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

C. Franco, J. Demongeot, Y. Fouquet, C. Villemazet, N. Vuillerme

TIMC-IMAG Laboratory,*AFIRM* and *AGIM*^{3} Teams
UMR UJF-CNRS 5525, Grenoble, France

18th February 2010

Outline

- Aging : a worldwide phenomenon
- The HIS project
- Human clock
- Activities of Daily Living (ADL) monitoring
- Perspectives

Outline

- Aging : a worldwide phenomenon
- The HIS project
- Human clock
- Activities of Daily Living (ADL) monitoring
- Perspectives

Outline

- Aging : a worldwide phenomenon
- The HIS project
- Human clock
- Activities of Daily Living (ADL) monitoring
- Perspectives

Outline

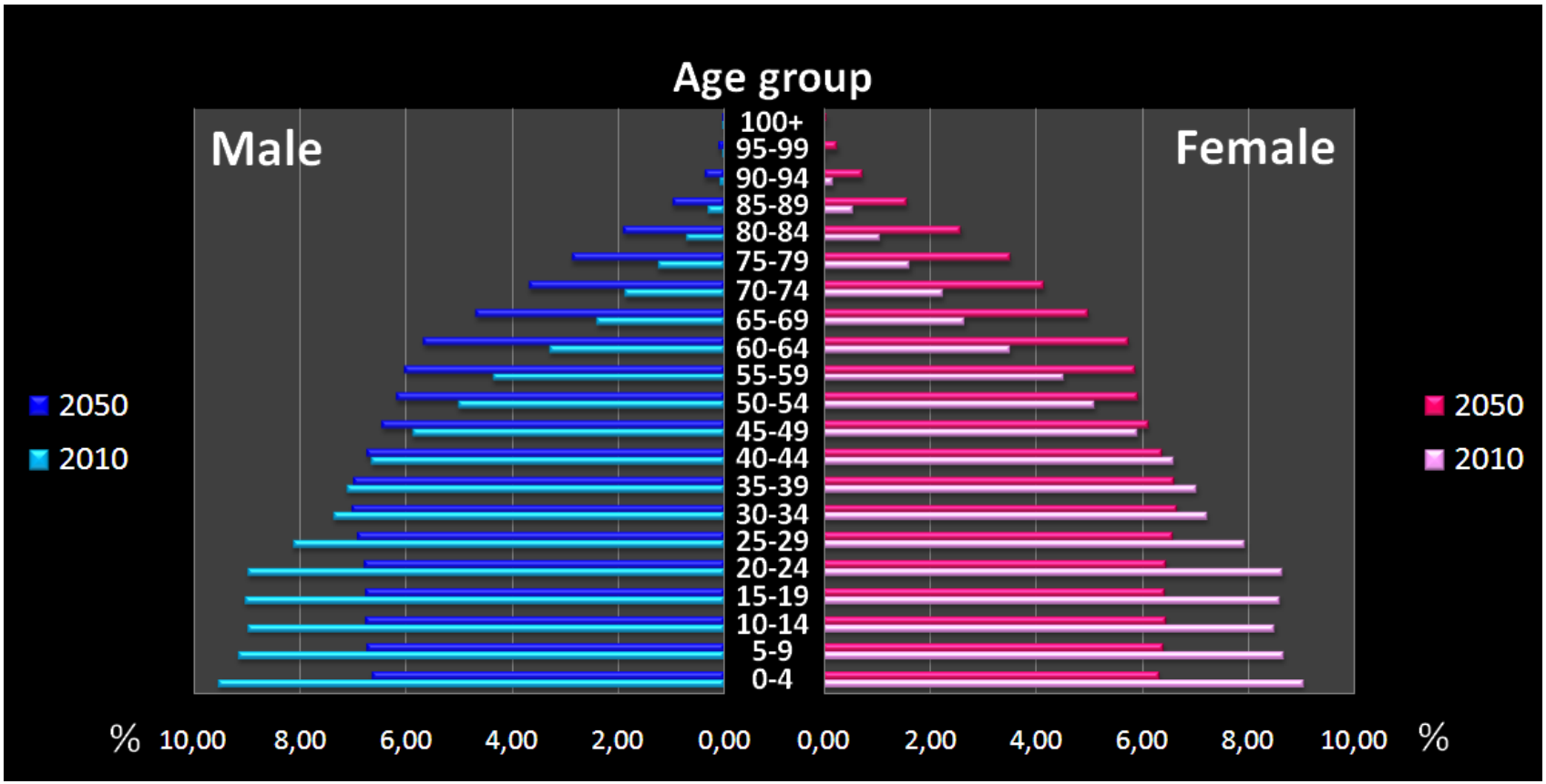
- Aging : a worldwide phenomenon
- The HIS project
- Human clock
- Activities of Daily Living (ADL) monitoring
- Perspectives

Outline

- Aging : a worldwide phenomenon
- The HIS project
- Human clock
- Activities of Daily Living (ADL) monitoring
- Perspectives

Evolution of the age distribution

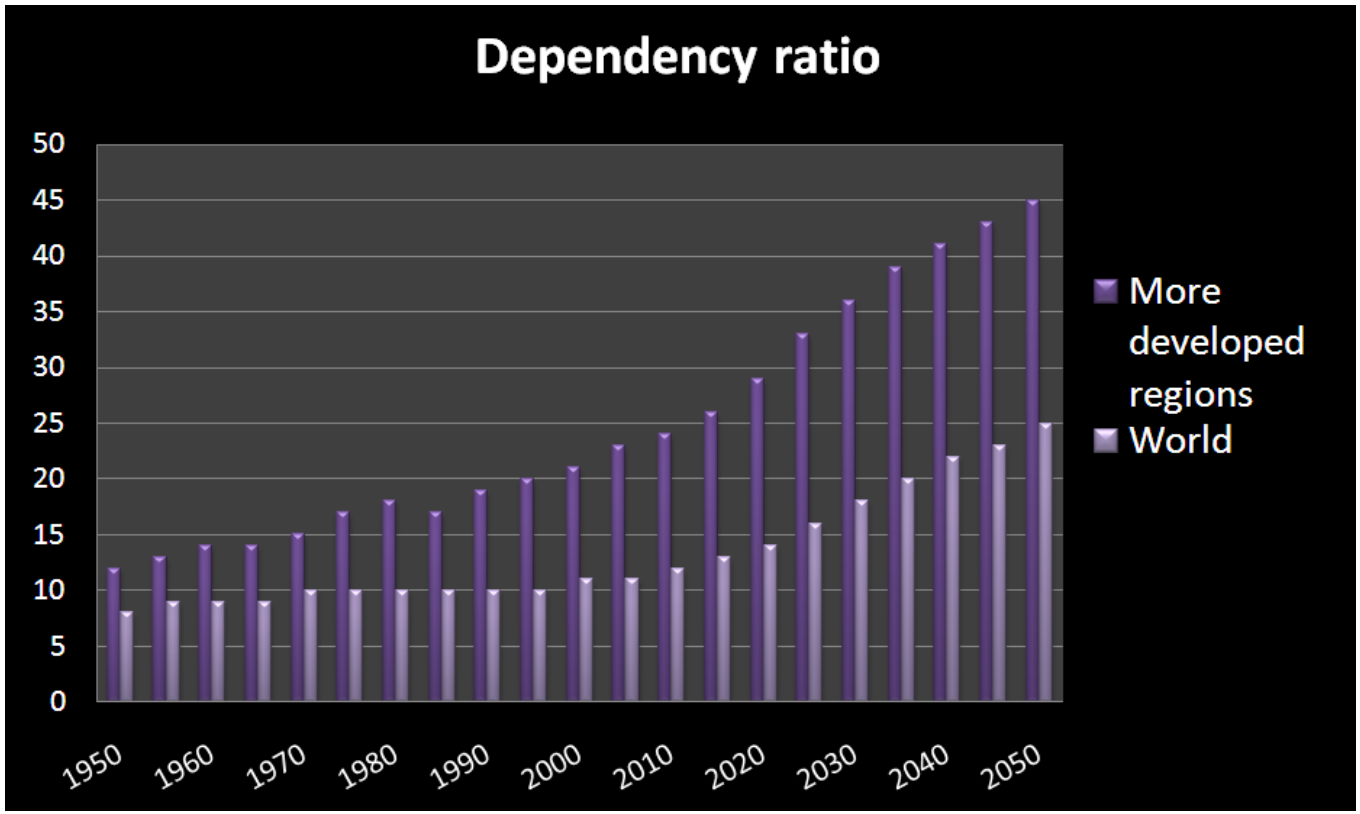
throughout the World



Source : http ://esa.un.org/unpp

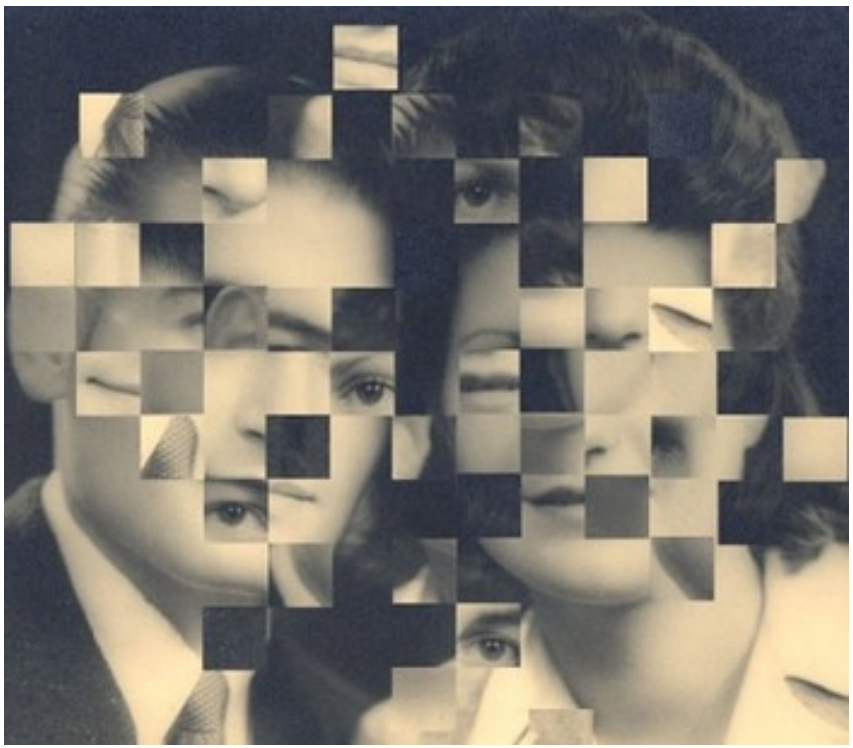
Evolution of the aged dependency ratio

$$\Rightarrow \textit{Aged dependency ratio} = \frac{\textit{number of people aged 65 and over}}{\textit{number of people aged } 15-64} \times 100$$



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)

Le projet HIS

L'appartement intelligent

FIGURE: Des capteurs infrarouges disséminés dans chaque pièce donnent la localisation : 0.Hall d'antrée, 1.Salon, 2.Chambre, 3.WC, 4.Cuisine, 5.Douche, 6.Lavabo.

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

Le projet HIS

L'appartement intelligent

FIGURE: Des capteurs infrarouges disséminés dans chaque pièce donnent la localisation : 0.Hall d'antrée, 1.Salon, 2.Chambre, 3.WC, 4.Cuisine, 5.Douche, 6.Lavabo.

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

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)...

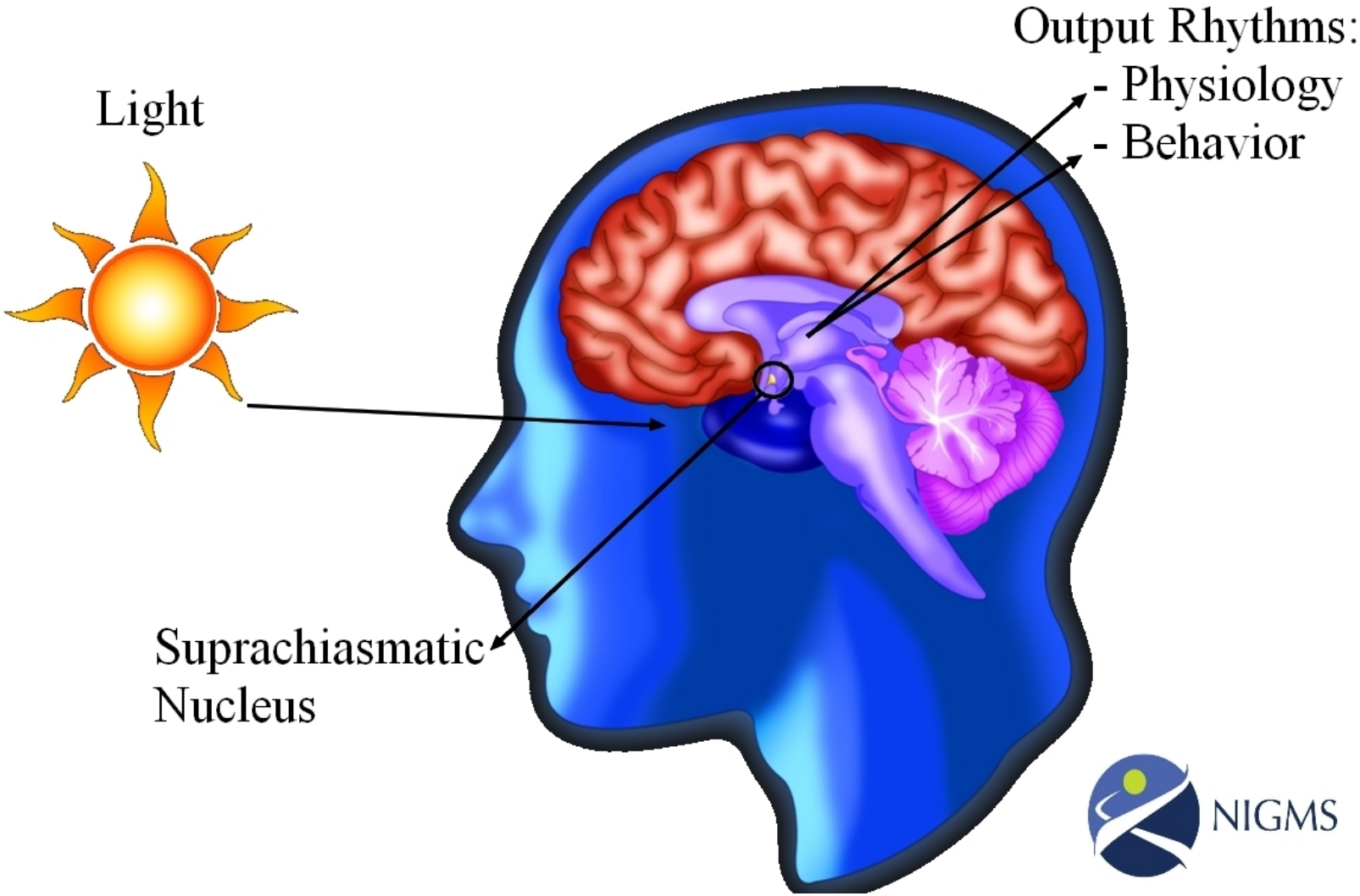
Synchonizors

- Environmental cues : light/darkness cycle, seasons...
- Clocks of the society : work, transport...

$\Rightarrow$ ADL follows a nycthemeral rhythm (*i.e.* a 24-hour cycle).

The SupraChiasmatic Nucleus :

the master clock



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

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

where σ is the circular permutation of the 1^{st} component of y

Detecting a shift

by comparison with the circular Gumbel distribution

$M = 24 - d_H(x, y) =$ *number of matches between* $x,\ y$

Hypothesis : M follows the circular Gumbel distribution.

$\Rightarrow$ E(M) is approximately Gaussian.

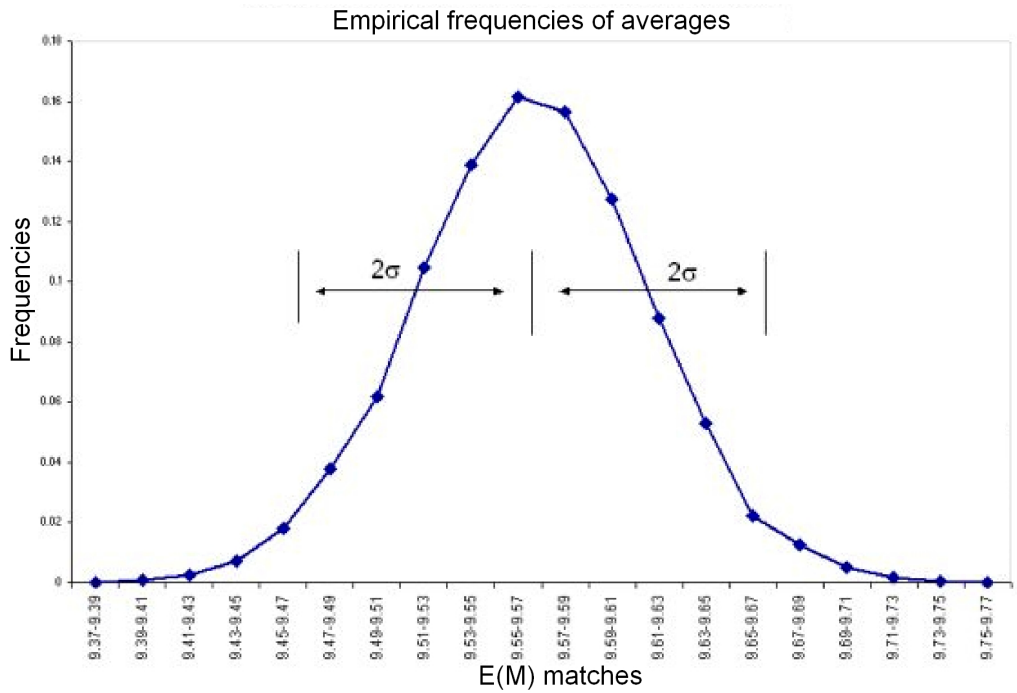


FIGURE: Empirical distribution of the average number of matches E(M) calculated between 500 activities sequences and 30,000 random sequences.

Towards a new tool for HomeHealthTelecare

Aims

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

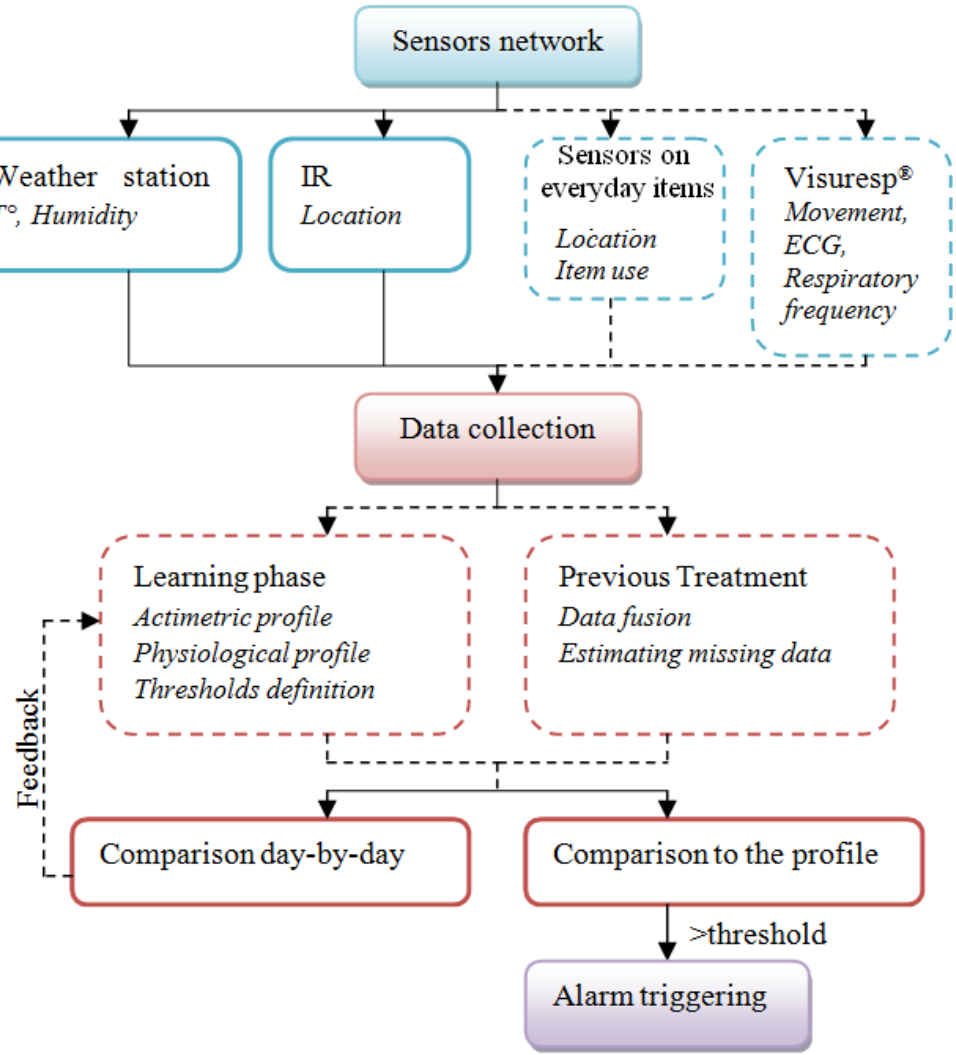


FIGURE: Plain lines : already available
Dashed lines : coming soon

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

[1] **J. Demongeot, N. Noury, and N. Vuillerme.**
Data fusion for analysis of persistence in pervasive actimetry of elderly people at home, and the notion of biological age.
In *Complex, Intelligent and Software Intensive Systems, 2008. CISIS 2008. International Conference on*, pages 589–594, 4–7 March 2008.

[2] **J. Demongeot, G. Virone, F. Duchêne, G. Benchetrit, T.Hervé, N. Noury, and V. Rialle.**
Multi-sensors acquisition, data fusion, knowledge mining and alarm triggering in health smart homes for elderly people.
Comptes Rendus Biologies, 325(6) :673 – 682, June 2002.

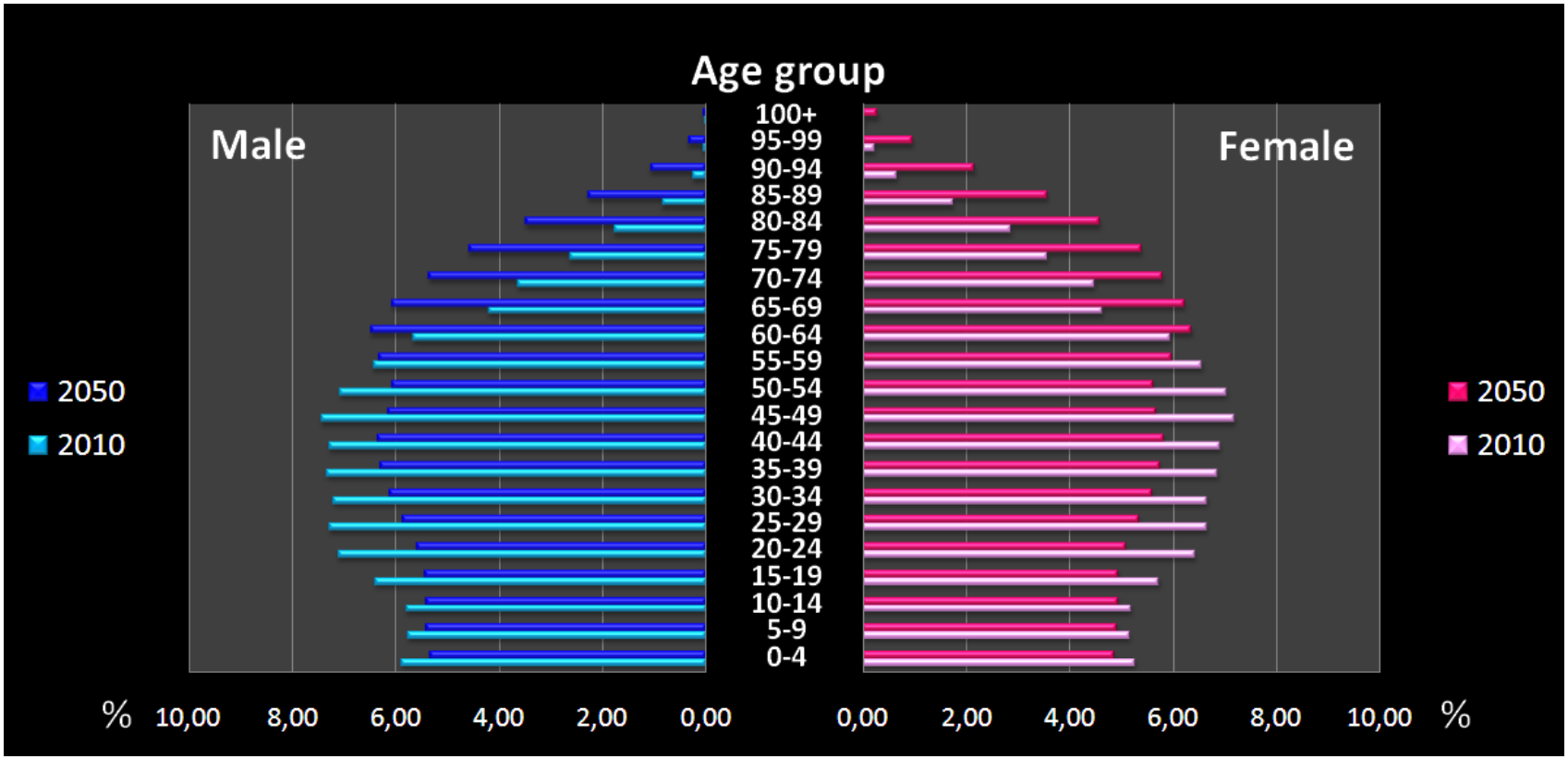
[3] **Y. Fouquet, J. Demongeot, and N. Vuillerme.**
Pervasive informatics and persistent actimetric information in health smart homes : From language model to location model.
In *Complex, Intelligent and Software Intensive Systems, 2009. CISIS '09. International Conference on*, pages 935–942, 16–19 March 2009.

[4] **M. A. Hofman and D. F. Swaab.**
Living by the clock : the circadian pacemaker in older people.
Ageing Res Rev, 5(1) :33–51, Feb 2006.

Contact : Celine.Franco@imag.fr

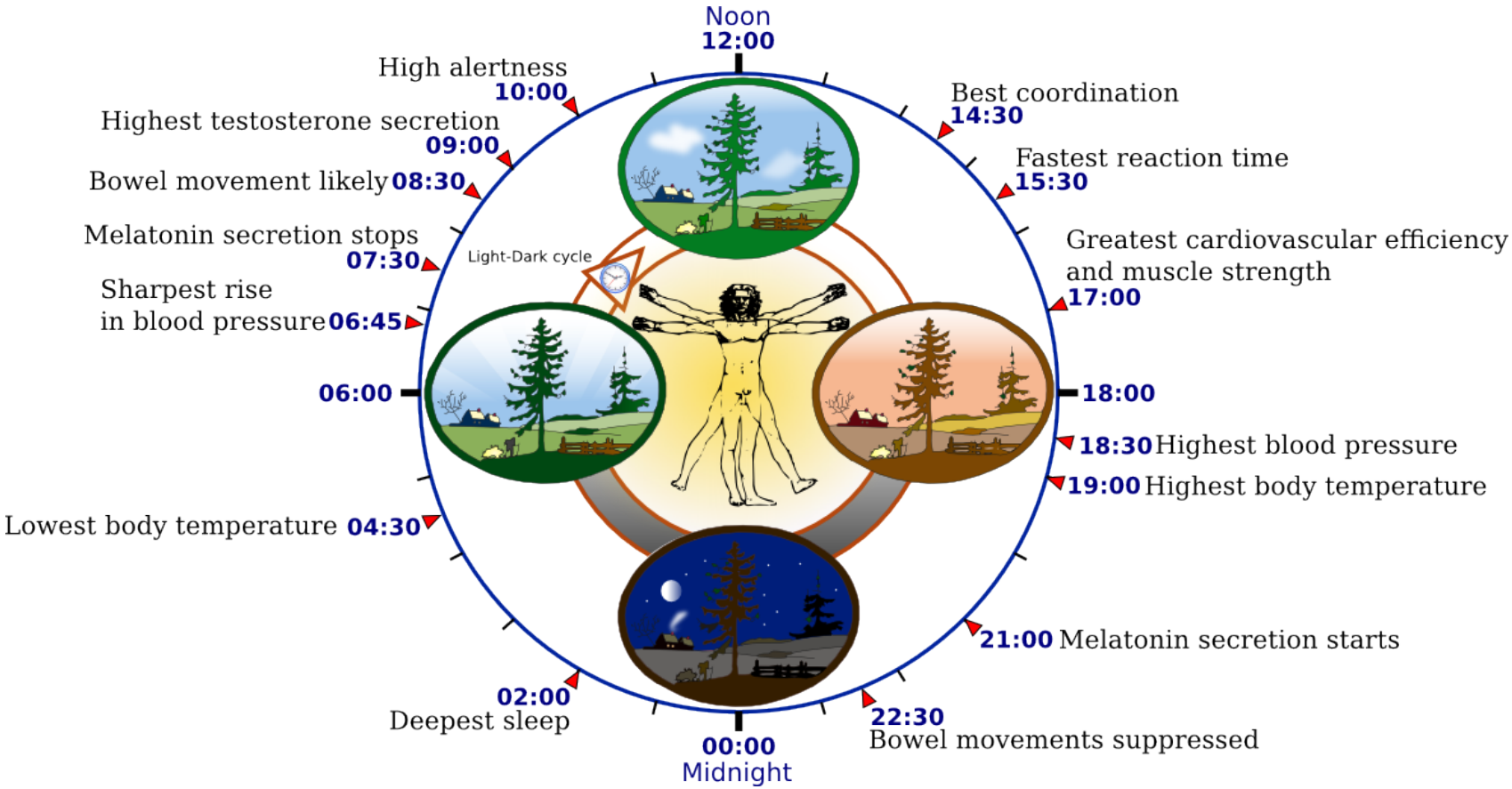
Evolution of the age distribution

in the more developed countries



Source : http ://esa.un.org/unpp

Rhythms of life



Source : Y. Mrabet & "The Body Clock Guide to Better Health" by M. Smolensky & L. Lamberg ; Henry Holt and Company, Publishers (2000)

Dealing with a multisensor network

Censored data and the estimation of joint probabilities

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

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

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

$$P_* = a_1 P_{\mathrm{Lan}} + a_2 P_{\mathrm{Ent}} + a_3 P_{\mathrm{Ind}},$$

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

$$a_1 = 1/2 - \mathrm{d}_{\mathrm{Ind}}/2(\mathrm{d}_{\mathrm{Exc}} + \mathrm{d}_{\mathrm{Ind}} + \mathrm{d}_{\mathrm{Ind}}),$$
$$a_2 = 1/2 - \mathrm{d}_{\mathrm{Exc}}/2(\mathrm{d}_{\mathrm{Exc}} + \mathrm{d}_{\mathrm{Ind}} + \mathrm{d}_{\mathrm{Ind}}),$$
$$a_3 = 1/2 - \mathrm{d}_{\mathrm{Ind}}/2(\mathrm{d}_{\mathrm{Exc}} + \mathrm{d}_{\mathrm{Ind}} + \mathrm{d}_{\mathrm{Ind}}).$$