LAU
Lebanese American University
Chartered in the State of New York
www.lau.edu.lb

UNITED NATIONS
ESCWA

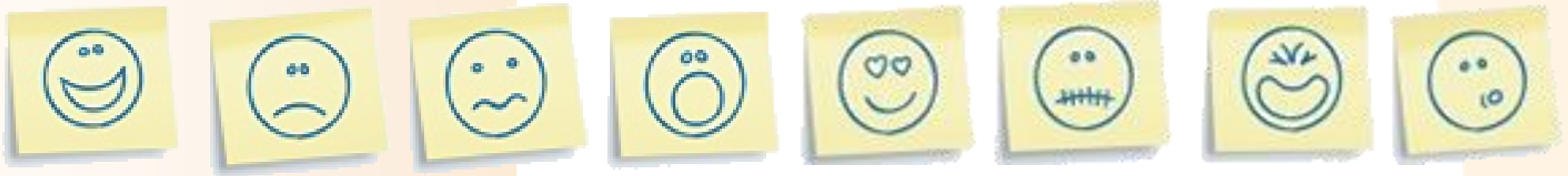
SOE
School of Engineering
Department of Electrical & Computer Engineering
www.lau.edu.lb/ece

Artificial Intelligence

Learning Human Emotions

through Intelligent Data Processing

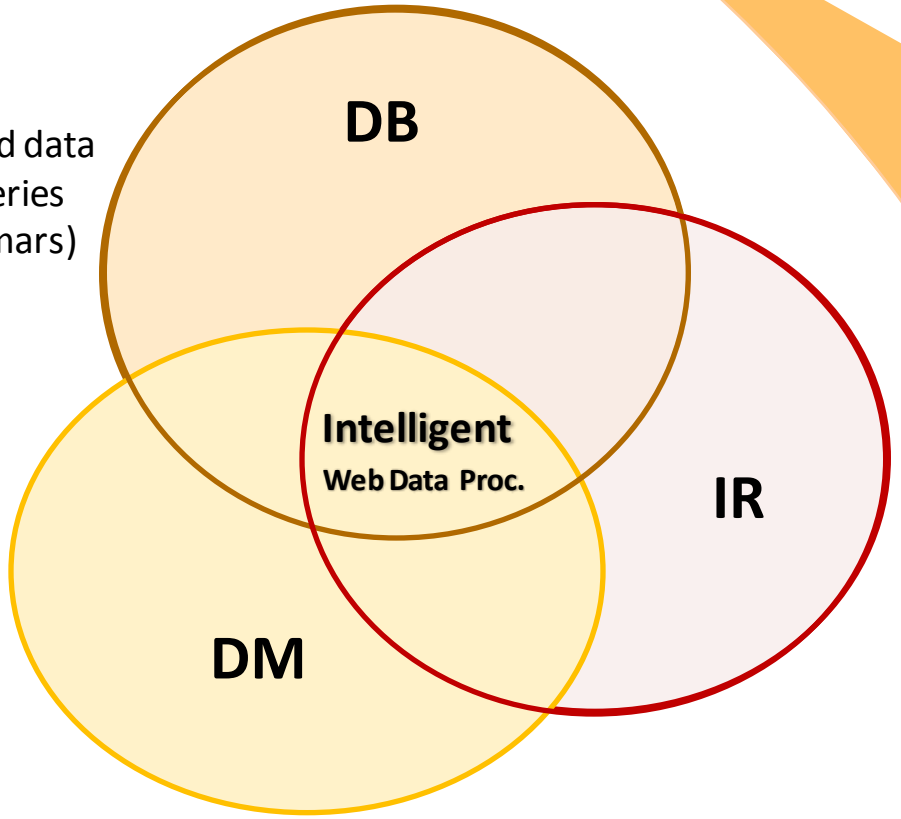
Joe Tekli, Ph.D.



My Area of Expertise

- **Web**-based **semi-structured data** **processing & applications**
  - XML, RDF, & OWL are at the center stage of data engineering
    - ⇨ Main building block toward **Intelligent Web Data Processing**

DataBases
Handling structured data and complex queries (e.g., SQL, grammars)



Information Retrieval
Handling flat data & ranked queries (e.g., keyword search)

Data Mining
Discovering & inferring hidden data patterns (e.g., clustering, classification)

Joe M. Tekli

More than 43 scientific publications in top international conferences and journals

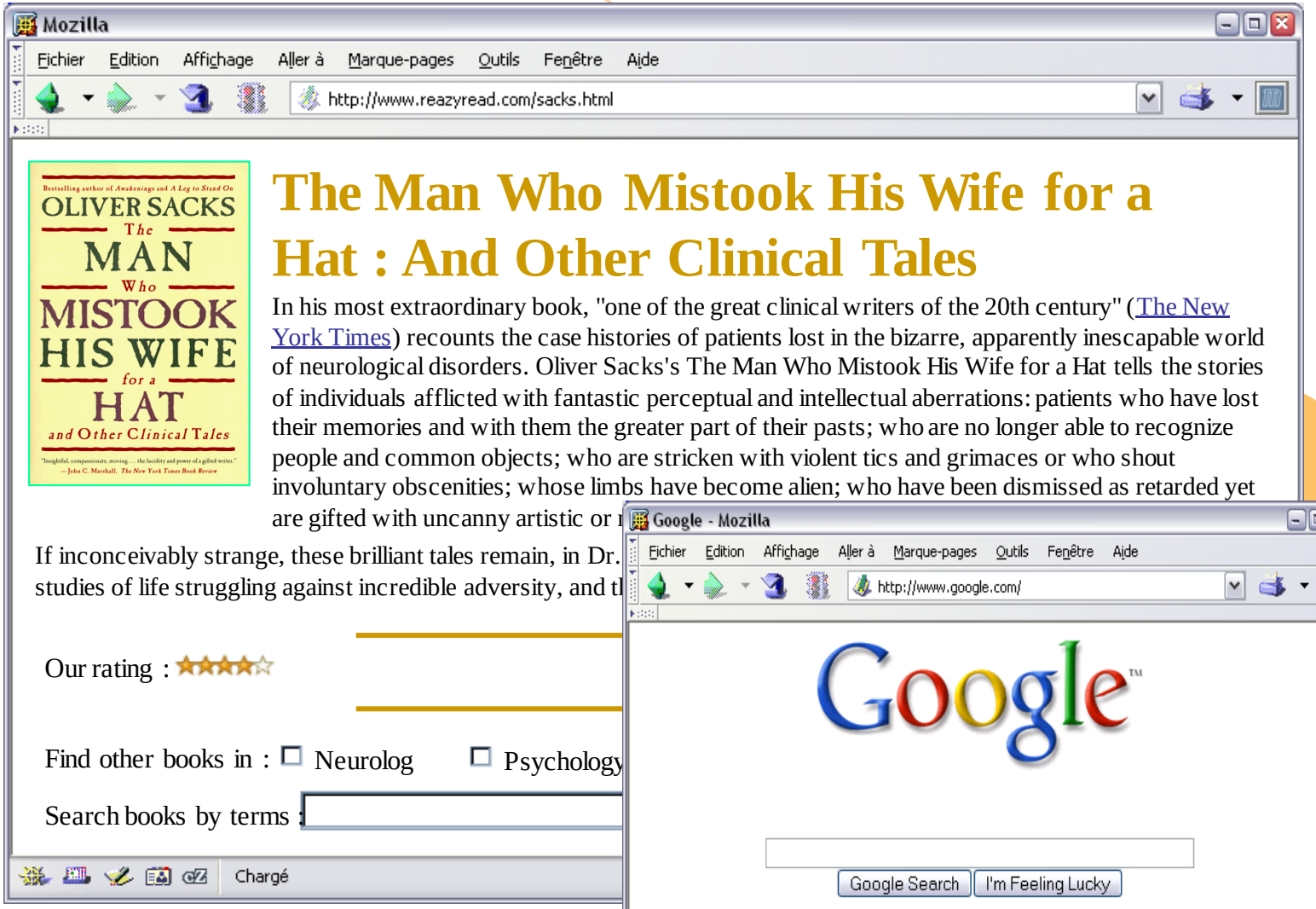
Coordinated 3 research projects: CEDRE 2012-13, CNRS-L 2015-16, & LAU-CNRS-L, 2017-19

Vice President of ACM SIGAPP French Chapter, France, since 2018

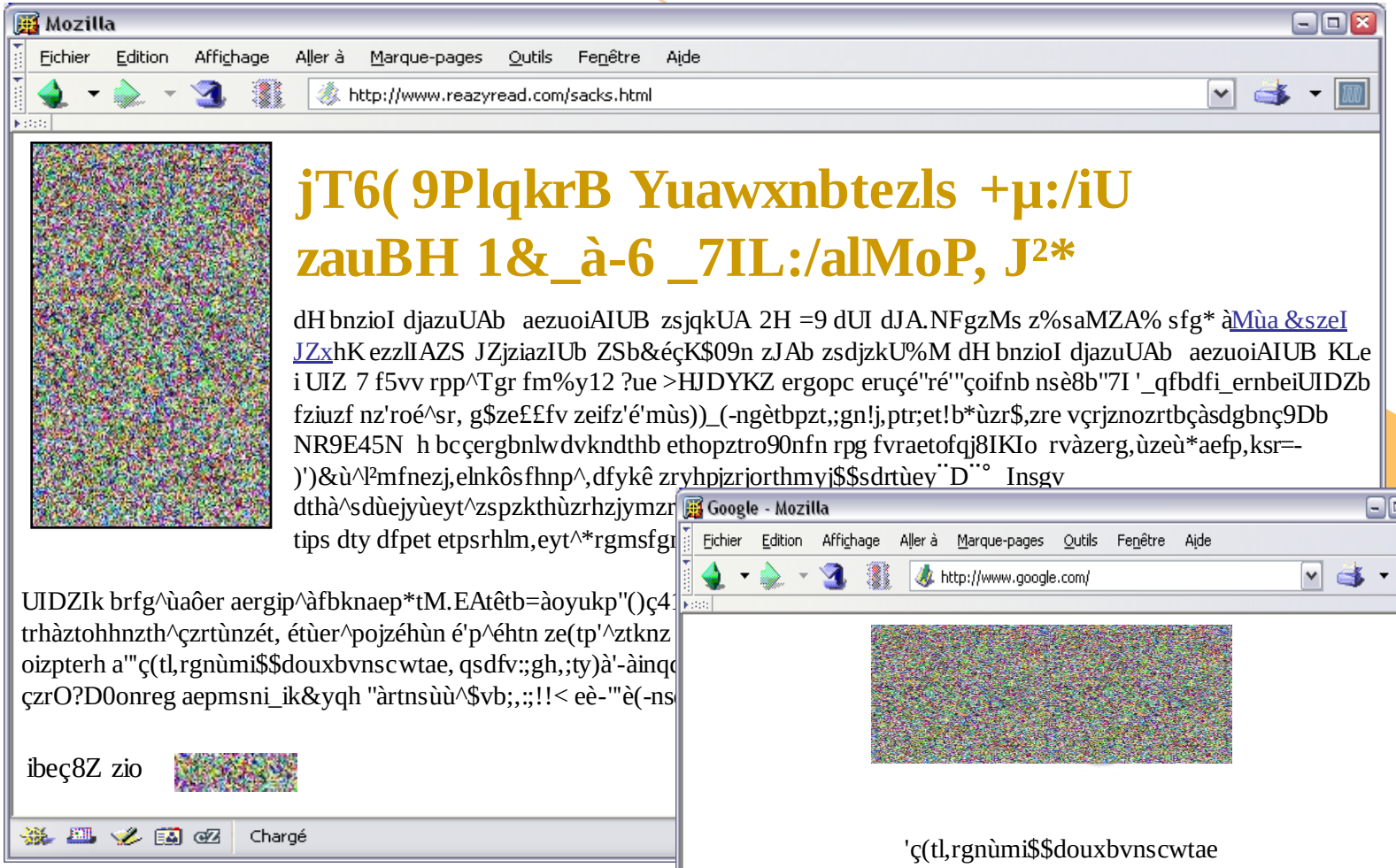
Visual Data Accessibility for the Blind
Semantic Indexing & Disambiguation
XML Collective Knowledge
XML Structure Validation
SOAP Multicasting
GML Ranked Retrieval
XML Grammar Matching
RSS Merging
XML Semantic Similarity
XML Structure Similarity
MM Data Fragmentation

2018 – Visiting Researcher Scholarship, **J. William Fulbright Scholarship Program, USA**
Since 2013 - Assistant Professor – ECE Dept., Lebanese American University (LAU), Lebanon
Since 2012 - Visiting Professor – LIUPPA Laboratory, University of Pau (UPPA), France
2010 - Postdoctoral Scholarship, **Research Support Foundation of the State of Sao Paulo (FAPESP), Brazil**
2010 - Postdoctoral Fellowship, **Japan Society for the Promotion of Science (JSPS), Japan**
2010 - Postdoctoral Research Grant, **Fondazione Cariplo, Italy**
2009 - Highest Honors (Summa Cum Laude), PhD, LE2I Laboratory UMR-CNRS, Dijon, France
2007 - PhD Graduate Fellowship, **Ministry of Education and Research, France**
2006 - Honors (Distinction Very Good - Top of Class) - Research Masters, University of Bourgogne, (UB) Dijon, France
2006 - Research Masters Scholarship, **AUF - International French Universities Agency (AUF), Beirut, Lebanon**
2005 - Honors (Distinction Very Good - Top of Class) - Masters of Engineering, Antonine University (UA), Lebanon

Data to Humans…



Data to Machines…



Computer is an Automated Calculator

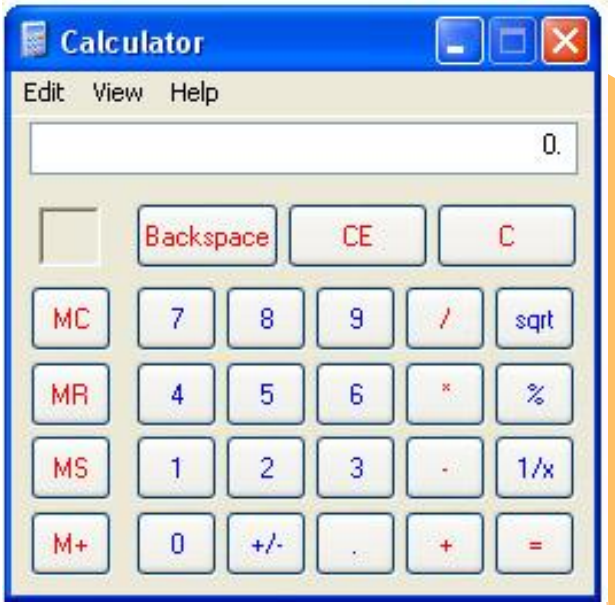
- A **computer** is a **programmable machine** designed to execute, in a sequential and automated manner, the computation operations in a program
  - Programming operations are also called: statements or instructions

```
Variables x, a, b of type integer
Variable i of type integer

For i strating at 0 until 5 do:
    x = a^i + b

Display x
```

Source code

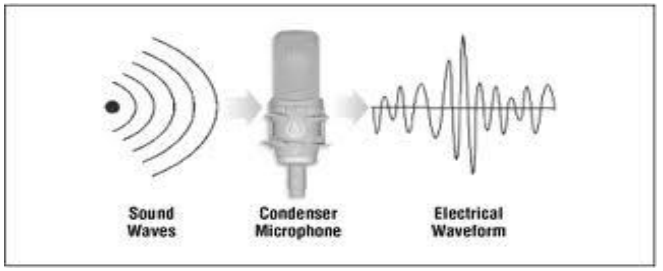
```
00101 10 1100 111
11010 010 101 001
11011 001 101 110
```

Machine code

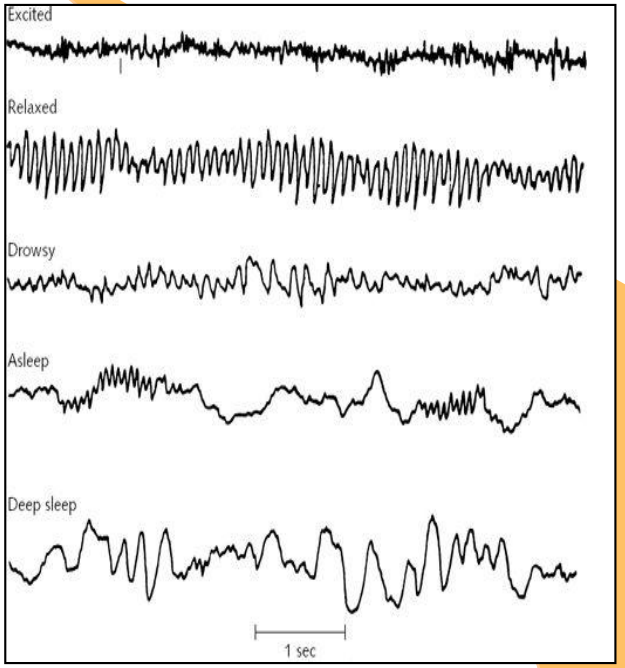


Computer Data Processing

- Example 1: Audio signal processing



1. Input acquisition
as electronic signal

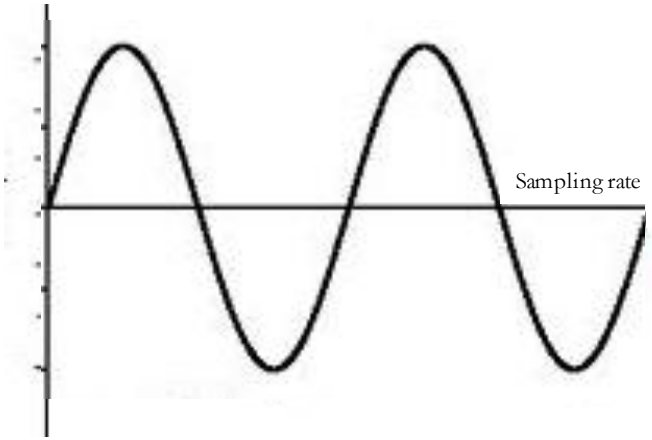


2. Feature extraction

Computer Data Processing

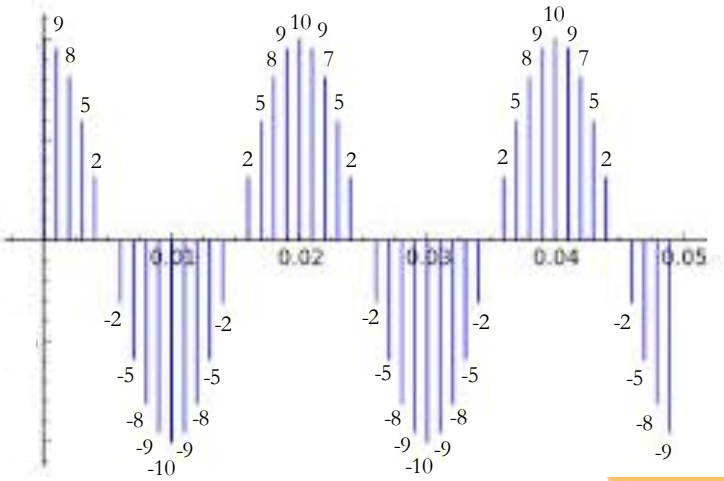
- Example 1: Audio signal processing (2)

For every feature:



3. Sampling

Sampling rate highlights precision in number of samples per second



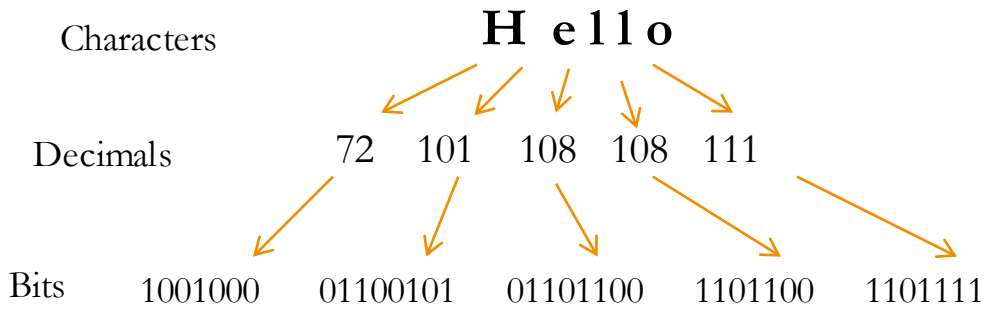
4. Digitization

Output signal: < 9; 8; 5; 2; 0; -2; -5; -8; -9; -10;
-9; -8; -5; -2; 0; 2; 5; 8; 9; 10;
9; 8; 5; 2; 0; -2; -5; -8; -9; -10;
9; -8; -5; -2; 0; 2; 5; 8; 9; 10; …>

Computer Data Processing

Example 2: Test processing

- **Binary format**
  - ASCII : American standard code for information interchange
    - Standard binary coding to represent characters of the Latin alphabet
      - **Text** is handled as a sequence of **numbers**



Character	Decimal	Binary
'A'	65	1000001
'B'	66	1000010
…	…	…
'Z'	90	1011010
…	…	…
'a'	97	1100001
…	…	…
'z'	122	1111010

Toward **Intelligent Data Processing**

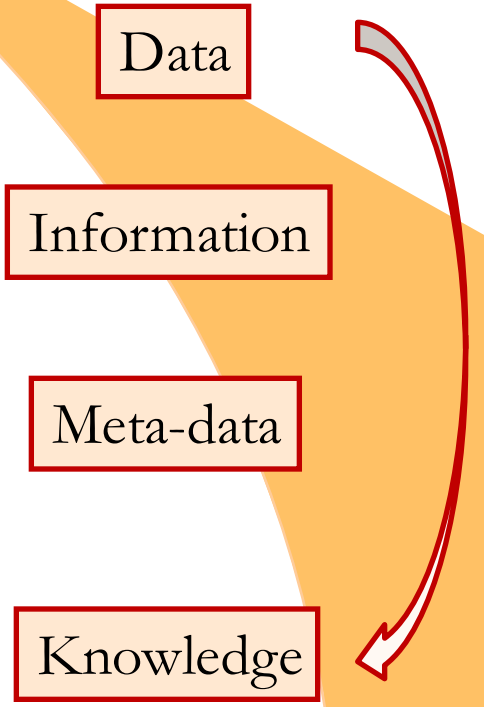
- Processing the **meaning** of data
  - Processing **sentiments** behind data

Hello

A conventional expression of greeting

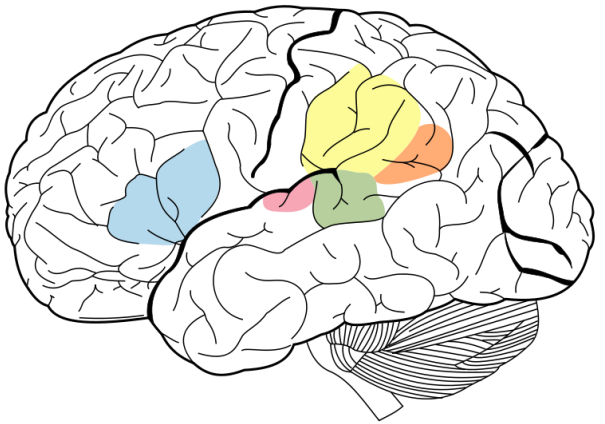
Who gave the data (*Merriam-Webster Dictionary*)?
When was it given (*published in 2002*), etc.

A conventional expression of greeting is *"Hello"*,
Following the *Merriam-Webster dictionary*
in its version *published in 2002*



Toward **Intelligent Data Processing**

- Involving different fields of study in AI
  - **Knowledge Representation**
  - **Search Agents**
  - **Machine Learning**
  - **Evolutionary Computation**



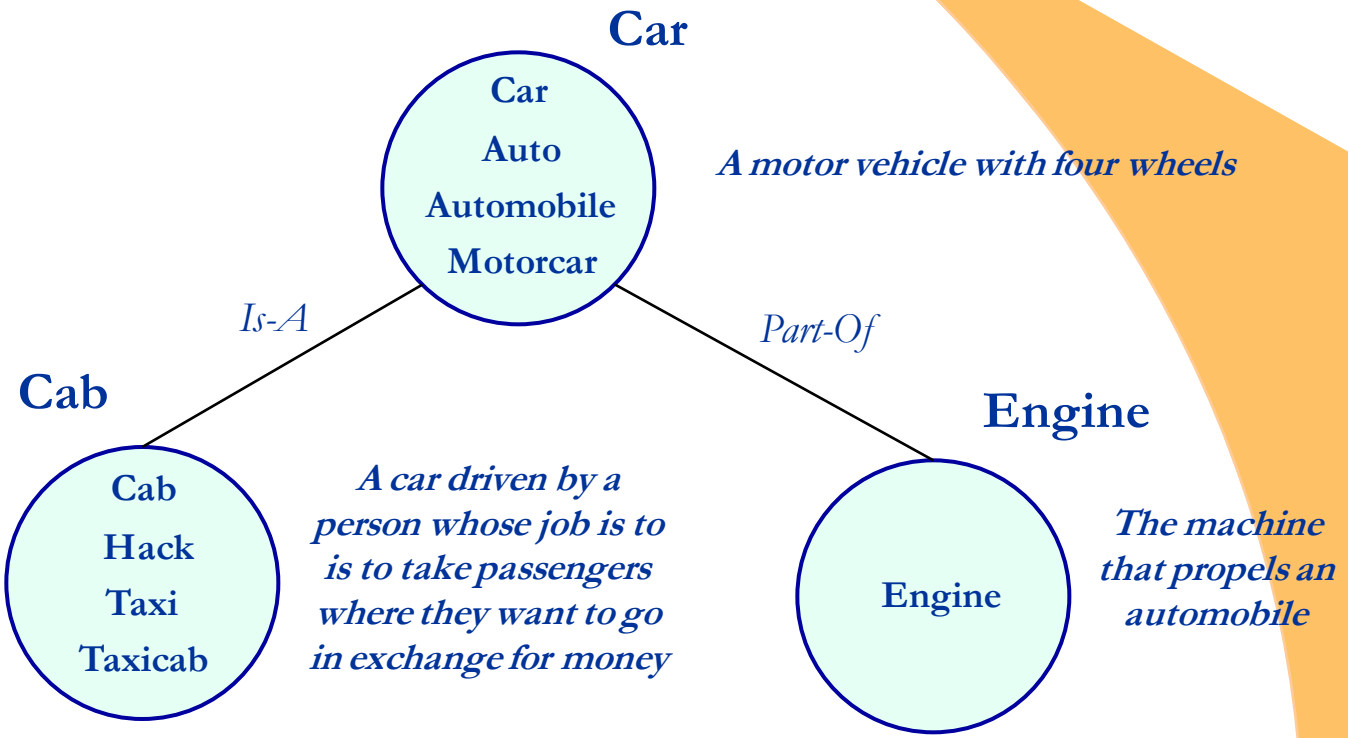
Attempting to mimic the **biological brain!**

1. Knowledge Representation

- Many of the problems machines are expected to solve will require extensive knowledge about the world
- **Main Premise**: Assigning information well defined **meaning**, to be automatically understood and processed by machines
- **Basic constructs:**
  - **Controlled vocabulary** (e.g., machine-readable dictionary)
    - A list of ordered words with explicit semantic meanings
  - **Thesaurus** (e.g., lexicon)
    - A dictionary enriched with semantic relations
      - Is-A, Related-To, Attribute-Of, See-Also, etc.
  - **Ontology** (e.g., knowledge base)
    - Thesaurus with an explicit formalization of relations
      - Using dedicated grammar rules

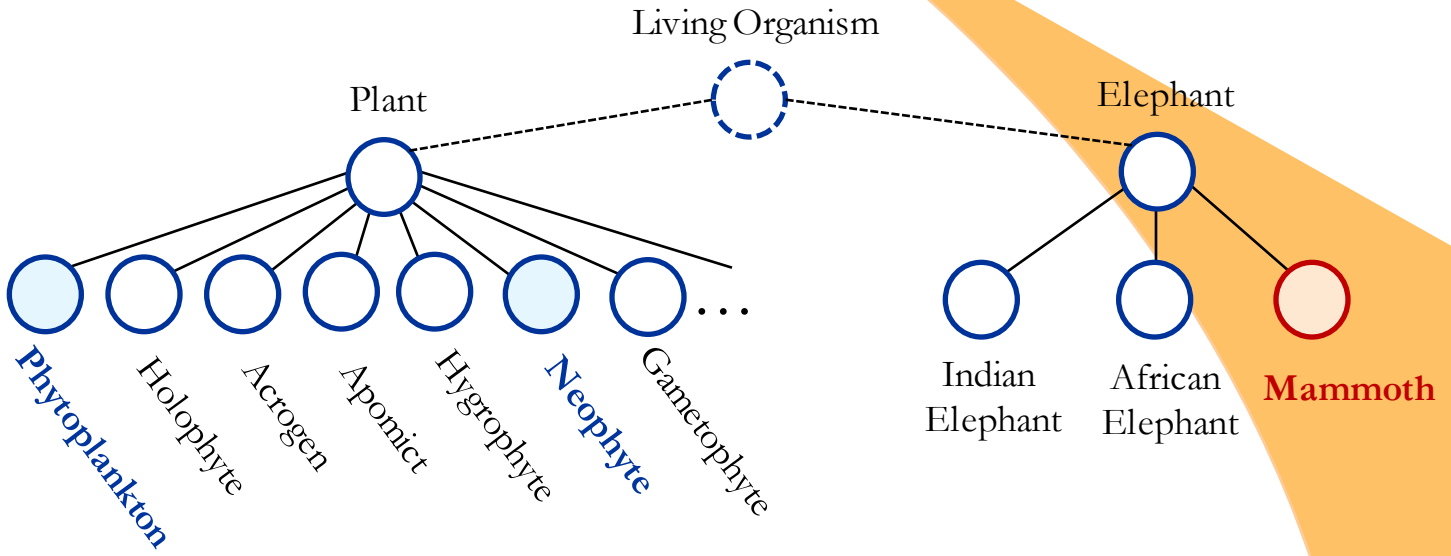
1. Knowledge Representation

- **Knowledge base** (e.g., ontology)
  - Modeled as a **Semantic Network**
    - Concepts connected via (hierarchical) relations



2. Search Agents

- **Knowledge processing**: evaluating relatedness between concepts
  - In the semantic network **search space**

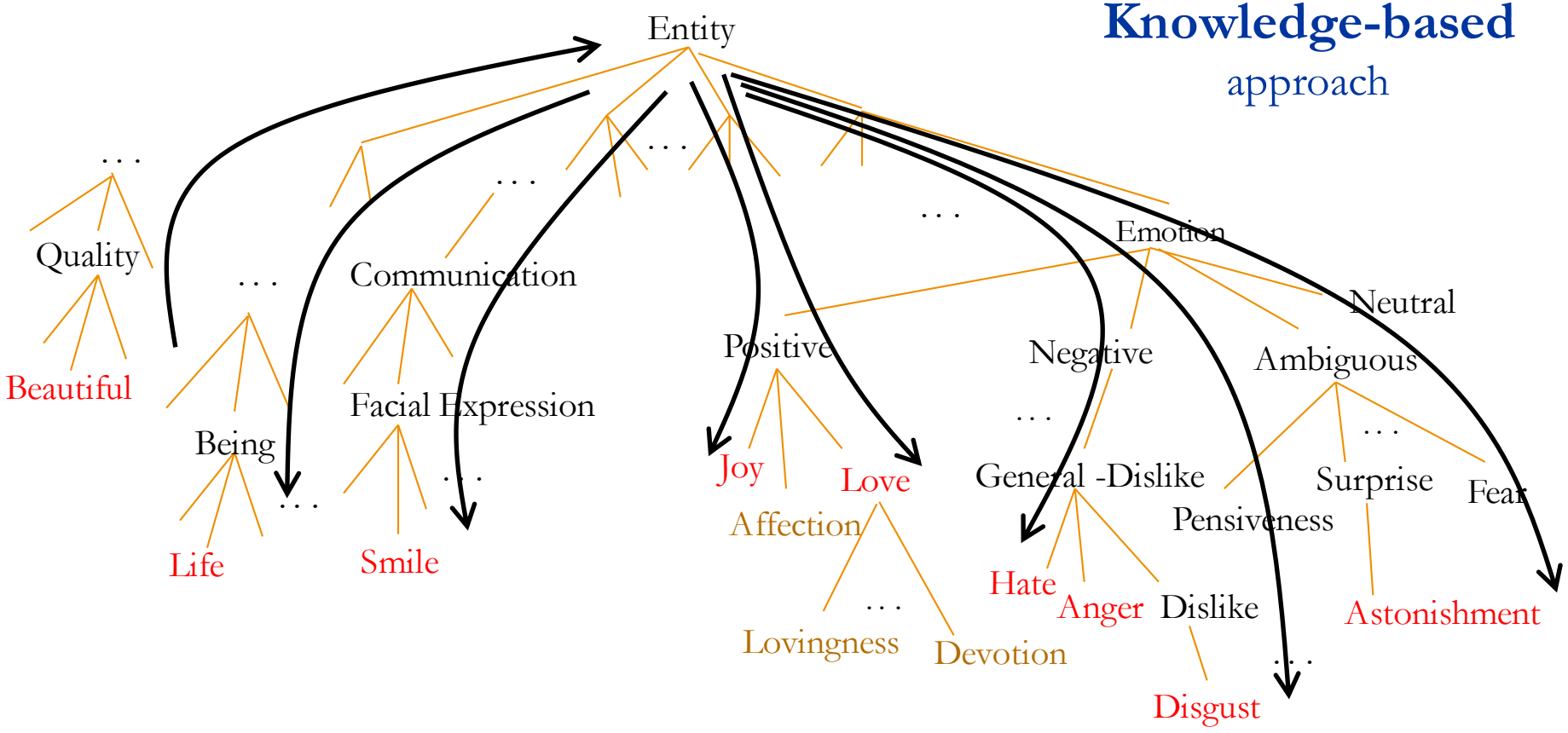


$$\mathrm{Dist}(c_1, c_2, SN) = \sum_{c \in MinPath(c_1, c_2, SN)} Weight(c_1, c, SN)$$

$$Weight(c_1, c_2, SN) = \left(\beta + (1-\beta) \times \frac{\mathrm{Child}(SN)}{|\mathrm{Child}(c_2)|}\right) \times \left(\frac{\mathrm{Depth}(c_2)+1}{\mathrm{Depth}(c_2)}\right)^{\alpha} \times \mathrm{Type}(c_1, c_2)$$

- **Example**: "Smile, life is beautiful"

Unsupervised Knowledge-based approach



Smile [joy:1.00000, sadness:0.02439, love:1.00000, anger:0.02439, disgust:0.04545, astonishment:0.02439]

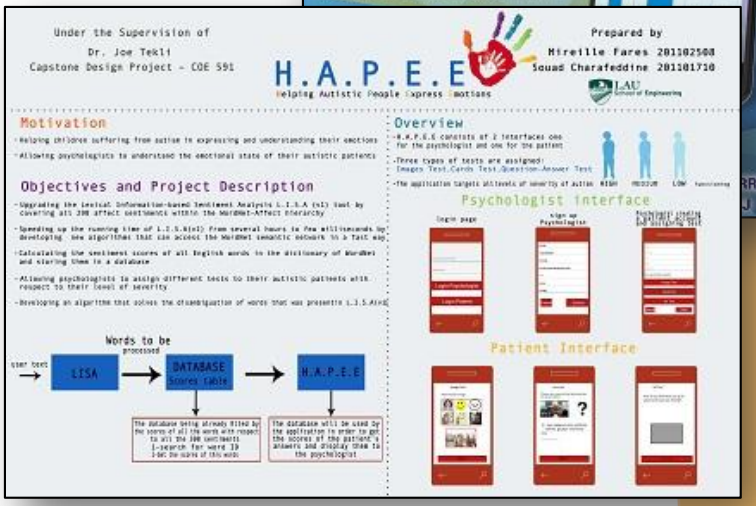
Life [joy:0.01389, sadness:0.12500, love:0.12500, anger:0.12500, disgust:0.01042, astonishment:0.00033]

Beautiful [joy:1.00000, sadness:0.02439, love:1.00000, anger:0.02439, disgust:0.04545, astonishment:0.02439]

Demo… http://sigappfr.acm.org/Projects/LISA

- **L.I.S.A.: Lexical Information-based Sentiment Analysis**
  2014-15
  - Angela Moufarreg
  - Eliane Jreij

- **H.A.P.E.E.: Helping Autistic People Express Emotions**
  2015-16
  - Mireille Fares
  - Souad Charafeddine



Challenges

- **Ambiguity**

"The **cricket** hops on the river **bank**"

A game played with bat by two teams of 11 players.

A sloping land, slope beside a body of water.

?

Leaping insect; male makes chirping noises by rubbing the forewings together.

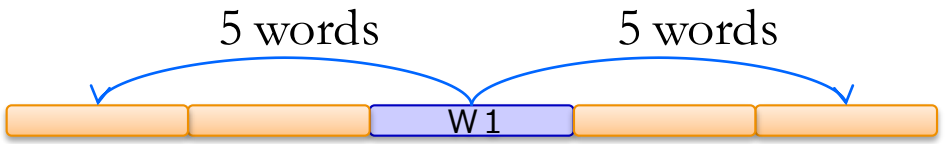
A financial institution that accepts deposits and channels the money into activities

Challenges

- **Context**

"I have a lecture today"

[joy:0.56250, sadness:0.50153, love:0.56250, anger:0.50153, disgust:0.04451, astonishment:0.00169]



W1 = {2, 1, …, 4}

Context feature vector

Terms highlighting **similar emotions** show similar **syntactic distributions** in a corpus

[joy:0.83721, sadness:0.50153, love:0.63158, anger:0.50153, disgust:0.04451, astonishment:0.00337]

Challenges

- **Features**
  - How to determine the **meaning of an image**?
    - How to determine the **sentiment** reflected by an image?

Happiness?

⇨ Bright colors

Challenges

- **Multimedia**
  - How to determine the **meaning of an image**?
    - How to determine the **sentiment** reflected by an image?

Happiness still?

⇨ Darker colors

3. Machine Learning

- **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 cars, practical speech recognition, effective web search, among other applications, as well as a vastly improved understanding of the human genome…

    ↳ Key to make progress towards **human-level AI**
- Machine learning techniques fall within two main categories:
  - **Unsupervised** learning
  - **Supervised** learning

3. Machine Learning

- **Main premise:** Identifying an output measure based on input data
  - By mapping inputs to desired output
    - Using sample input/output data provided by experts:

      training data

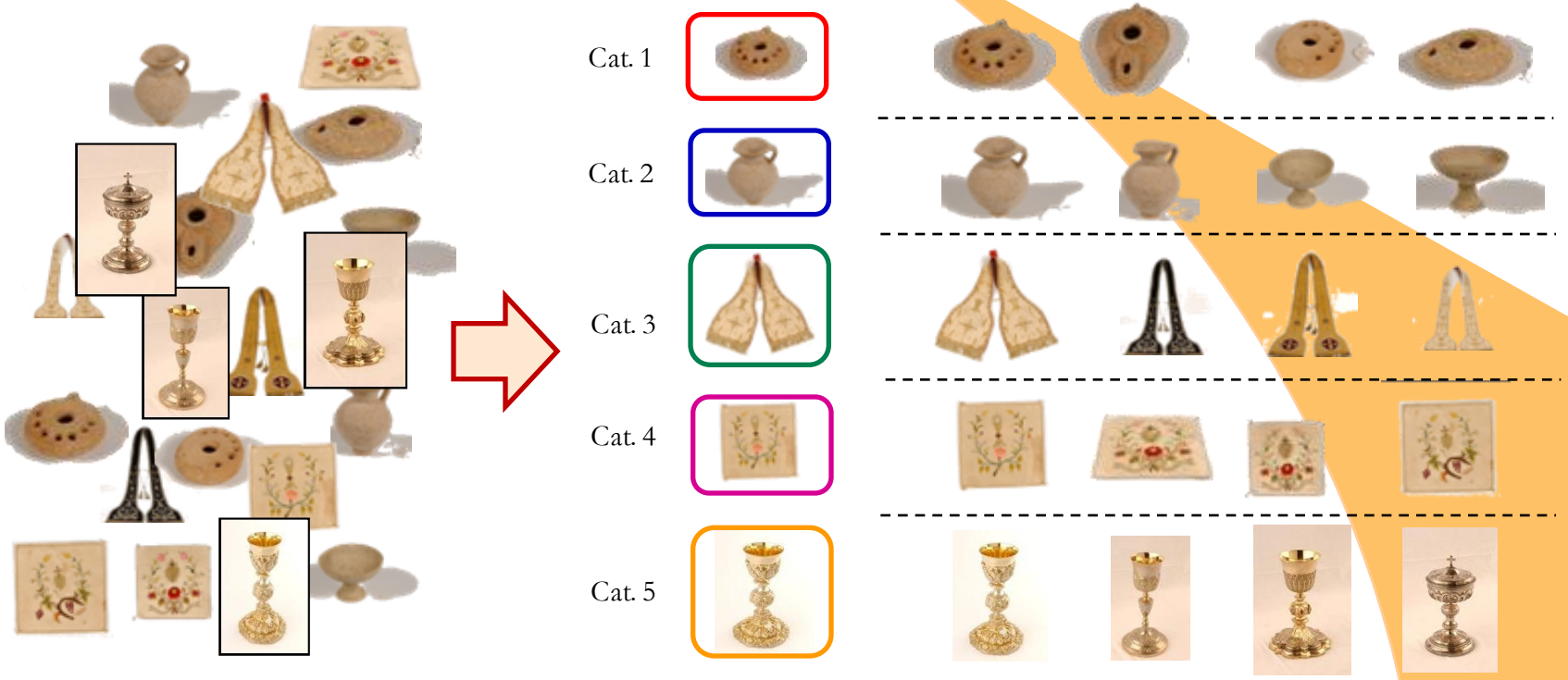
- Training data provided in the form of examples $(X_1, y_1), \ldots, (X_m, y_m)$
  - where **X** is a vector of $x_1, \ldots, x_k$ input values
  - And **y** is the output generate by unknown/**desired** activation function ***f***

    ↳ Discover a function ***h*** that approximates the desired activation function ***f***

    - Approach known as **classification**

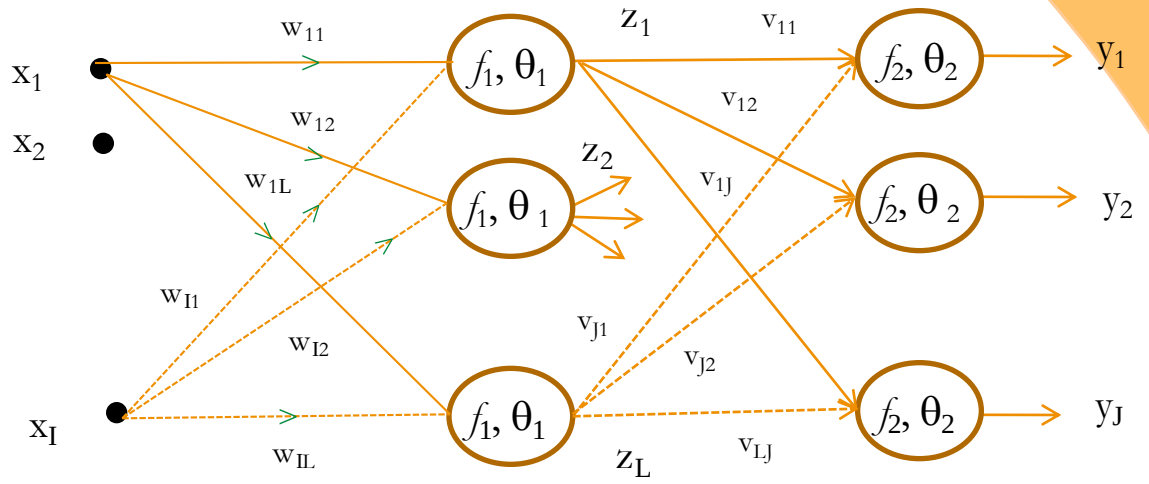
3. Machine Learning

- **Supervised learning:**



3. Machine Learning

- **Supervised learning:**
  - Different classification algorithms exist in the literature
    - E.g., **Instance-based**, **Support Vector Machines**, and **Artificial Neural Networks**



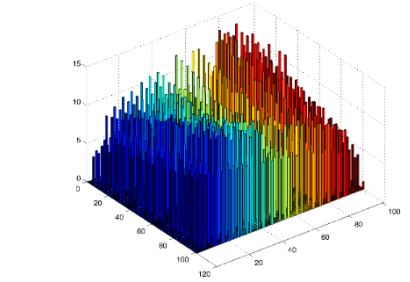
Two-layer *feed-forward* neural network, known as **perceptron**

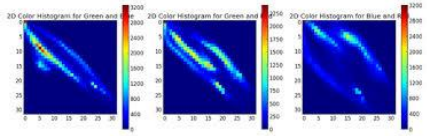
↳ Inspired by biological **brain**: ideal learning/recognition system

Input object

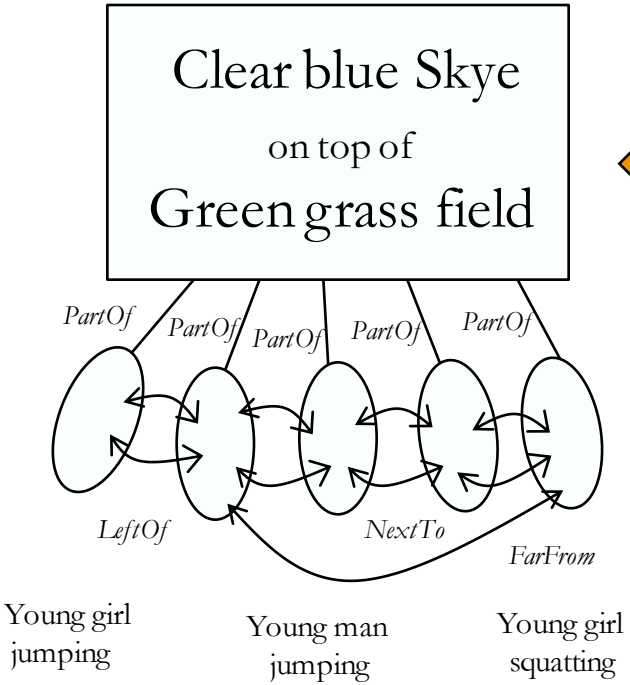
Object segmentation

Feature Extraction

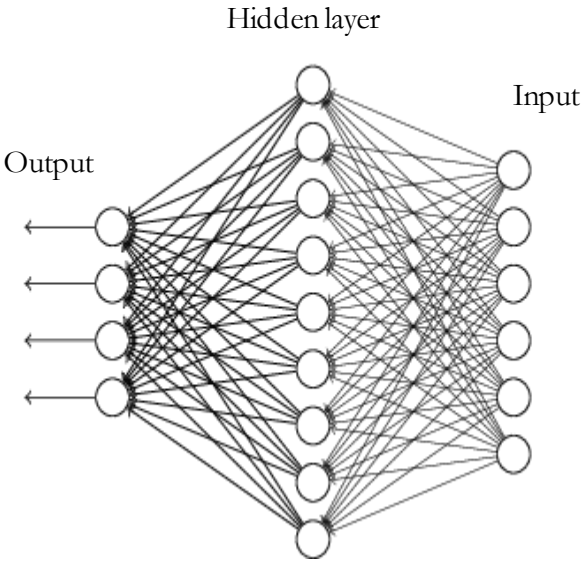


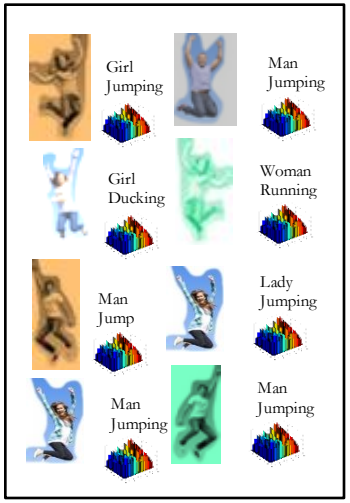


Knowledge representation



Learner



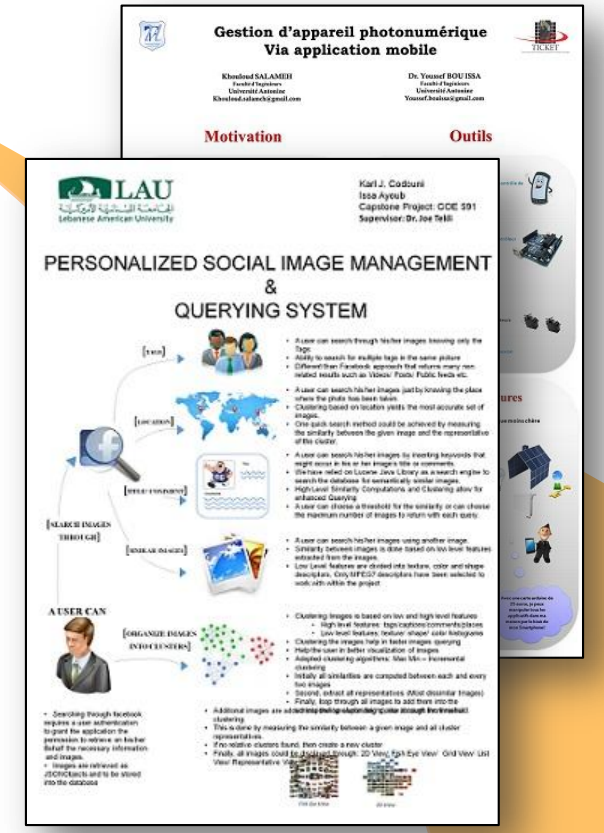


1. Training

2. Labeling

Demo… http://sigappfr.acm.org/Projects/SICOS

- **SVG-2-RDF: Image Semantization**
  - Khouloud Salameh, *2013-14*
- **S.I.C.O.S.: Social Images Organization and Search,** *2015-16*
  - Ayoub Issa
  - Karl Kodoumi
- **M.U.S.E.: Music Sentiment-based Expression,** *2016-17*
  - Ralph Abboud

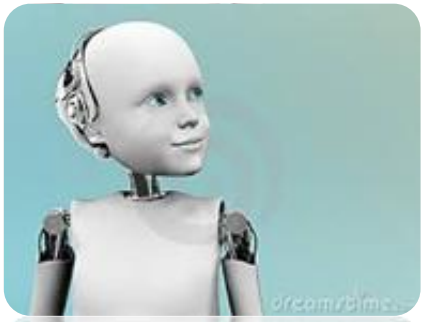


http://sigappfr.acm.org/Projects/SVG-To-RDF/

Autonomous Exploration

Is it **enough** to **learn?**

- **Problem generator:** Suggests actions that can lead to **new experiences** and **discoveries** for the agent
  - Without a problem generator, the agent repeats infinitely what it knows to do
    - However, discovering new sequences of actions is central in order to achieve **true intelligence**
      - Example: A child continuously learns new experiences and evolves its behavior



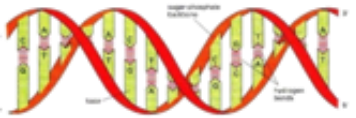
4. Genetic Algorithms

Evolutionary Computation

- **Main premise**: The AI system should be able to **create** and **pursue its own goals**
  - To **persist without** (human) **assistance**, for a long time
  - To **expand its knowledge** beyond predefined constraints

  ↳ To take the initiative: to **evolve**!

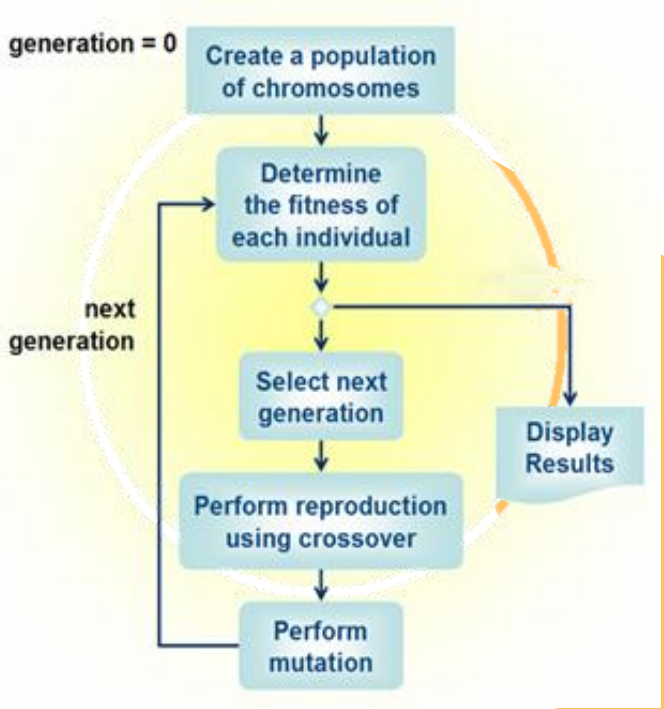
- **Evolutionary computation**
  - Inspired by the **Darwinian Theory of Evolution**
    - **Genetic algorithms**
      - Mimicking genetic processes nature uses



4. Genetic Algorithms

Evolutionary Computation

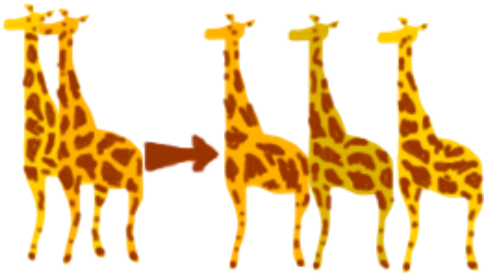
- **Same process mimicked in GA:**
  - An **organism** represents a solution to a problem
  - A **gene** represents a sequence of symbols
  - Simulating **crossover** and **mutation** functions
  - **Fitness** is evaluated using a performance function
    - To be maximized/minimized
  - Multiple **generations** are created
    - Until reaching the fittest



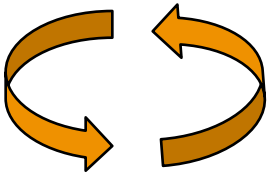
4. Genetic Algorithms

Evolutionary Computation

- **Background in genetics:**



Reproduction
(crossover)



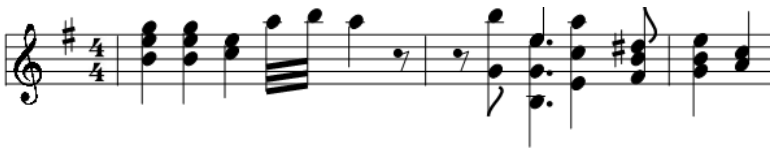
Diversification
(mutation)

Natural selection
(survival of fittest)

Fields of Study in AI

7. Evolutionary Computation

- Example: ***Music Composition***



- Sample start chromosome: A B C D E F
- Single gene mutation: A B C **D** E F => A B C **C** B A ✗ Non-fit
- Gene swapping: A B **C D** E F => A B **D C** E F
- Crossover: A B C | D E F + F E D | C B A = A B C C B A ✗ Non-fit

  A B C | D E F + | F E D C B A = A B C F E D ✓ Fit

Demo… http://sigappfr.acm.org/Projects/MUSEC

- **M.U.S.E.C.: Music Sentiment-based Expression and Composition,** *2016-18*
  - Ralph Abboud

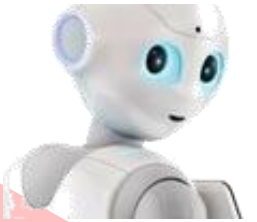
"Next to the Word of God, the noble art of music", MLK

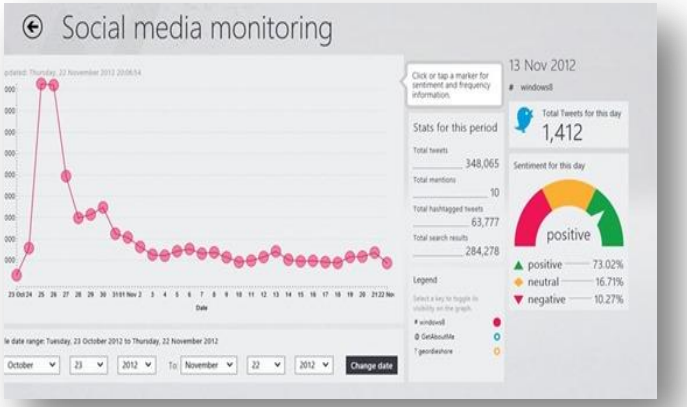
joe.tekli@lau.edu.lb

Social Intelligence

Applications:

- Enhancing **social media** apps
  - With human like suggestions
- **Customers reviews** on products
- Information and **tutoring tools**
  - Digital instructors
- **Population mood analysis**
  - **Elections** and **voting** tendencies





Social Intelligence

Applications:

- **Social monitoring**
  - Car monitoring the emotions of its occupants
    - Health care and the case of aging populations
  - Personal emotion monitoring

Personal conditioning
Engaging autism
Customer service

- **Human-Computer interaction**
  - Human like robotics
    - Health care and the case of aging populations

Next Frontier?

Next Frontier?

Three scenarios:

- **Social monitoring** and **conditioning** of human astronauts
  - Burdon of sustaining human life in space
- Transporting human embryos and hatching them on arrival
  - **Robot nannies**
- **Transporting sentient robots**
  - Created in the image of humans…

Social Intelligence

joe.tekli@lau.edu.lb