Machine Intelligence

Department of Computer Science

Machine Intelligence

"The study is to proceed on the basis of the conjecture that every aspect of learning or any other feature of intelligence can in principle be so precisely described that a machine can be made to simulate it. An attempt will be made to find how **to make machines** use language, form abstractions and concepts, **solve kinds of problems now reserved for humans, and improve themselves**."

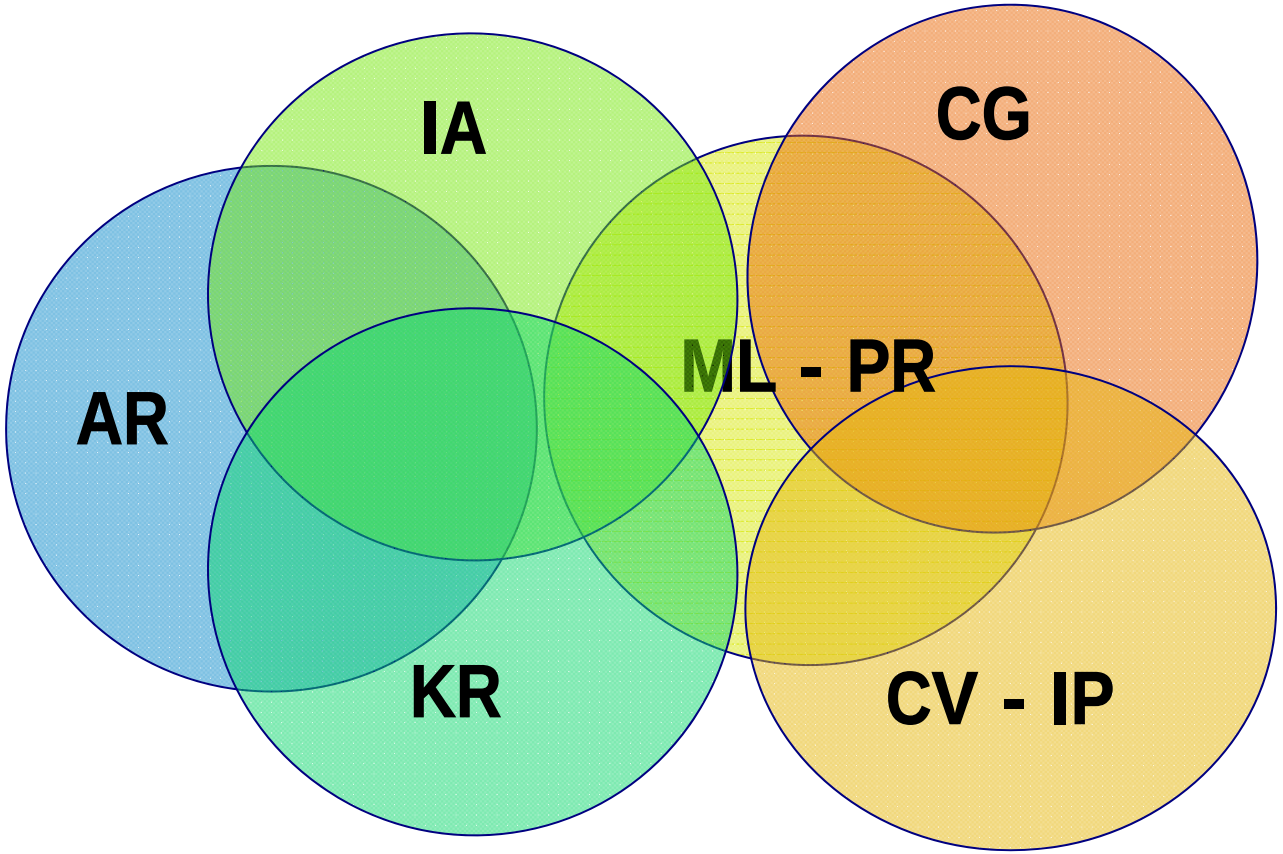
learn to avoid obstacles while flying…

Who we are

Maria Paola Bonacina (AR) home page
Gloria Menegaz (ML, IP) home page
Manuele Bicego (ML, PR) home page
Domenico Bloisi (IA) home page
Umberto Castellani (CG, CV, ML) home page
Ferdinando Cicalese (KR, ML) home page
Marco Cristani (CV, PR) home page
Matteo Cristani (IA, KR, AR) home page
Alessandro Daducci (IP) home page
Alessandro Farinelli (IA) home page
Andrea Giachetti (CG, CV, IP) home page
Vittorio Murino, on leave (CG, CV, ML, PR, IP) home page

AR - Automated Reasoning
KR – Knowledge Rep.
IA - Intelligent Agents
ML - Machine Learning
PR - Pattern Recognition
CV - Computer Vision
IP - Image Processing
CG - Computer Graphics

Our research focus



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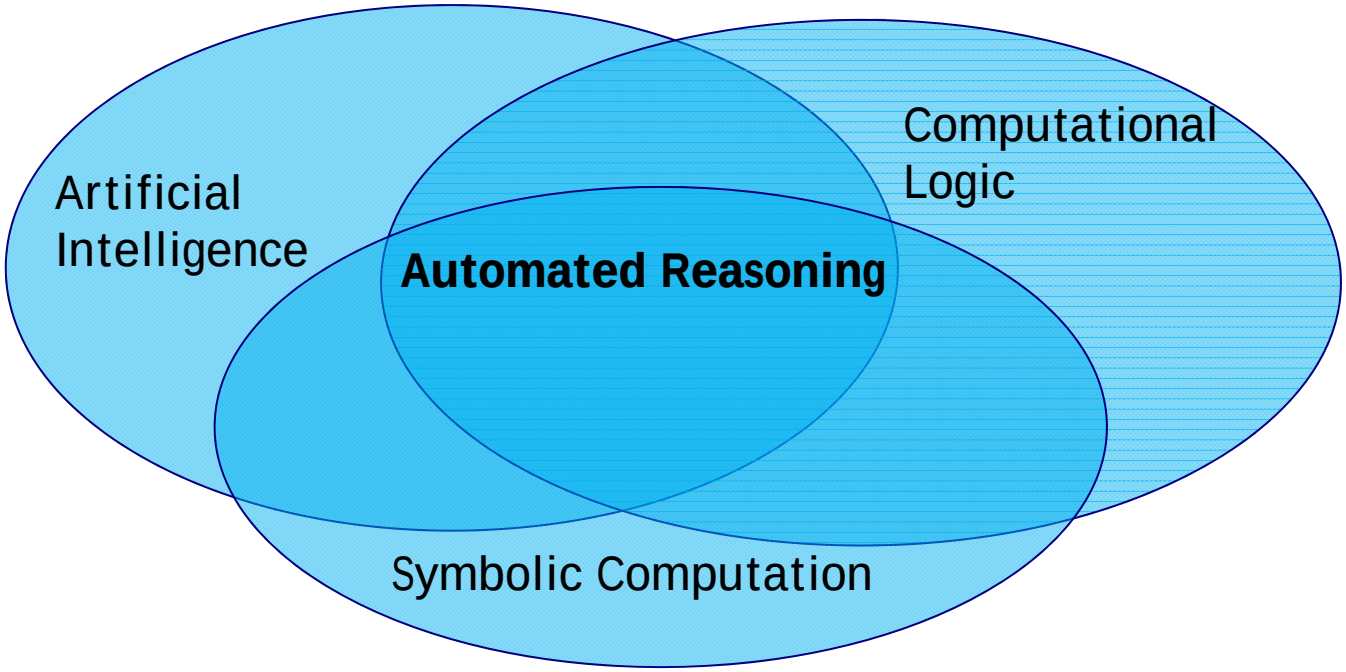
Automated Reasoning

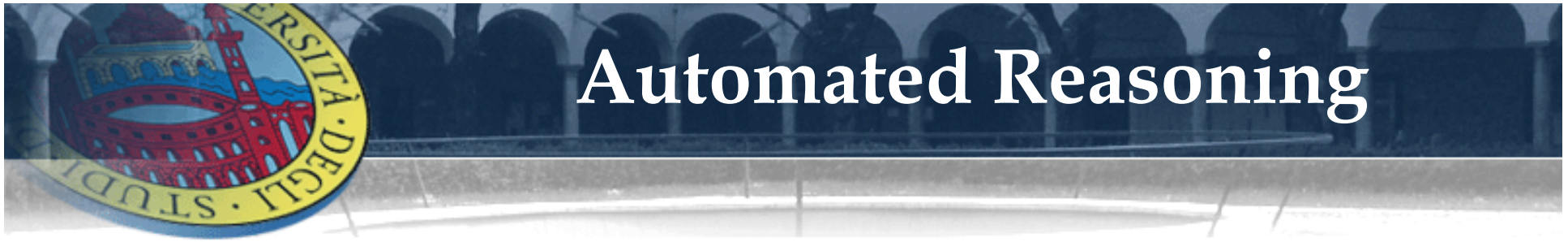
Machines do think ☺

Maria Paola Bonacina



Automated Reasoning: symbols to precisely define features of intelligence

Symbolic reasoning: Logico-deductive, probabilistic, …



Logico-Deductive Reasoning

Theorem proving → Constraint Solving or Model Finding → Inference and Search

Logic: a Machine language

$\mathcal{T} \models \varphi$, $y \simeq x \vee y \simeq z$, $\mathcal{T}$-model of φ, $x^2 + y^2 \leq 1 \vee xy > 1$, $\neg L_1 \vee Q_2 \ldots \vee Q_k$, explain, learn, backjump, $a \sqsubseteq b$, $f \vee \neg e \vee \neg b$, conflict, $\mathcal{T} = \bigcup_{i=1}^{n} \mathcal{T}_i$, resolution, linear arithmetic, $\simeq$, SAT, expansion, contraction, bit-vectors, ...

Applications: Automated System Verification, including Testing and Synthesis; Natural Language Understanding; Planning; Computer-checked Mathematics; …

Knowledge Representation

Matteo Cristani

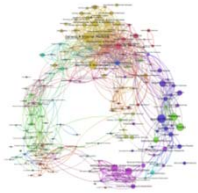
Constructs models for representing rich aspects of human knowledge and reason about it.

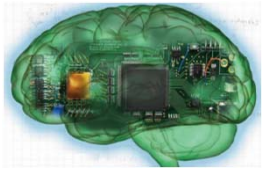
STATISTICAL NATURAL LANGUAGE PROCESSING

KNOWLEDGE-BASED AGENTS

NONSTANDARD COMPUTATIONAL INTELLIGENCE

ONTOLOGY





NON MONOTONIC REASONING

$$P = \left\{ \begin{array}{lcll} r_1 & : & bird & \leftarrow penguin \\ r_2 & : & fly & \leftarrow bird, not\ nofly \\ r_3 & : & nofly & \leftarrow penguin, not\ fly \\ r_4 & : & penguin & \leftarrow \\ r_5 & : & wings & \leftarrow bird \end{array} \right\}$$

Applied artificial intelligence

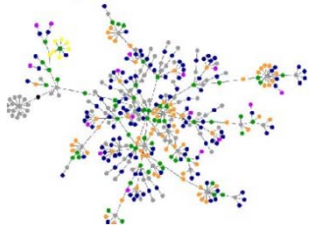
Applications

Legal reasoning

Social network security

Intelligent document analysis

Social network analysis



Social semantic multimodal documents

Business process compliance

collaborations:
Leeds Univ. (UK)
King's College (UK)
NICTA (Australia)

Decision Trees
(active learning and experimental design)

Ferdinando Cicalese

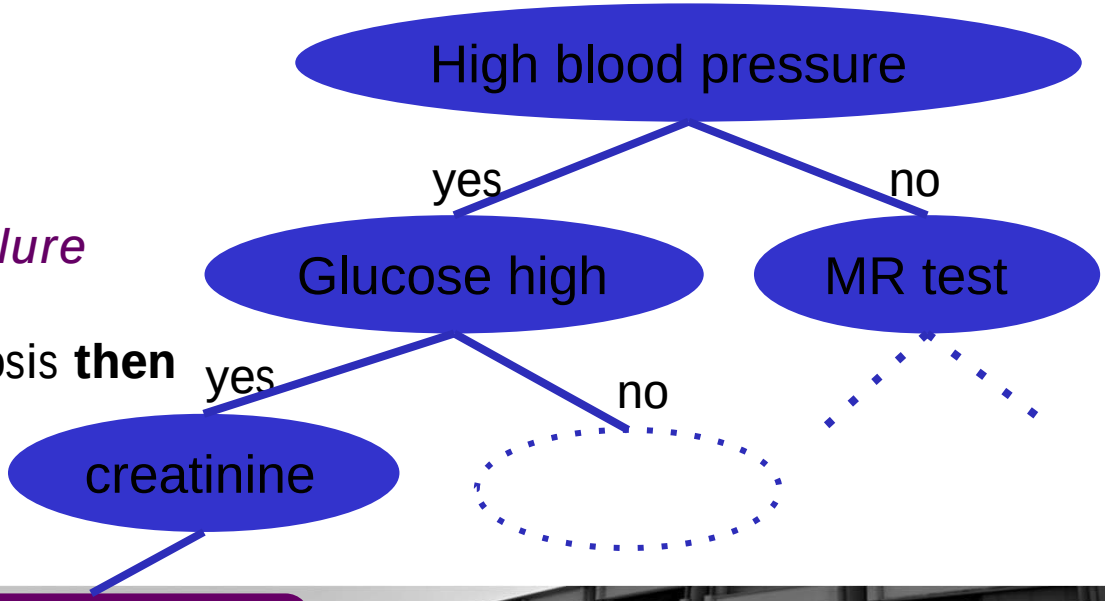
Natural model for knowledge representation

if … **then** rules are naturally represented as decision trees

Applications:

Classification, automatic diagnosis, learning, sensor networks, event detection, information spreading in social networks, data base query optimization, …

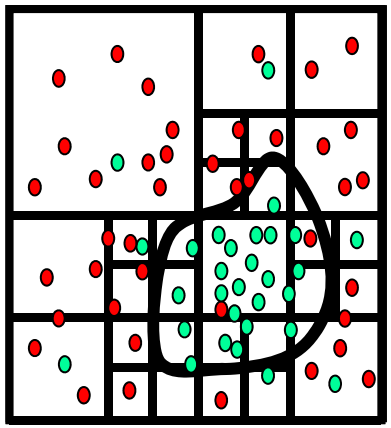
If blood pressure is high **then**
  If glucose level is high **then**
    If creatinine high **then**
      high risk of kidney failure
    else if test
  else if MR reveals artery stenosis **then**
    …
Else if …

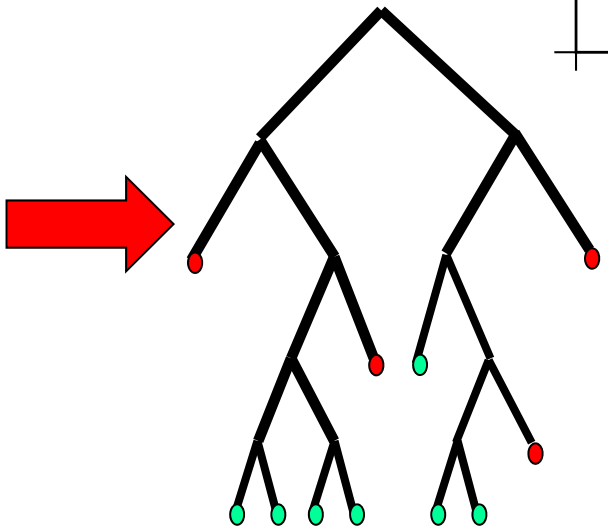


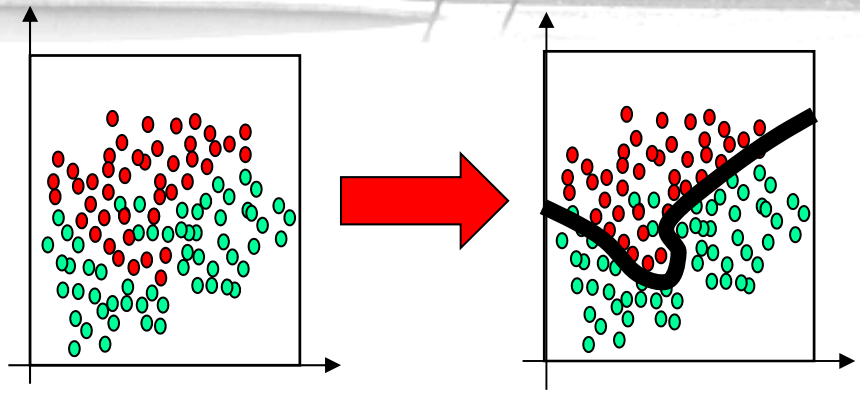
Decision Trees
(active learning and experimental design)

Learning and Classification

Partitioning labeled data







Adaptive partition defined by a (decision) tree

- simple design
- simple interpretation
- simple implementation
- good performance

collaborations: PUC-Rio (Brazil), Rényi Institute (Hungary), NII-Tokyo (Japan)
Chalmers U. (Sweden), CMU (USA)

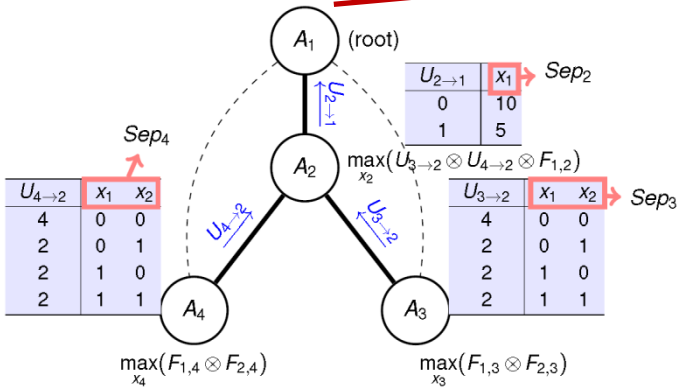
Intelligent Agents and MAS

Alessandro Farinelli

Develop agents that **interact** with environment and other agents

Intelligent Agent

Multi-Agent System

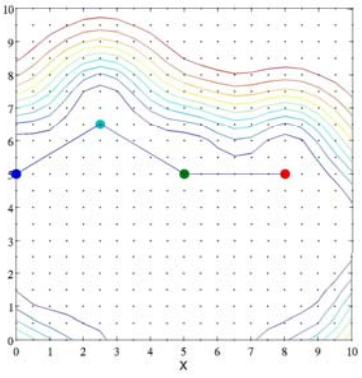


$U_{2\to1}$	x_1
0	10
1	5

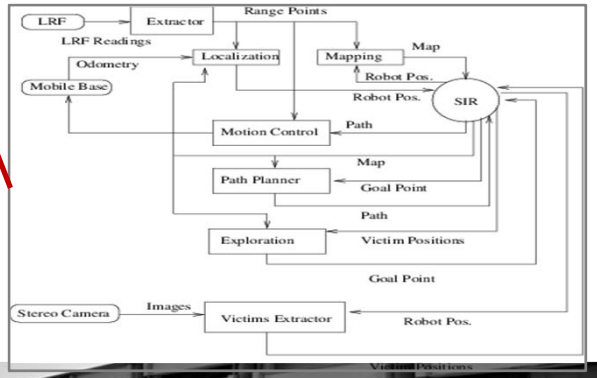
$U_{4\to2}$	x_1	x_2
4	0	0
2	0	1
2	1	0
2	1	1

$U_{3\to2}$	x_1	x_2
4	0	0
2	0	1
2	1	0
2	1	1

Optimization



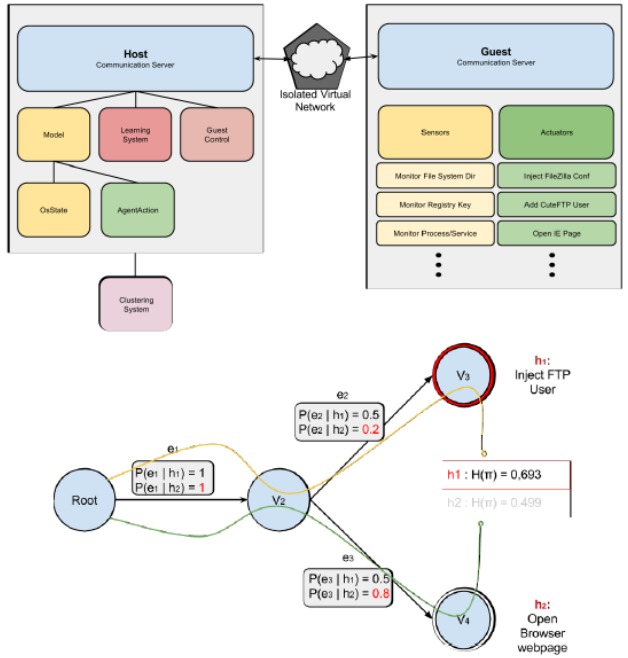
Uncertainty



Complex Software Systems

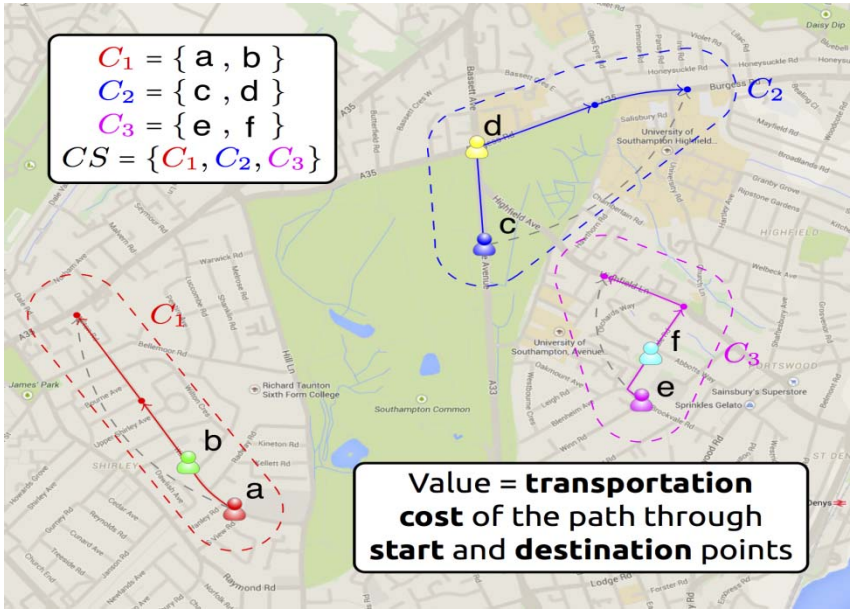
Intelligent Agents and MAS

Malware Analysis (Stochastic Games)



Group Formation (Constraint Optimization)

Ride Sharing



Energy Puchasing

collaborations:
Southampton Univ. (UK), IIIA-CSIC (Spain)

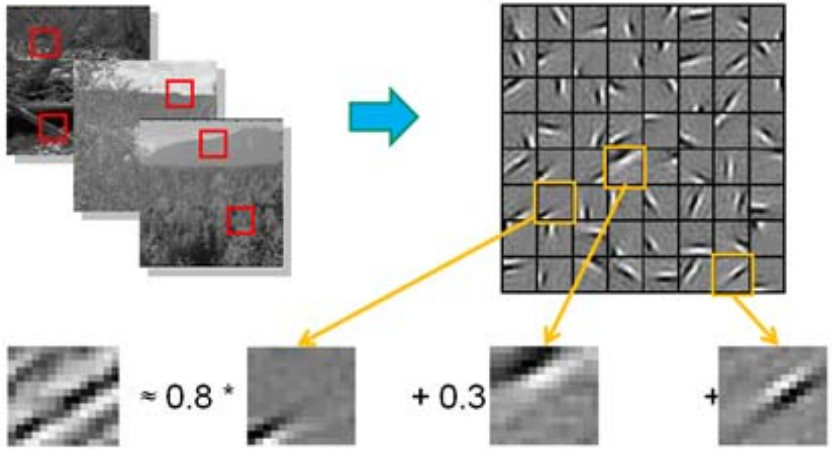
Machine Learning

Umberto Castellani

Manuele Bicego

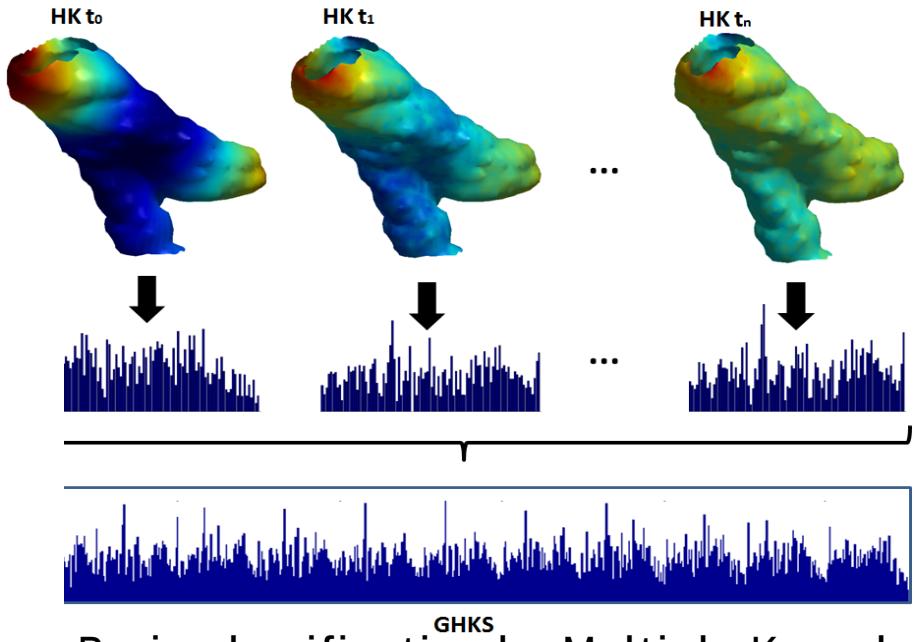
Gloria Menegaz

Learn from data to make predictions or decisions



$[a_1, \ldots, a_{64}] = [0, 0, \ldots, 0, \mathbf{0.8}, 0, \ldots, 0, \mathbf{0.3}, 0, \ldots, 0, \mathbf{0.5}, 0]$
(feature representation)

Dictionary Learning



Brain classification by Multiple Kernel Learning

Intelligent imaging

VIPS

Image processing

Computer Graphics

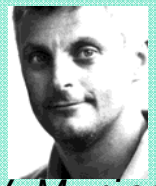
A. Giachetti

A. Daducci

G. Menegaz

Computer Vision

M. Cristani



V. Murino

U. Castellani

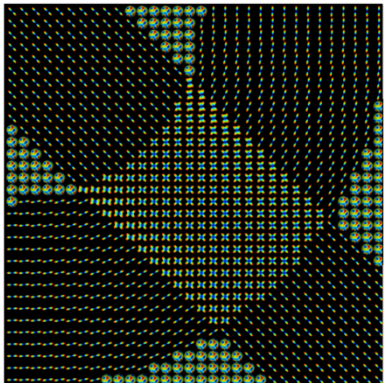
Machine Learning

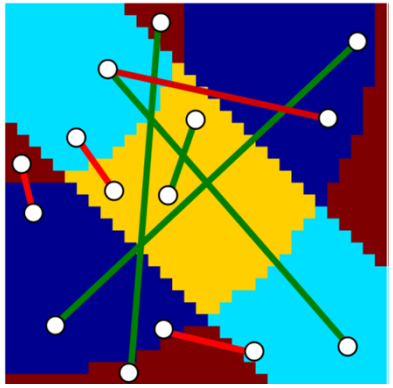
M. Bicego

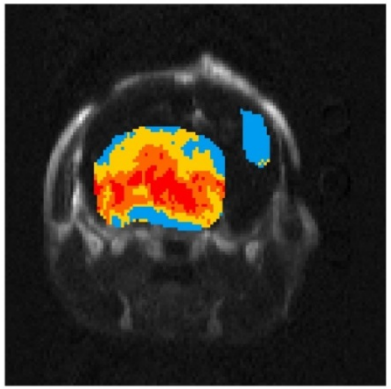
Pattern Recognition

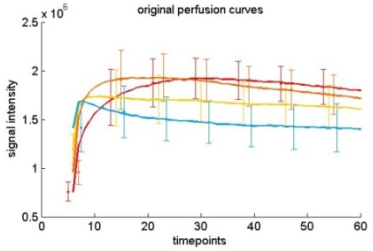
Machine Learning

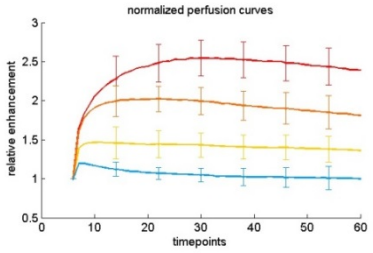
Constrained Spectral Clustering for HARDI data



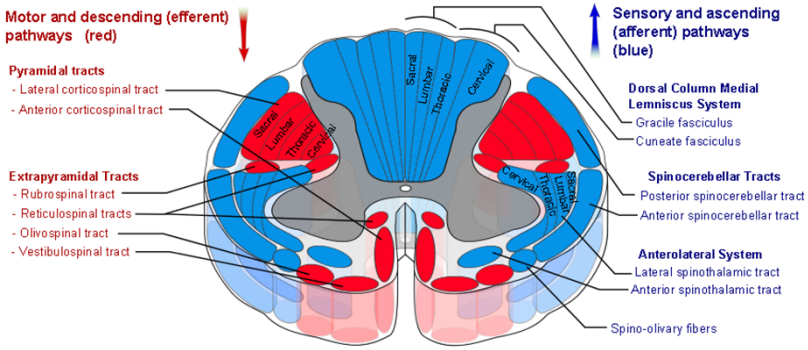


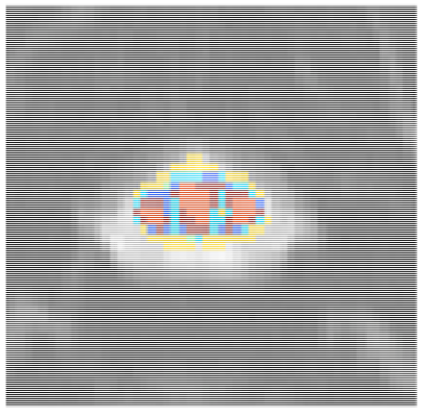


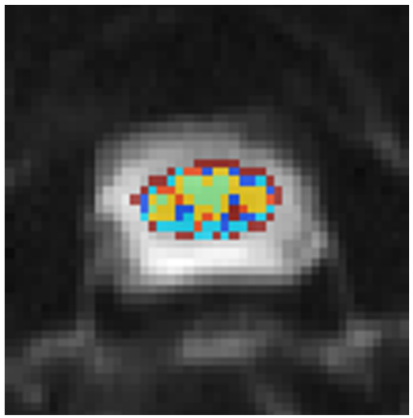




Cortico-spinal tract segmentation







Pattern Recognition

Manuele Bicego

Marco Cristani

What is pattern recognition ?

What is this ?

Where am I ?

How many pasta shapes

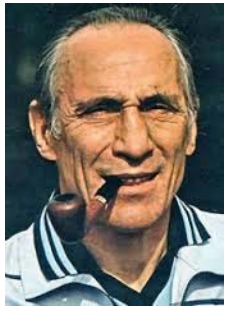
automatic systems that can perform recognition of patterns (classification, clustering)

PLAY HERE!!!

http://places.csail.mit.edu/demo.html

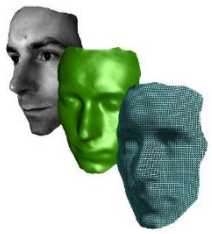
Pattern Recognition

Person recognition (biometrics)



Who is this guy ?

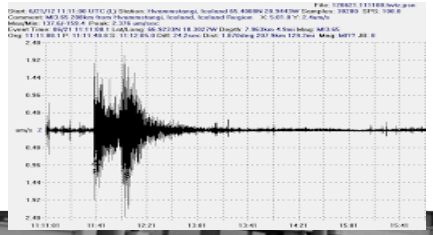
Recognition from <u>physiological</u> traits:
(how a person appears)



Recognition from <u>behavioural</u> traits:
(how a person behaves)

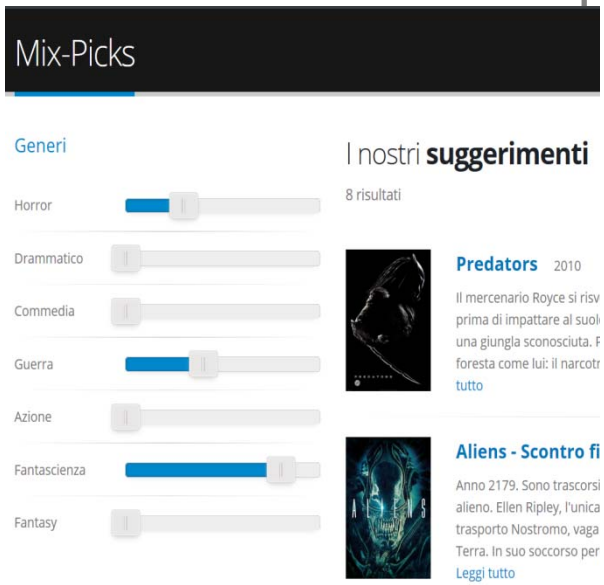
posture, actions…

Classification of seismic signal



Recommender systems

amazon



COME IN THE VIPS LAB (FLOOR -2) FOR A DEMO!

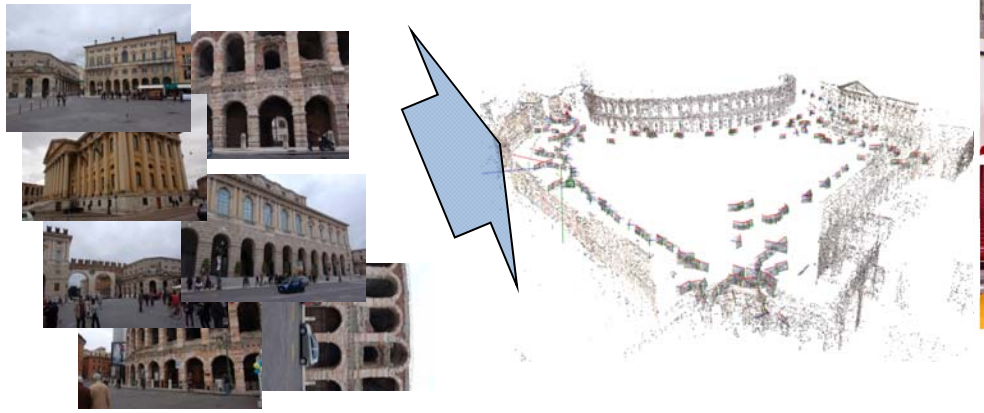
Computer Vision

Umberto Castellani

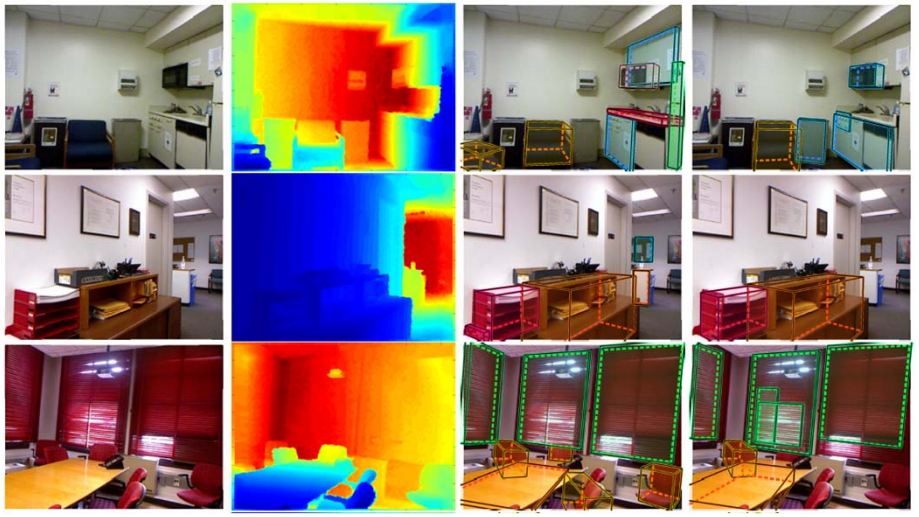
Marco Cristani

Andrea Giachetti

automatic systems that perceive and understand the visual world



3D reconstruction



Images and depth information

3D object segmentation

Computer Vision

Not only rigid objects: a personal 3D structure, for gaming, medical or surveillance aims

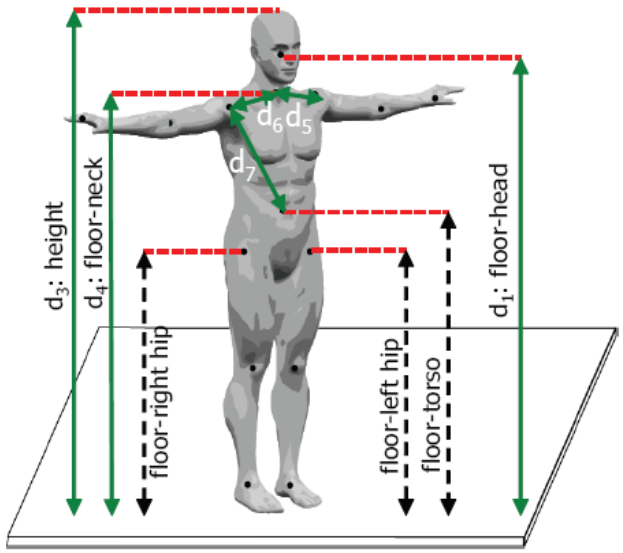


Image Processing

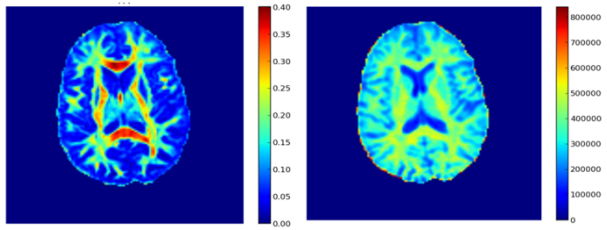
Gloria Menegaz

A. Daducci

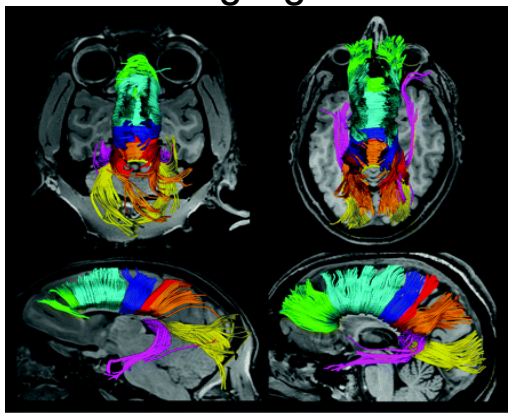
A. Giachetti

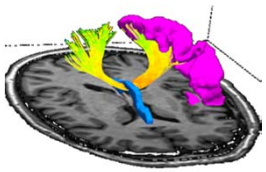
Image super resolution

Microstructure



Neuroimaging





Vampire

Computer Graphics

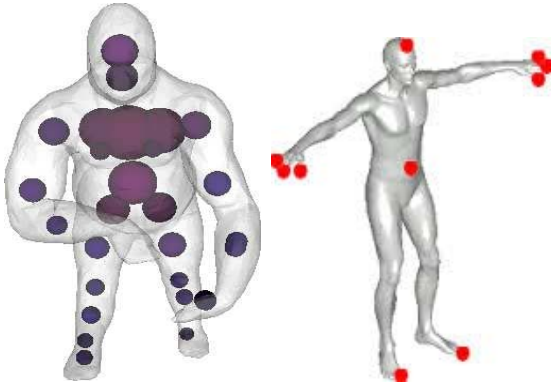
Umberto Castellani

Andrea Giachetti

Modeling 3D objects and scenes

Mesh segmentation and skeletonization

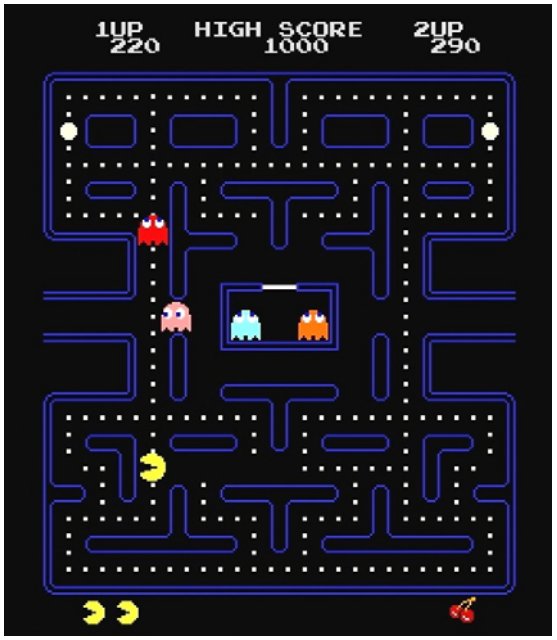
‘Shape google’: a query-shape and retrieved models



Feature points detection and description

Computer Graphics

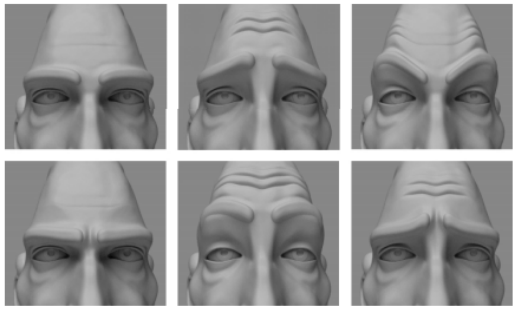
Visualization, gaming and visual interaction



Video game development

Augmented reality

3D interaction in Virtual Reality

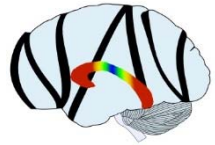


Facial animation

COME IN THE
VIPS LAB
(FLOOR -2)
FOR A DEMO!

Research Facilities

- 3 Laboratories
  - *VIPS1 (soft lab)* (Ca' Vignal 2, *floor-2*)
  - *VIPS2 (hard lab – different equipments* (Ca' Vignal 2, *floor-2*)
  - *NavLab (neuroimaging)*(Ca' Vignal 2, *floor-1*)



- ~12 seats
- Advanced Technology
  - Sensors (Kinect, Oculus Rift, Leapmotion, Brainwave)

Take a look at: vips.sci.univr.it for more info

Start-up and Master in CGD

3Dflow s.r.l. - www.3dflow.net

- computer vision and image processing

eVS s.r.l. – www.embeddedvisionsytems.it

- embedded vision systems

Humatics - http://www.humatics.it/

Master in Computer Game Development

- Computer graphics, visual computing, HCI, image processing