Social things

Now we can

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Why now?

- Because Internet of Things connects things almost everywhere to constitute a network
- Because we trust on Social Network
- Because we are used to dialoguing with Internet
- Because things become more and more complex
- Because we expect optimal performances by things in a continuous updating process
What they aren’t

- Things shared by people (the socialism of things)
- Things connected to Internet to form an autonomous social network (SIoT)
- Things governed by owners community’s consensus (the I-like tyranny)
What they are

- Things
  - directly conducted by a social network of facts
  - thanks to a continuous optimization process
  - based on the learning of the users' needs and preferences
To be concrete:

**social household appliances**

You ask a task for your appliance

**The network executes it through proper recipes**
A social network of facts that physically manages all appliances parameters on my name

A four layers approach to implement an overall ecosystem

Transactions

Logic Layer
- Transport Layer
  - TCP
  - SSL/TLS
- Application Layer
  - MQTT
  - DATA

Physic Layer
- Eahouker

Eahouker

INSTRUCTIONS

TASK

RECIPE

FEEDBACKS

Wash, cook exactly as you want with the help of others

The remainder is in the cloud

Check the operations

Decide the parameters

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Future Internet Research and Experimentation – FIRE
SandS – Social & Smart
http://www.sands-project.eu

PROJECT DATA
Start Date: 01 November 2012, Duration: 30M
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CONSORTIUM
- Unimi, ITALY
- Amis, SLOVENIA
- Arduino, SWITZERLAND
- Ntua, GREECE
- Cartif, SPAIN
- Gorenje, SLOVENIA
- Libelium, SPAIN
- Upv, SPAIN

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Lead philosophy

- I don’t know how optimally operate my appliances, hence I ask the network.
- The network learns to optimally satisfy the user request on the basis of the informative triplet <task|recipe|evaluation>
- The social feature of the network stands in the members’ contribution in terms of profiles (of them and their appliances) and log of the above triplets.
A peculiar cognitive problem

- Recipes are sequences of parameter/value pairs.
- Tasks and evaluations are sets of both crisp and fuzzy variables.

**but**

- Fuzzy quantifiers do not refer to a specific metric space
The scientific challenge

- Consider Horn clauses such as
  - If less crusty and soggy then increase rising time
  - If very crusty and crisp then decrease rising time

- Involving:
  - Crisp variables: rising time
  - Fuzzy variables: crustiness, humidity
  - With fuzzy quantifiers: less, normal, very
Fuzzy Inference System

- The generic fuzzy rule system

\[
\text{if } x_1 \text{ is } A_{11} \text{ and } x_2 \text{ is } A_{12} \text{ and } \ldots \text{ and } x_n \text{ is } A_{1n} \text{ then } y \text{ is } B_1,
\]
\[
\text{if } x_1 \text{ is } A_{21} \text{ and } x_2 \text{ is } A_{22} \text{ and } \ldots \text{ and } x_n \text{ is } A_{2n} \text{ then } y \text{ is } B_2,
\]
\[
\vdots \quad \vdots \quad \vdots
\]
\[
\text{if } x_1 \text{ is } A_{k1} \text{ and } x_2 \text{ is } A_{k2} \text{ and } \ldots \text{ and } x_n \text{ is } A_{kn} \text{ then } y \text{ is } B_k,
\]

- The Sugeno variant

![Diagram of Sugeno variant](image)
With the further complication

Hence we must infer \( x \) as well

\[
\begin{align*}
\text{Input } x &= (x_1, x_2) \\
\text{Fuzzy set } A, B \\
\text{Weight } w_{ij} \\
\text{Normalized weight } \overline{w}_{ij} \\
\text{Sugeno functions } f_i \\
\text{Output } f \\
\end{align*}
\]

\[
f = \overline{w}_1 f_1(x, \alpha) + \overline{w}_2 f_2(x, \alpha)
\]
With the further complication

Rather we must infer from the evaluation $g$ induced by $f$

Output $f$: rising time setting

Evaluation $g$: evaluation proposed on crustiness and humidity

It tastes somewhat custy for my teeth

$$f = \overline{w_1} f_1(x, \alpha) + \overline{w_2} f_2(x, \alpha)$$
1. A mixture of identification and control

Let’s recall **distal learning** by Rumelart and Jordan

Learn to compute the \( u \)

once you have learnt the PLANT *model* for whatever \( u \)
Computational issues

Active variables

- **Output** $f$: rising time $\rightarrow$ positive continuous
- **Evaluation** $g$: judgement $\rightarrow$ likert scale
- **Parameters** $\theta$:
  - of a membership function
    - Vertex of triangular mf
    - Mean and std of asymmetric Gaussian mf
    - ...
  - of the Sugeno function
    - usually linear in the function
  - the input position within the membership function as well
    - to identify input coordinates
- **Error** $E$: e.g. $g^2$
2. Computational issues

Simply a richer derivative chain

Identification phase

\[ E = (y - f)^2 \]
\[ \frac{\partial E}{\partial f} = 2(y - f) \]
\[ \frac{\partial f}{\partial \theta} = \text{canonical learning update rule} \]

Control phase

\[ E = g^2 \]
\[ \frac{\partial E}{\partial g} = g \]
\[ \frac{\partial g}{\partial f} \approx \frac{g(t + 1) - g(t)}{f(t + 1) - f(f)} \]
\[ \frac{\partial f}{\partial \theta} = \text{canonical learning update rule} \]

Legend

- **Output** \( f \): rising time
- **Evaluation** \( g \): judgement
- **Parameters** \( \theta \)
- **Error** \( E \): e.g. \( g^2 / (y - f)^2 \)
Two kinds of retropropagated signals

1. Task-related signals
   a. User judgment
      - On-line
   b. Target appliance parameter
      - off-line mode

2. Empirical evidence-related signals

The doble life of g_i:s: fuzzy sets as for antecedents, Likert metrics as for consequent
1. On-line learning

1. Prepare a new bread
2. Taste it
3. Evaluate the bread
4. On the basis of the evaluation, adjust the bread machine parameters through the neurofuzzy system

Neurofuzzy system

\[ f(t) \rightleftharpoons g(t) \rightleftharpoons f(t+1) \rightleftharpoons g(t+1) \]
Early numerical results: case study

Membership function and coordinates inference

True mf (green triangles) vs. inferred mf (green triangles)

The coordinates tracks

Error computed on arbitrary target with non-linear Sugeno functions

Error course

Input trajectory (green arrow) and true input (red points)
Early experiments
a close case

Main features:
- 10 parameters to beautify the face
- 4 evaluation criteria (from -5 to +5)
- No analytical nor monotone relations between parameters

http://37.187.78.130/facedeform/
The identification phase

Relating the four judgements to two parameters
Training and generalization problems

- No training from judgements if no on-line learning
- No on-line learning if the training algorithm is not efficient.
The overall procedure in three steps

- Mining
- Fuzzy System Inference
- Reinforcement learning
Thank you for your attention

Say bye bye Bruno