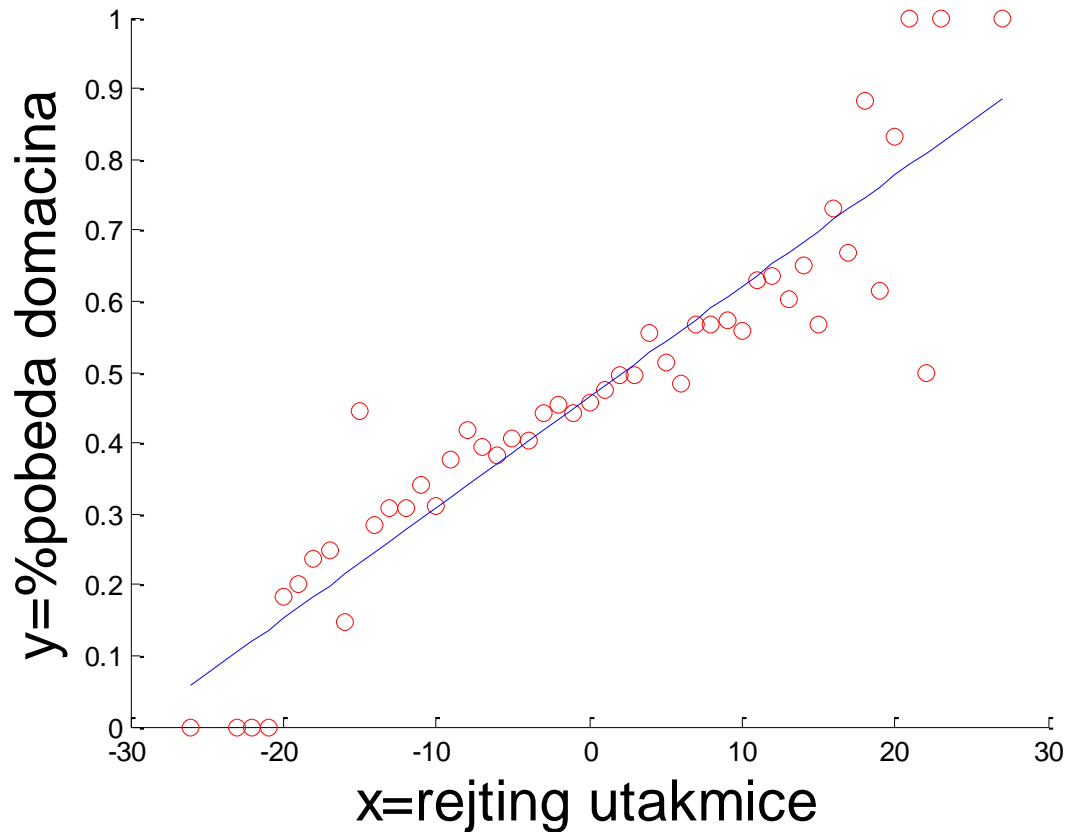
x : atributi automobila
(npr. broj pređenih kilometara)

y : cena



Regresija – još primera

Predikcija ishoda utakmica



Regresija – još primera

Ekonomija/Finansije: predikcija vrednosti akcija ili kripto-valuta...

Epidemiologija – predikcija širenja neke bolesti

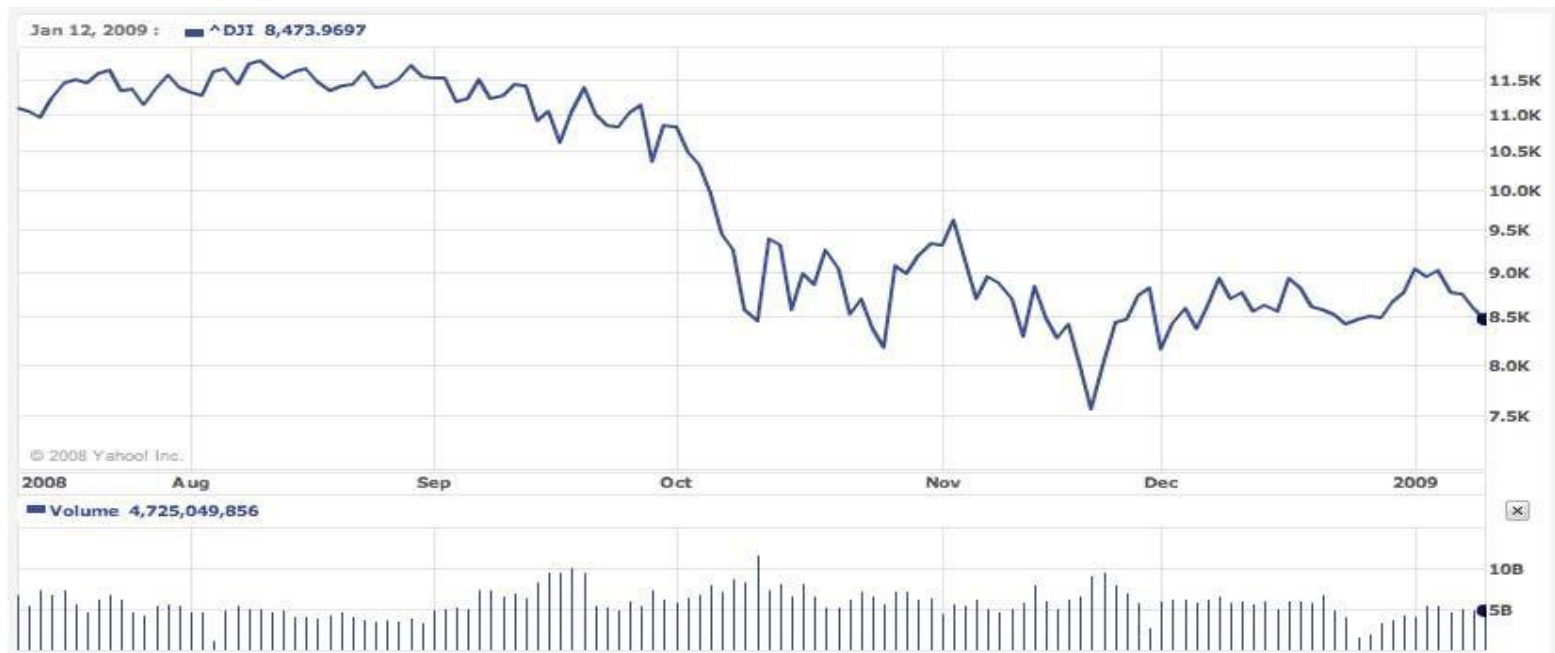
Navigacija vozila: ugao volana, ubrzanje, ...

Prognoza temperature vazduha

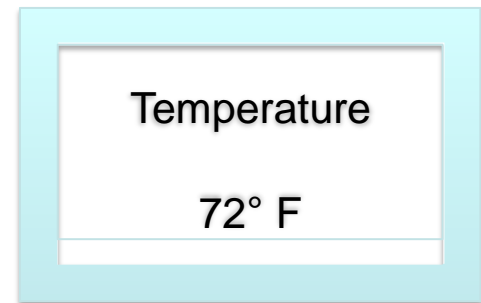
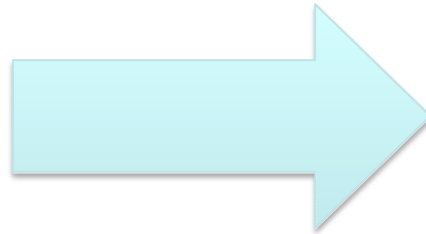
...

Još neki primeri regresije sa ilustracijama:

Predikcija vrednosti akcija



Još neki primeri regresije sa ilustracijama:
Prognoza vremena (za razliku od klasifikacije
sad predviđamo temperaturu tj. kontinualnu
vrednost)



Nadgledano učenje: rangiranje

Oznaka



1



4



2

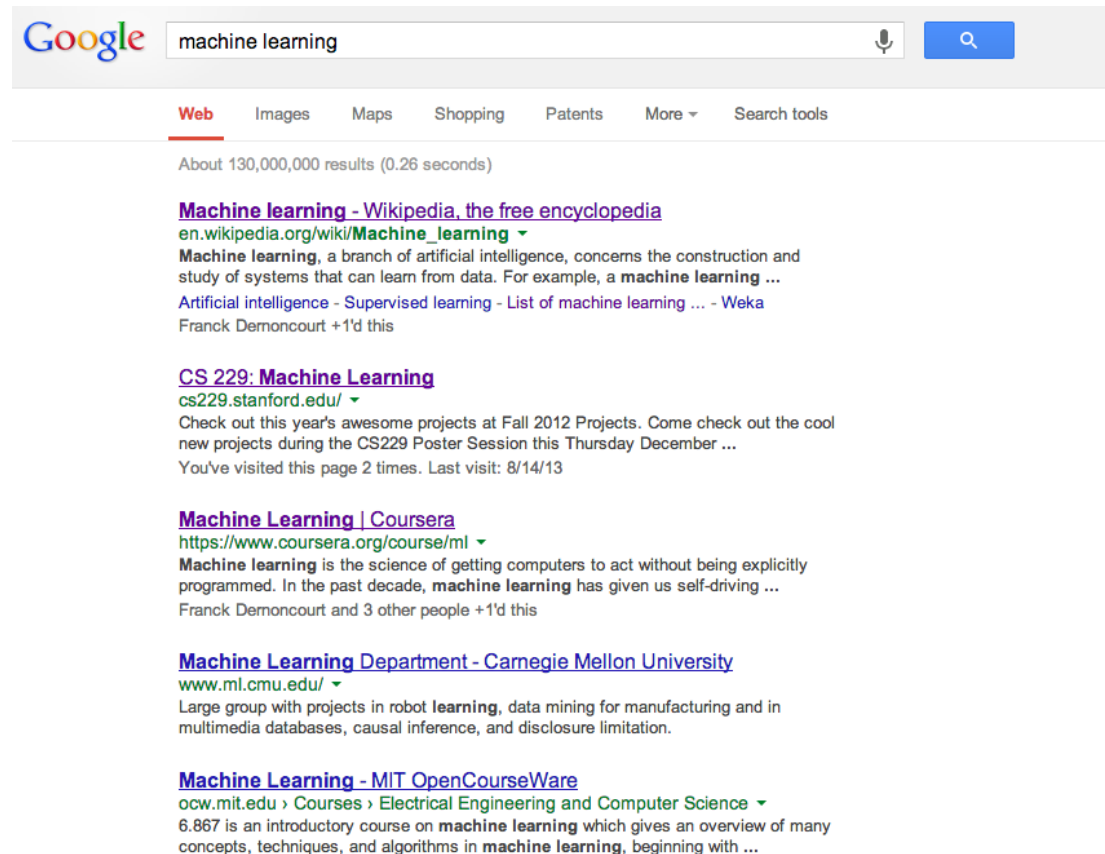


3

Rangiranje: oznaka je rang (npr.
1 je bolje od 2, a 2 od 3 itd.)

Rangiranje - primeri

Web pretraga:
Rangiranje web
strana po relevantnosti
u odnosu na upit



The image shows a Google search results page for the query "machine learning". The search bar at the top contains the text "machine learning" and a blue search button. Below the search bar, there are tabs for "Web", "Images", "Maps", "Shopping", "Patents", "More", and "Search tools". The "Web" tab is selected. The results show "About 130,000,000 results (0.26 seconds)". The first result is "Machine learning - Wikipedia, the free encyclopedia" with a link to "en.wikipedia.org/wiki/Machine_learning". The second result is "Machine learning, a branch of artificial intelligence, concerns the construction and study of systems that can learn from data. For example, a machine learning ..." followed by "Artificial intelligence - Supervised learning - List of machine learning ... - Weka". The third result is "CS 229: Machine Learning" with a link to "cs229.stanford.edu/". The fourth result is "Machine Learning | Coursera" with a link to "https://www.coursera.org/course/ml". The fifth result is "Machine Learning Department - Carnegie Mellon University" with a link to "www.ml.cmu.edu/". The sixth result is "Machine Learning - MIT OpenCourseWare" with a link to "ocw.mit.edu".

Google machine learning

Web Images Maps Shopping Patents More Search tools

About 130,000,000 results (0.26 seconds)

Machine learning - Wikipedia, the free encyclopedia
en.wikipedia.org/wiki/Machine_learning ▾
Machine learning, a branch of artificial intelligence, concerns the construction and study of systems that can learn from data. For example, a **machine learning** ...
[Artificial intelligence - Supervised learning - List of machine learning ... - Weka](#)
Franck Demoncourt +1'd this

CS 229: Machine Learning
cs229.stanford.edu/ ▾
Check out this year's awesome projects at Fall 2012 Projects. Come check out the cool new projects during the CS229 Poster Session this Thursday December ...
You've visited this page 2 times. Last visit: 8/14/13

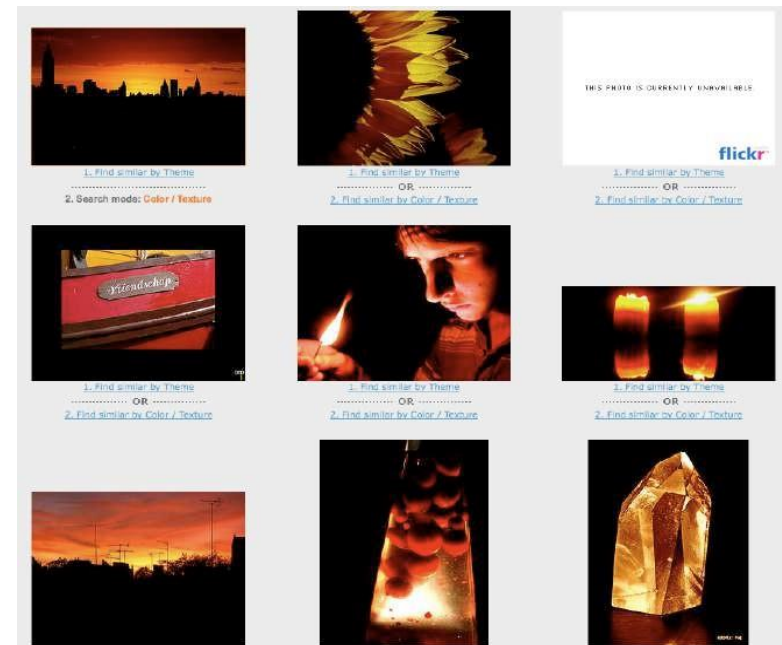
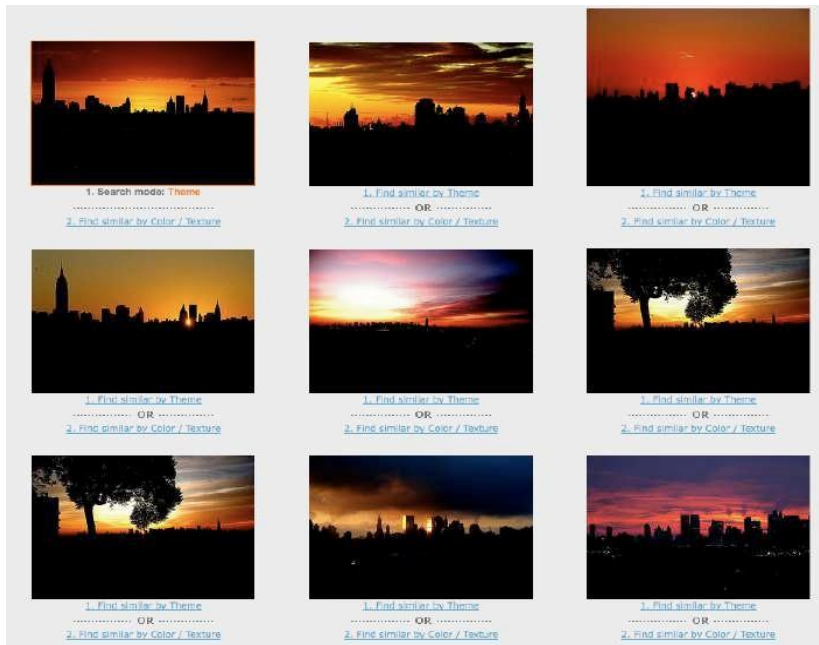
Machine Learning | Coursera
<https://www.coursera.org/course/ml> ▾
Machine learning is the science of getting computers to act without being explicitly programmed. In the past decade, **machine learning** has given us self-driving ...
Franck Demoncourt and 3 other people +1'd this

Machine Learning Department - Carnegie Mellon University
www.ml.cmu.edu/ ▾
Large group with projects in robot **learning**, data mining for manufacturing and in multimedia databases, causal inference, and disclosure limitation.

Machine Learning - MIT OpenCourseWare
ocw.mit.edu ▸ [Courses](#) ▸ [Electrical Engineering and Computer Science](#) ▾
6.867 is an introductory course on **machine learning** which gives an overview of many concepts, techniques, and algorithms in **machine learning**, beginning with ...

Rangiranje - primeri

Za datu sliku pronaći slične slike



Rangiranje – Sistemi za preporuke

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[Philosophy of Biology](#)
[Philosophy of Medicine](#)


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view: **All** | [New Releases](#) | [Coming Soon](#)

- 


Causality: Models, Reasoning and Inference
by Judea Pearl (September 14, 2009)
Average Customer Review: (110)
In Stock
List Price: \$50.00
Price: \$32.49
61 used & new from \$29.00

☐ I own it ☐ Not interested ☒ Rate this item
Recommended because you purchased [Probabilistic Graphical Models](#) and more (Fix this)

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- 

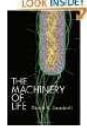
The Lady Tasting Tea: How Statistics Revolutionized Science in the Twentieth Century
by David Salsburg (May 1, 2002)
Average Customer Review: (76)
In Stock
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The Machinery of Life
by David S. Goodsell (April 28, 2009)
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Rangiranje – Sistemi za preporuke

Takmičenje sa nagradom od milion dolara

Leaderboard

Display top leaders.

Rank	Team Name	Best Score	% Improvement	Last Submit Time
1	The Ensemble	0.8553	10.10	2009-07-26 18:38:22
2	BellKor's Pragmatic Chaos	0.8554	10.09	2009-07-26 18:18:28
Grand Prize - RMSE \leq 0.8563				
3	Grand Prize Team	0.8571	9.91	2009-07-24 13:07:49
4	Opera Solutions and Vandelay United	0.8573	9.89	2009-07-25 20:05:52
5	Vandelay Industries I	0.8579	9.83	2009-07-26 02:49:53
6	PragmaticTheory	0.8582	9.80	2009-07-12 15:09:53
7	BellKor in BigChaos	0.8590	9.71	2009-07-26 12:57:25
8	Dace	0.8603	9.58	2009-07-24 17:18:43
9	Opera Solutions	0.8611	9.49	2009-07-26 18:02:08
10	BellKor	0.8612	9.48	2009-07-26 17:19:11
11	BigChaos	0.8613	9.47	2009-06-23 23:06:52
12	Feeds2	0.8613	9.47	2009-07-24 20:06:46

Progress Prize 2008 - RMSE = 0.8616 - Winning Team: BellKor in BigChaos

13	xianqiang	0.8633	9.26	2009-07-21 02:04:40
14	Gravity	0.8634	9.25	2009-07-26 15:58:34
15	Ces	0.8642	9.17	2009-07-25 17:42:38
16	Invisible Ideas	0.8644	9.14	2009-07-20 03:26:12
17	Just a guy in a garage	0.8650	9.08	2009-07-22 14:10:42
18	Craig Carmichael	0.8656	9.02	2009-07-25 16:00:54
19	J Dennis Su	0.8658	9.00	2009-03-11 09:41:54
20	acmehill	0.8659	8.99	2009-04-16 06:29:35

Progress Prize 2007 - RMSE = 0.8712 - Winning Team: KorBell

Cinematch score on quiz subset - RMSE = 0.9514

The image shows a composite of a Netflix website interface and a green background with code. Silhouettes of two people are in the center, looking at the website. Below the website is a matrix diagram representing user-movie ratings.

Netflix Interface:

- NETFLIX logo
- Navigation: Browse, Recommendations, Friends, Queue, Buy DVDs
- Home, Genres, New Releases, Previews, Netflix Top 100, Critic's Picks
- Section: Movies For You
- Text: Randy, the following movies were chosen based on your interest in: Bowling for Columbine, Carnival: Season 1, Fahrenheit 9/11
- Section: The Big One
- Text: Now owned for just \$5.99
- Section: You really liked it...
- Section: Lewis Black: No and Score

Matrix Diagram:

Users: 1, 2, 3, 4, 5

Movies: 1, 2, 3, 4, 5

1	?	3	5	?
?	1			2
	4	4	5	?

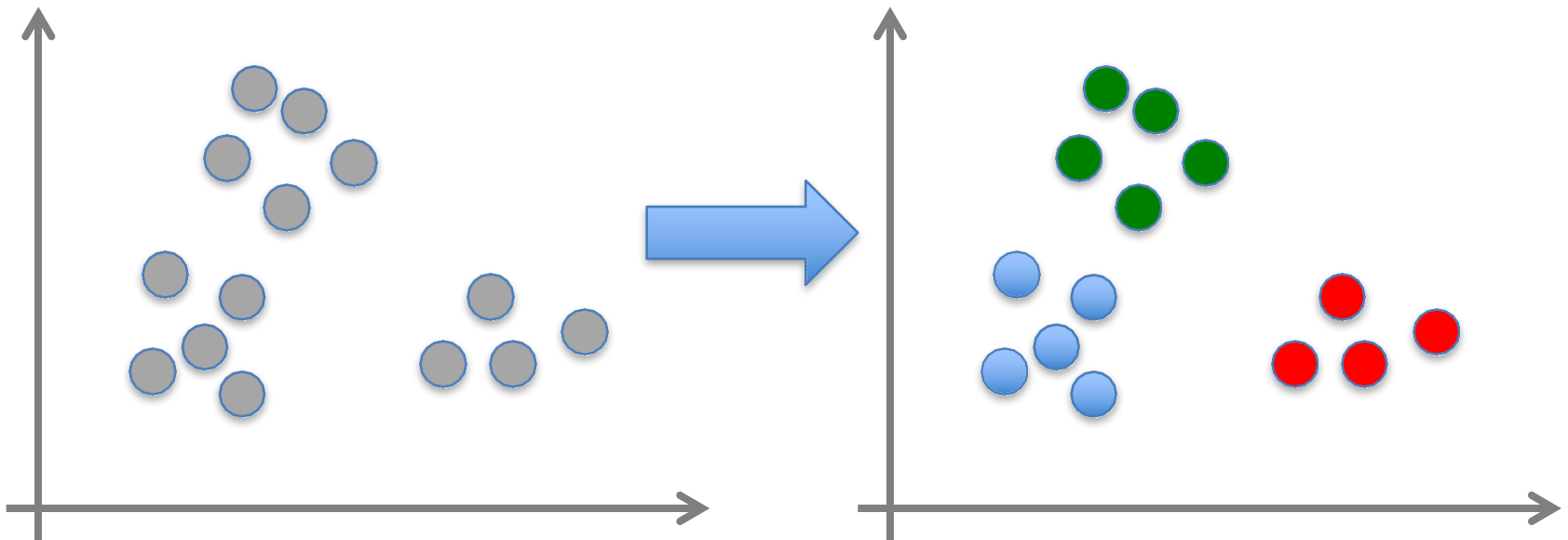
Nenadgledno Učenje

Nenadgledno učenje: dati su nam podaci ali bez oznaka



Nenadgledno Učenje

- Dato je x_1, x_2, \dots, x_n (bez oznaka)
- Izlaz je neka struktura (šablon) koji važi za x -ove
 - Npr. automatsko grpuisanje (klasterovanje)



Nenadgledno Učenje - Konkretnije

Na osnovu čega se uči?

Nadgledano

(označeni podaci)

Nenadgledano - bez učitelja

(ne označeni podaci)

Sa uslovljavanjem

Nenadgledno Učenje - Konkretnije

Podeliti tačke u dva regiona

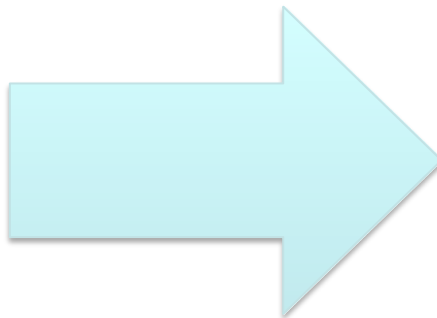
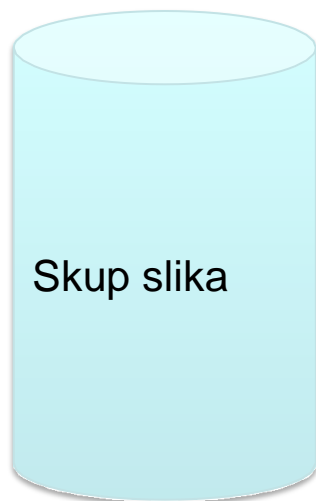


255, 127, 0


192, 192, 192

R	G	B	Region
153	141	125	
151	139	123	
152	140	124	
153	140	123	
154	142	126	
154	141	124	
156	143	126	
155	142	125	
151	138	121	
155	143	127	
152	139	122	
150	138	122	
197	142	23	
158	145	128	
201	146	27	
199	144	25	
149	136	119	
156	144	128	
157	144	127	

Još neki primeri nenadglednog učenja sa ilustracijama: Klasterovanje slika



Još neki primeri nenadglednog učenja sa ilustracijama: Klasterovanje rezultata Web pretrage



web news images wikipedia blogs jobs more »

race

Search

advanced preferences

clusters sources sites

All Results (238) remix

Car (28)

Race cars (7)

Photos, Races Scheduled (5)

Game (4)

Track (3)

Nascar (2)

Equipment And Safety (2)

Other Topics (7)

Photos (22)

Game (14)

Definition (13)

Team (18)

Human (8)

Classification Of Human (2)

Statement, Evolved (2)

Other Topics (4)

Weekend (8)

Ethnicity And Race (7)

Race for the Cure (8)

Race Information (8)

more | all clusters

find in clusters: Find

Cluster **Human** contains 8 documents.

Search Results

1. [Race \(classification of human beings\) - Wikipedia, the free ...](#)

The term **race** or racial group usually refers to the concept of dividing **humans** into populations or groups on the basis of various sets of characteristics. The most widely used **human** racial categories are based on visible traits (especially skin color, cranial or facial features and hair texture), and self-identification. Conceptions of **race**, as well as specific ways of grouping **races**, vary by culture and over time, and are often controversial for scientific as well as social and political reasons. History · Modern debates · Political and ...
[en.wikipedia.org/wiki/Race_\(classification_of_human_beings\)](#) - [cache] - Live, Ask

2. [Race - Wikipedia, the free encyclopedia](#)

General. **Racing** competitions The **Race** (yachting **race**), or La course du millénaire, a no-rules round-the-world sailing event; **Race** (biology), classification of flora and fauna; **Race** (classification of **human** beings) **Race** and ethnicity in the United States Census, official definitions of "**race**" used by the US Census Bureau; **Race** and genetics, notion of racial classifications based on genetics. Historical definitions of **race**; **Race** (bearing), the inner and outer rings of a rolling-element bearing. **RACE** in molecular biology "Rapid ... General · Surnames · Television · Music · Literature · Video games
[en.wikipedia.org/wiki/Race](#) - [cache] - Live, Ask

3. [Publications | Human Rights Watch](#)

The use of torture, unlawful rendition, secret prisons, unfair trials, ... Risks to Migrants, Refugees, and Asylum Seekers in Egypt and Israel ... In the run-up to the Beijing Olympics in August 2008, ...
[www.hrw.org/background/usa/race](#) - [cache] - Ask

4. [Amazon.com: Race: The Reality Of Human Differences: Vincent Sarich ...](#)

Amazon.com: **Race: The Reality Of Human Differences: Vincent Sarich, Frank Miele**: Books ... From Publishers Weekly Sarich, a Berkeley emeritus anthropologist, and Miele, an editor ...
[www.amazon.com/Race-Reality-Differences-Vincent-Sarich/dp/0813340861](#) - [cache] - Live

5. [AAPA Statement on Biological Aspects of Race](#)

AAPA Statement on Biological Aspects of **Race** ... Published in the American Journal of Physical Anthropology, vol. 101, pp 569-570, 1996 ... PREAMBLE As scientists who study **human** evolution and variation, ...
[www.physanth.org/positions/race.html](#) - [cache] - Ask

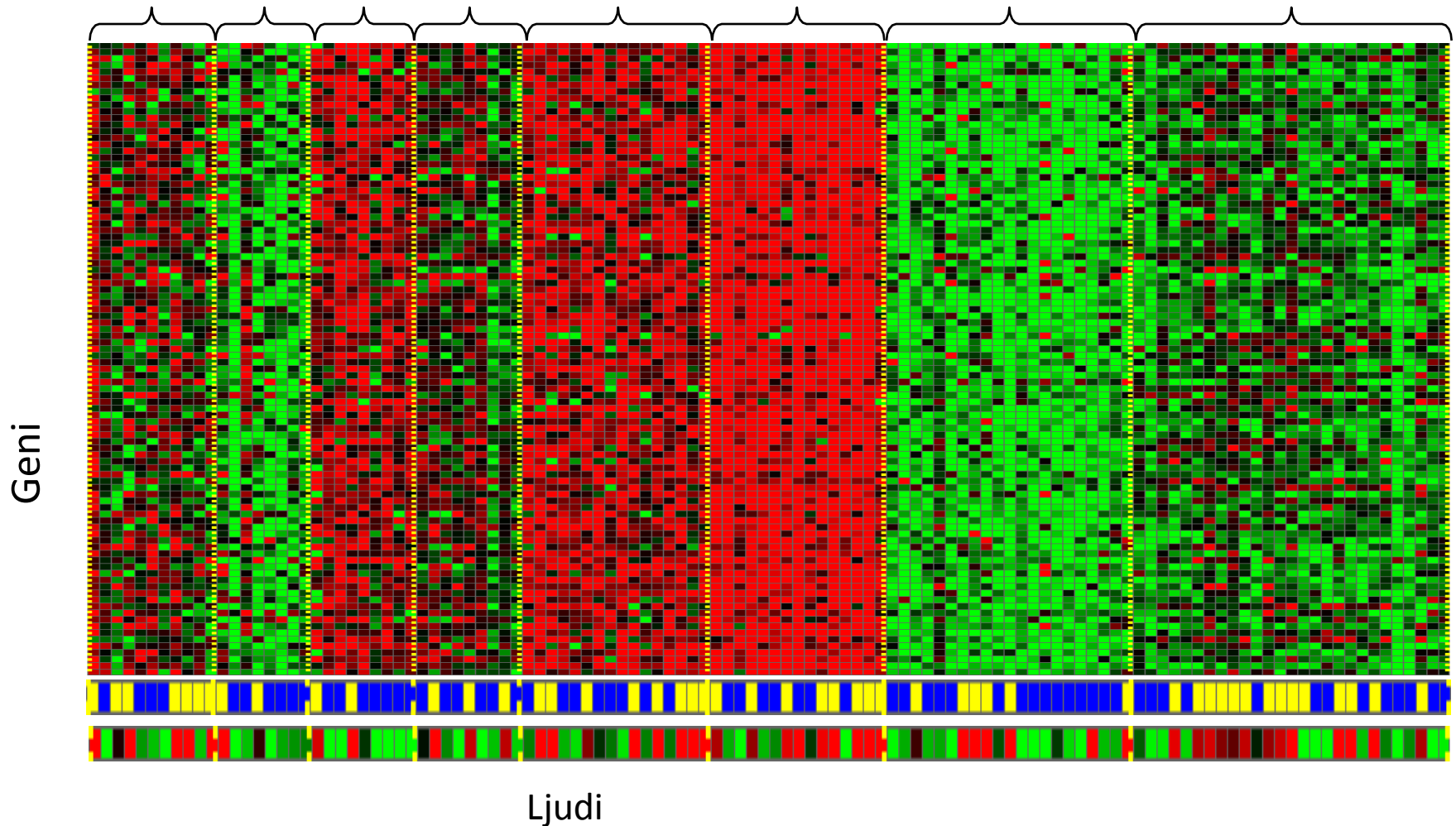
6. [race: Definition from Answers.com](#)

race n. A local geographic or global **human** population distinguished as a more or less distinct group by genetically transmitted physical
[www.answers.com/topic/race-1](#) - [cache] - Live

7. [Dopefish.com](#)

Site for newbies as well as experienced Dopefish followers, chronicling the birth of the Dopefish, its numerous appearances in several computer games, and its eventual take-over of the **human** **race**. Maintained by Mr. Dopefish himself, Joe Siegler of Apogee Software.
[www.dopefish.com](#) - [cache] - Open Directory

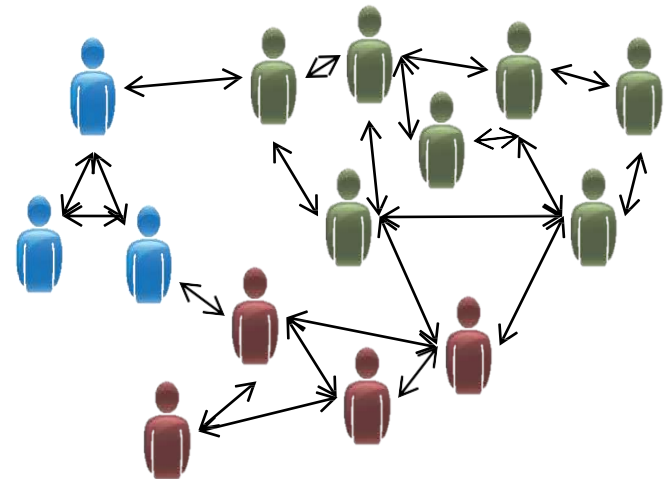
Još neki primeri nenadglednog učenja sa ilustracijama: Klasterovanje ljudi po genetskoj sličnosti



Još neki primeri nenadglednog učenja sa ilustracijama



Kreiranje klastera računara



Otkrivanje zajednica u društvenim mrežama



Otrivanje grupa mušterija

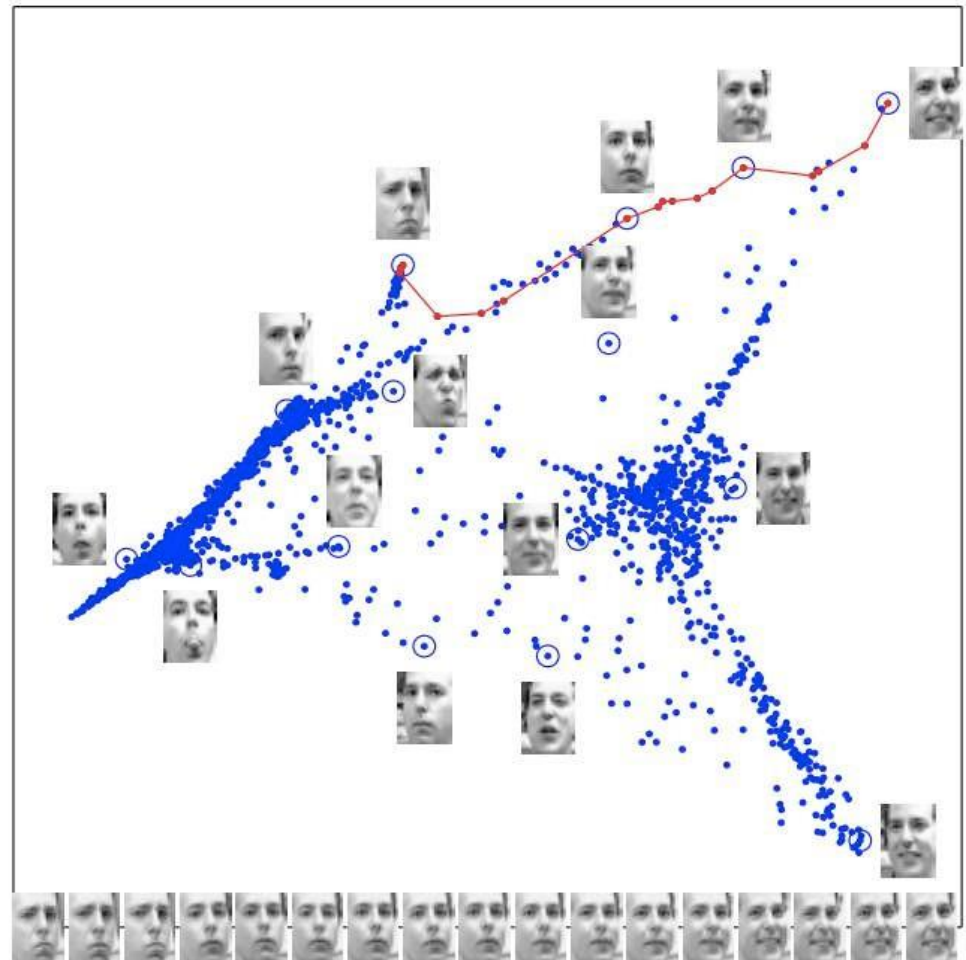


Image credit: NASA/IPS-Caltech/E. Churchwell (Univ. of Wisconsin, Madison)

Grupisanje nebskih tela na slikama

Nenadgledano učenje – redukcija dimenzionalnosti – Primer:slike

- Slike imaju hiljade ili milione piksela.
- Da li ih možemo nekako predstaviti u 2d tako da su slične slike blizu jedna druge?



[Saul & Roweis '03]

Nenadgledano učenje – redukcija dimenzionalnosti – Primer:reči



[Joseph Turian]

Nenadgledano učenje – redukcija dimenzionalnosti – Primer:reči (zoom)



[Joseph Turian]

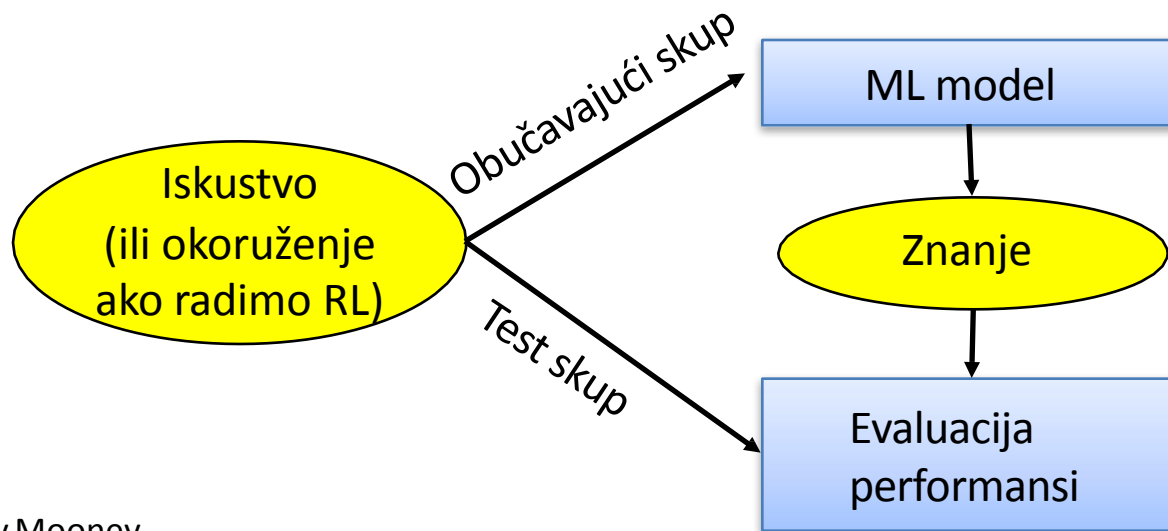
Učenje uslovljavanjem

- Učenje uslovljavanjem je vrsta mašinskog učenja
- Detaljno smo ga razmatrali na prethodnim predavanjima
- Iz tog razloga neće sad biti razmatrano

Preciznije formulisanje
rešavanja problema
pomoću mašinskog učenja

Kreiranje sistema za učenje

- Biramo iskustvo iz kojeg se uči tj. obučavajući skup
- Biramo šta u stvari želimo da naučimo
 - tj. **ciljnu funkciju (ne mora biti funkcija u matematičkom smislu, već na neki način formalizujemo ono što želimo da sistem radi – biće detaljnije objašnjeno tokom kursa)**
- Biramo način na koji reprezentujemo ciljnu funkciju
- Biramo algoritam mašinskog učenja koji bi trebalo da nauči ciljnu funkciju od obučavajućeg skupa



Distribucija obučavajućih i test podataka

- Prilikom razvoja ML algoritama generalno se pretpostavlja da su obučavajući i test podaci nezavisno izvučeni iz iste distribucije
 - Tipčna oznaka za to u ML literaturi je “i.i.d” - “independent and identically distributed”

ML u suštini

- Desetine hiljada algoritama
 - Stotine novih svake godine
- Svaki algoritam mašinskog učenja ima tri komponente:
 - **Reprezentacija**
 - **Optimizacija**
 - **Evaluacija**

Različiti načini reprezentacije ciljne funkcije

- Numeričke funkcije
 - Linearna regresija
 - Neuronske mreže
 - Mašine potpornih vektora (Support vector machines, SVM)
 - ...
- Simboličke funkcije
 - Stabla odlučivanja
 - Pravila u predikatskim logikama prvog reda
 -
- Funkcije zasnovane na instancama (podacima)
 - K-najbližih komšija
- Probabilistički modeli
 - Naivni Bajes
 - Bajesove mreže
 - Skriveni modeli Markova
 -

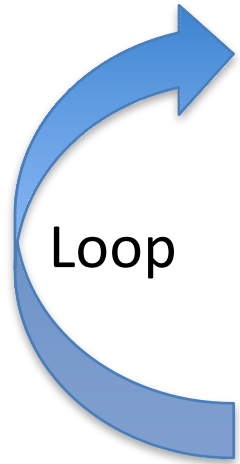
Različiti algoritmi za optimizaciju i pretragu

- Gradijentni spust
 - Perceptron
 - Backpropagation
- Dinamičko programiranje
 - Učenje Skrivenih Modela Markova
- „Podeli pa Vladaј“ - Divide and Conquer
 - Učenje stabala odlučivanja
 - Učenje pravila
- Evolutivni Algoritmi
 - Genetski algoritmi
 - ...

Evaluacija

- Tačnost (*Accuracy*)
- Preciznost i Odziv (*Precision and Recall*)
- Kvadrat greške (*Squared error*)
- Verovatnost (Verodostojnost) - *Likelihood*
- Posteriorna verovatnoća (*Posterior probability*)
- Trošak / Korisnot (*Cost / Utility*)
- Margina
- Entropija
- KLdivergencija
- ...

Mašinsko Učenje u Praksi



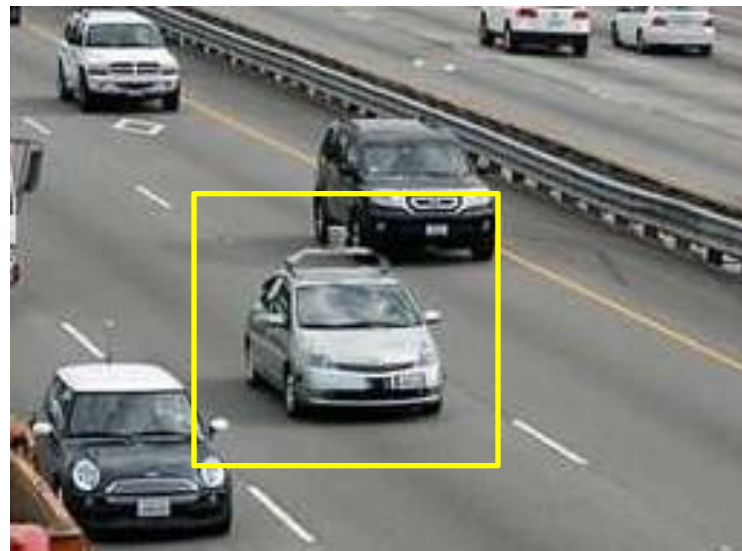
- Razumeti problem i domen problema, shvatiti šta je dostupno od podataka, shvatiti šta su ciljevi
- Integracija podataka, selekcija, čišćenje, pred-procesiranje, itd.
- Učenje (obučavanje) modela
- Interpretacija rezultata
- Konsolidacija i upotreba (deployment) dobijenog znanja

Šta smo do sad shvatili o ML?

- Mašinsko učenje se može posmatrati kao upotreba iskustva (podataka) za aproksimaciju neke ciljne funkcije.
- Proces aproksimacije funkcije može se posmatrati kao pretraga u prostoru različitih reprezentacija funkcija (npr. pravih linija) za onom koja se najbolje uklapa u podatke.
- Različiti algoritmi mašinskih učenja koriste različite reprezentacije funkcija i koriste (ili ne) različite tehnike pretrage u tom prostoru.

Vrhunske (State-of-the-Art) Primene Mašinskog Učenja

Autonomni Automobili



- Američka država Nevada je 2011 godine dozvolila da upotrebnu autonomnih vozila na putevima.
- Još četiri države (Nevada, Florida, Kalifornija i Mičigen su legalizovale autonomne automobile)

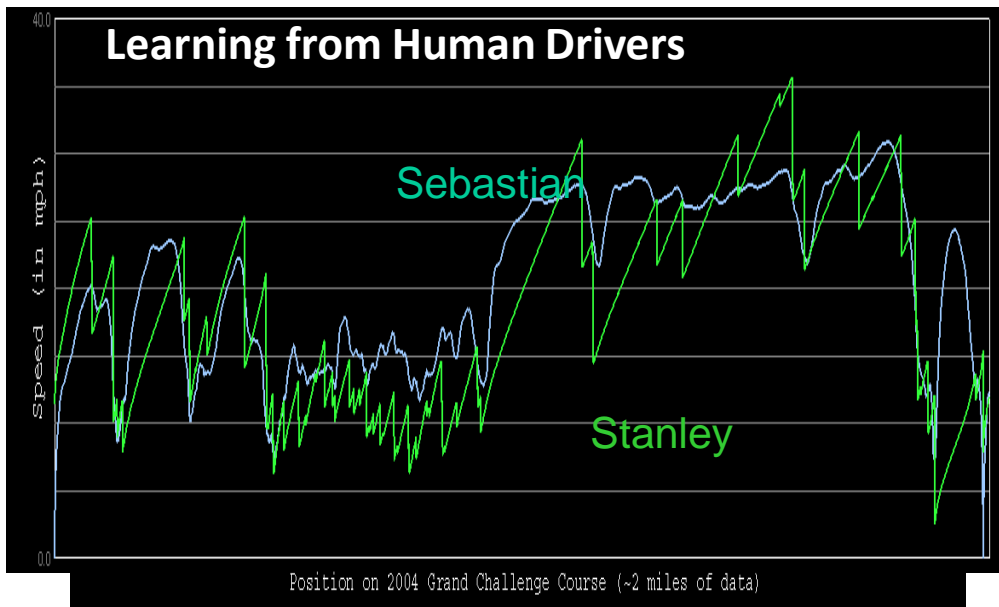
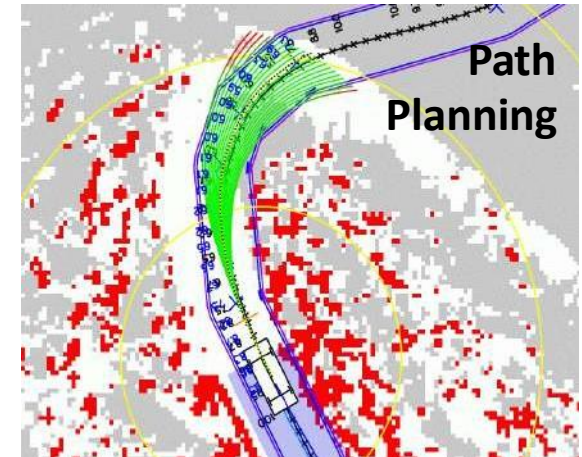
Georgia Tech's Autonomous Car 
(Sting Racing Team)



Senzori na autonomnom automobilu



Tehnologije vezane za autonomne automobile



Deep Learning u medijima

BUSINESS NEWS

MIT
Technology
Review

Is Google Cornering the Market on Deep Learning?

A cutting-edge corner of science is being wooed by Silicon Valley, to the dismay of some academics.

By Antonio Regalado on January 20, 2014



How much are a dozen deep-learning researchers worth? Apparently, more than \$400 million.

This week, Google reportedly paid that much to acquire DeepMind Technologies, a startup based in



This is Freescale
make it

BloombergBusinessweek Technology

Acquisitions

The Race to Buy the Human Brains Behind Deep Learning Machines

By Ashlee Vance | January 27, 2014

intelligence projects. “DeepMind is bona fide in terms of its research capabilities and depth,” says Peter Lee, who heads Microsoft Research.

According to Lee, Microsoft, Facebook (FB), and Google find themselves in a battle for deep learning talent. Microsoft has gone from four full-time deep learning experts to 70 in the past three years. “We would have more if the talent was there to

WIRED

GEAR SCIENCE ENTERTAINMENT BUSINESS SECURITY DESIGN

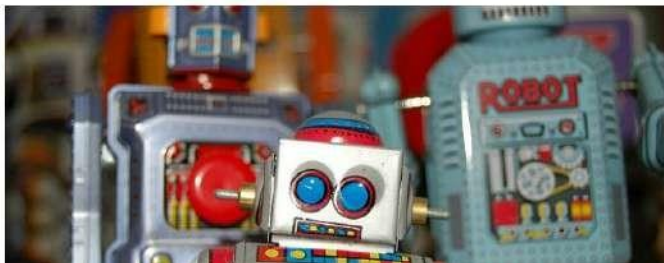
INNOVATION INSIGHTS

community content

featured

Deep Learning's Role in the Age of Robots

BY JULIAN GREEN, JETPAC 05.02.14 2:56 PM



DEEP LEARNING

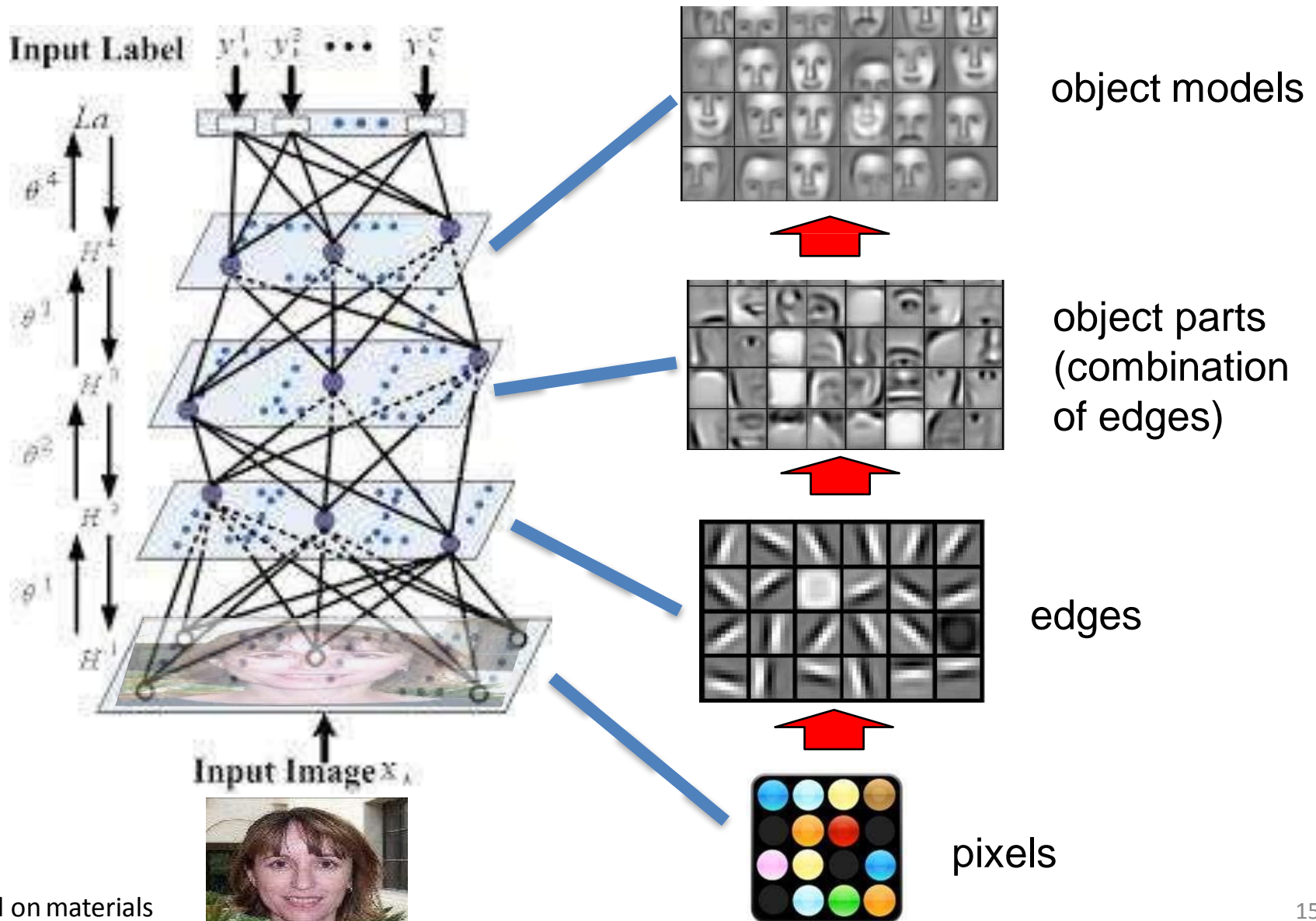
- » Computers learning and growing on their own
- » Able to understand complex, massive amounts of data

DATA ECONOMY

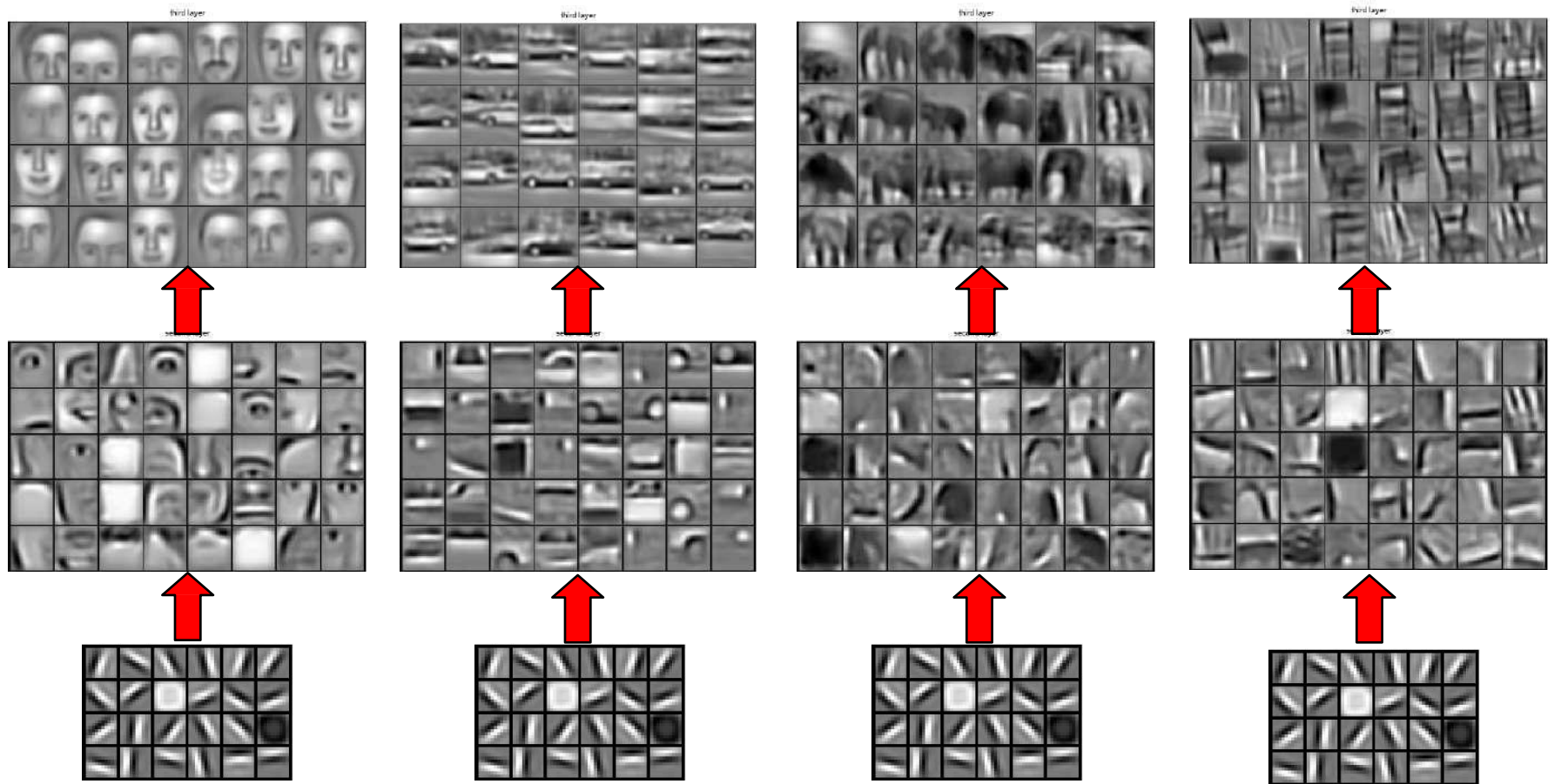
DEEP LEARNING

BROUGHT TO YOU BY:

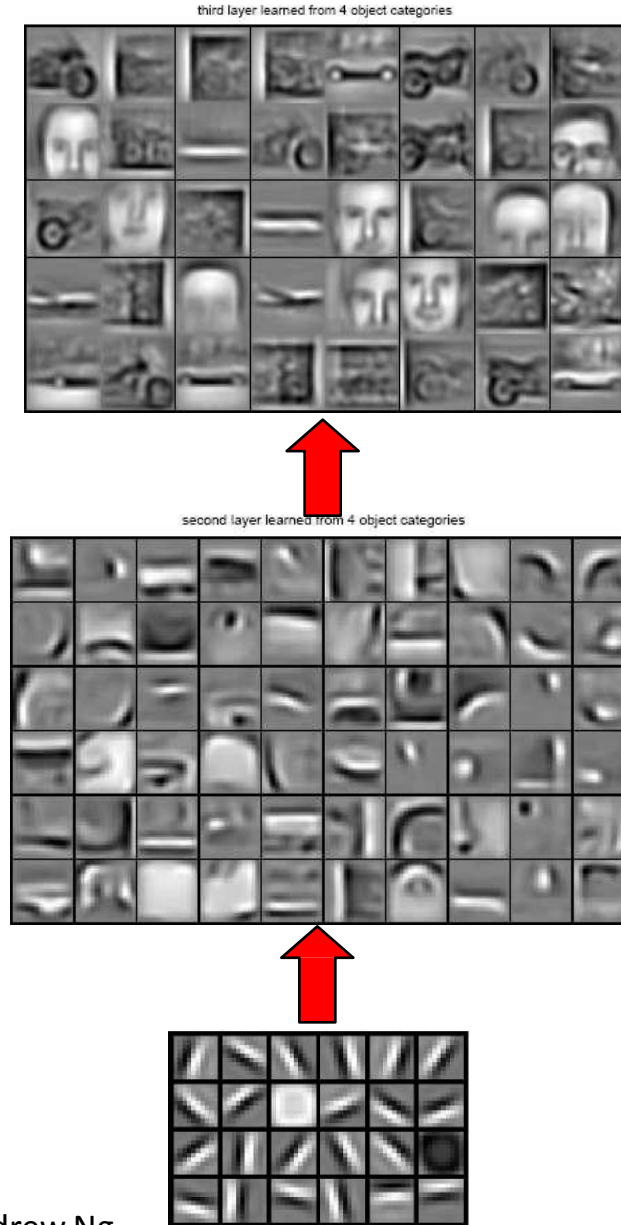
Deep Belief Net za prepoznavanje lica



Učenje karakteristika objekata na slikama



Obučavanje na mnogo različitih objekata

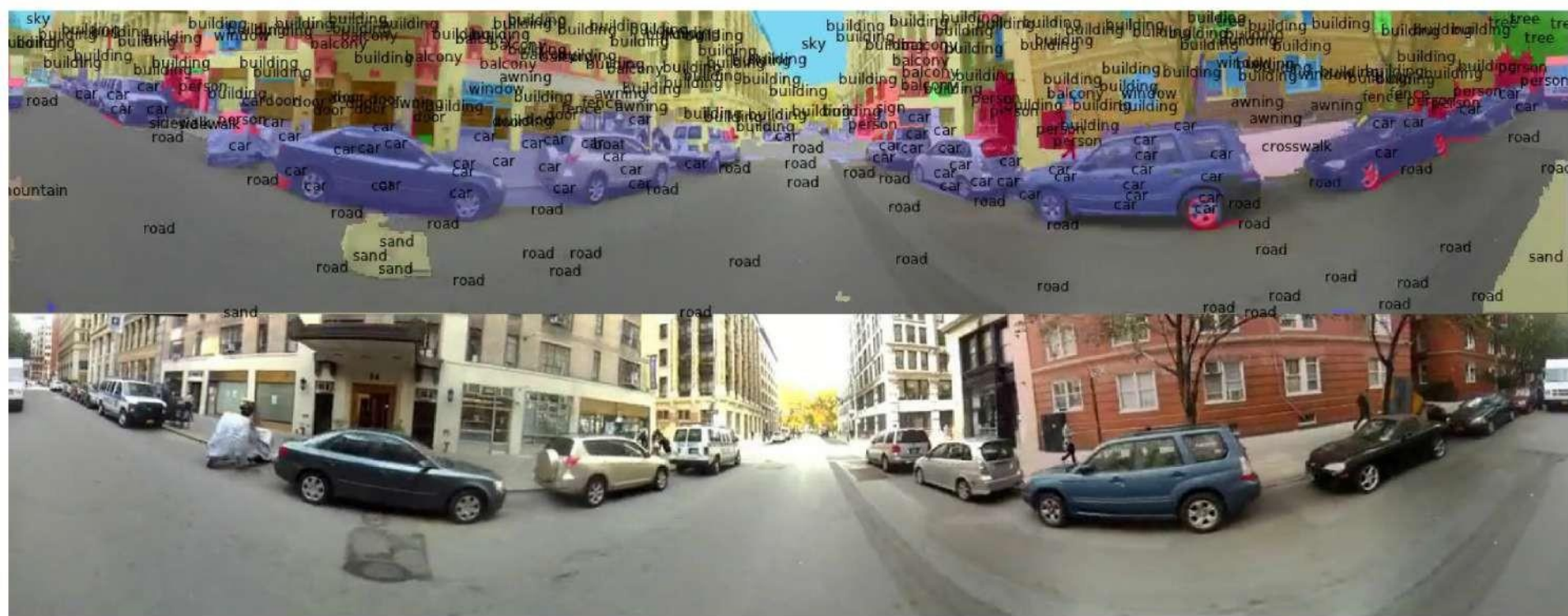


Na primer, 4 klase objekata (automobili, motori, lica i avioni).

Drugi sloj: Karakteristike koje su specifične za svaki objekat i karakteristike koje dele svi objekti

Treći sloj: Još specifičnije karakteristike objekata

Obeležavanje Scena (*Scene Labeling*) pomoću Deep Learning



[Farabet et al. ICML 2012, PAMI 2013]

Značajan uticaj Deep Learning na sve tehnologije vezane za govor

