Perspectives in home TeleHealthCare system: 
Daily routine nycthemeral rhythm monitoring from location data

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Aging: a worldwide phenomenon

The HIS project

Human clock

Activities of Daily Living (ADL) monitoring

Perspectives
Outline

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Evolution of the age distribution throughout the World

Source: http://esa.un.org/unpp
Aging: a worldwide phenomenon

Evolution of the aged dependency ratio

\[ \Rightarrow \text{Aged dependency ratio} = \frac{\text{number of people aged 65 and over}}{\text{number of people aged 15–64}} \times 100 \]

Source: http://esa.un.org/unpp
Alzheimer’s and dementia-related diseases (1)

An everyday challenge

- A new case every 7 seconds
- Main cause of entrance in institution
- No automatic and noninvasive mean of detection
- No curative treatment
- Lack of care providers
Alzheimer’s and dementia-related diseases (2)

In daily life

- Memory loss
- Difficulty performing activities of daily living
- Repetition in task
- Disorientation of time and place

**Figure:** “Recognize the onsets of the Alzheimer disease” (in the middle)
“Don’t forget the Alzheimer's disease” (on the bottom)
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Conclusion

Le projet HIS

L’appartement intelligent

What do we aim at?

• Monitoring the inhabitant’s activities
• Developing his/her individual activity profile
• Triggering alarms
• Developing gerontechnologies to support aging-in-place
• Lightening the carer’s burden

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Living by the clock

Rhythms of life

• **Physiological** variables:
  Temperature, heart rate, muscular strength, blood sugar level...

• **Behavioral** variables:
  Alertness, Activities of daily living (ADL)...

⇒ ADL follows a *nycthemeral* rhythm (*i.e.* a 24-hour cycle).

Synchronizers

• **Environmental** cues:
  light/darkness cycle, seasons...

• Clocks of the **society**:
  work, transport...
The SupraChiasmatic Nucleus:
the master clock

Output Rhythms:
- Physiology
- Behavior

Suprachiasmatic Nucleus

Light
ADL Monitoring

Elementary activities considered

- A : Ambulatory Activity
- G : Generic Social or Cultural Activity
- C : Cooking & Eating
- U : Unassigned to a Specific Activity

The Hamming distance $d_H$

$\Rightarrow$ Comparison of day-to-day or day-to-profile sequences of ADL

$$d_H(x, y) = \min_{k=1, \ldots, 24} \text{Card} \left\{ i \in \{1, \ldots, 24\} \mid x_i \neq \sigma^k(y)_i \right\}$$

where $\sigma$ is the circular permutation of the 1st component of $y$
Detecting a shift
by comparison with the circular Gumbel distribution

\[ M = 24 - d_H(x, y) = \text{number of matches between } x, y \]

Hypothesis: \( M \) follows the circular Gumbel distribution.
\[ \Rightarrow E(M) \text{ is approximately Gaussian.} \]

**Figure:** Empirical distribution of the average number of matches \( E(M) \) calculated between 500 activities sequences and 30,000 random sequences.
Towards a new tool for Home Health Telecare

Aims

- Providing a detection tool of pathological behavior
- Building a complete aware system for telemonitoring

**Figure:** Plain lines: already available. Dashed lines: coming soon.
Final thoughts

Gerontechnologies at home, what we have at stake:

- Using them to support aging healthy and secure in place and improve the elderly quality of life
- Making them a lifestyle choice rather than a life stage need
References


Contact: Celine.Franco@imag.fr
Evolution of the age distribution in the more developed countries

Source: http://esa.un.org/unpp
Rhythms of life

Dealing with a multisensor network

Censored data and the estimation of joint probabilities

\[ d_{\text{Inc}}(\{A_i\}_{i=1,\ldots,n}) = \frac{\sum_{i<j}[P(A_i) + P(A_j) - 2P(A_i \cap A_j)]}{\sum_{i<j}[P(A_i) + P(A_j)]} \]

\[ d_{\text{Exc}}(\{A_i\}_{i=1,\ldots,n}) = \frac{\sum_{i<j} P(A_i \cap A_j)}{\sum_{i<j} \min[P(A_i), P(A_j)]} \]

\[ d_{\text{Ind}}(\{A_i\}_{i=1,\ldots,n}) = \frac{\sum_{i<j} |P(A_i \cap A_j) - P(A_i)P(A_j)|}{\sum_{i<j} \max[\max_{i<j}|P(A_i \cap A_j) - P(A_i)P(A_j)|]} \]

\[ P_* = a_1 P_{\text{Lan}} + a_2 P_{\text{Ent}} + a_3 P_{\text{Ind}}, \]

where we have chosen \( \sum_{i=1}^{3} a_i = 1 \) and

\[ a_1 = 1/2 - d_{\text{Ind}}/2(d_{\text{Exc}} + d_{\text{Ind}} + d_{\text{Ind}}), \]

\[ a_2 = 1/2 - d_{\text{Exc}}/2(d_{\text{Exc}} + d_{\text{Ind}} + d_{\text{Ind}}), \]

\[ a_3 = 1/2 - d_{\text{Ind}}/2(d_{\text{Exc}} + d_{\text{Ind}} + d_{\text{Ind}}). \]