Data Analyzing with Gaussian Mixture Models and Split-Merge Algorithm for AAL

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Project ATTEND

Abstract:

Within the scope of the project ATTEND a system will be developed that increases the time frame of independent living of elderly persons in their used living environment. The system comprises an intelligent, adaptive network of sensors, which are to be installed in the living environment of the user in order to thoroughly observe his behavior. An important aspect is that the sensors shall work independent and in a preferably invisible fashion.
ATTEND learns about normal behavior of the user. In case of unusual behavior an alarm plan can be worked out (e. g. enquiring the user, calling a neighbor, calling an external organization). The system is intended to increase comfort, security and social inclusion of the customer and ideally also help with the early detection of upcoming medical problems. In case of an emergency the system can contact primary and secondary users (family, neighbor, care giver) via external interfaces.

Features:

Intelligent, adaptive network of sensors; No camaras, No microphones, No sensors to be worn on the body; Nothing should be activated by the user; Observation of elderly persons' daily routine; Situation and scenario recognition; Sending alarm to caregiver in case of emergency; Protection of privacy; Increasing comfort and security

Contents:

Sensor Fusion; Situation and Scenario Recognition; Machine Learning; Combine the Rule and Learning System

Gaussian Mixture Model:

$$\varphi_{\mu,\sigma^2}(x) = \frac{1}{\sigma\sqrt{2\pi}} e^{-\frac{(x-\mu)^2}{2\sigma^2}}$$

$$x = \{x_1, x_2 \ldots\ldots x_n\}$$
$$\mu = \{\mu_1, \mu_1 \ldots\ldots \mu_n\}$$
$$\sigma = \{\sigma_1, \sigma_2 \ldots\ldots \sigma_n\}$$

Split-Merge Algorithm:

- $P_s(T_r) = P_s * \varphi_{\mu,\sigma^2}(T_r)$; $P_s(T_r) = P_s(T_r) / \sum P_s(T_r)$ (1)

  P is the percent value of each time point component. The index s is the component index within the mixture model. Each new time point is T_r ($r \geq 1$).

- $\mu_s = (1-P_s(T_r))*\mu_s + P_s(T_r)*(C'*\mu_s + T_r)/(C'+1)$ (2)

  C is the maximum number of time points for adjusting the learning rate and current angle count is C'.

- $\sigma_s = ((1-P_s(T_r))*\sigma_s + P_s(T_r)*(C'*\sigma_s + |\mu_s - T_r|)/(C'+1)$ (3)

- $P_s = (C' * P_s + P_s(T_r)) / (C' + 1)$ (4)

- If $C' \geq C$, $C' = C$ (5)

  After some initial iteration, start checking if it is necessary to split components: If $\sigma_s > \sigma_{threshod}$, then create new component (index S) from old component (index s)

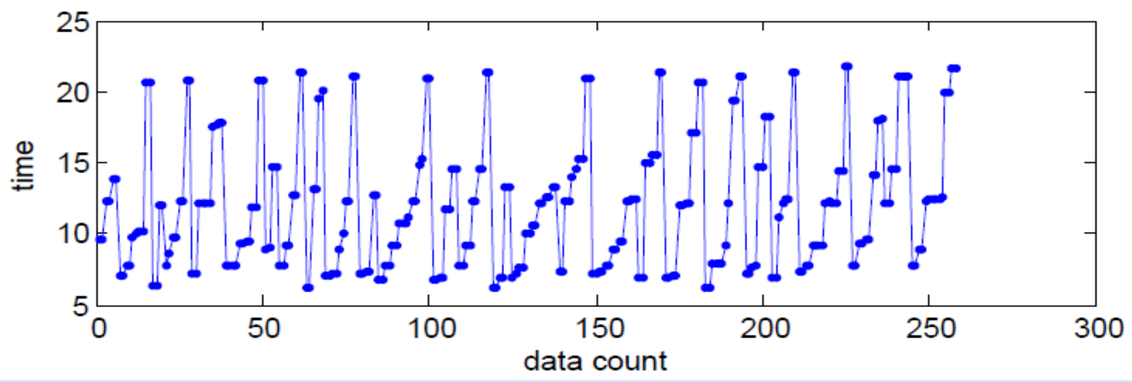
- $\mu_S = \mu_s + \sigma_s / 2$; $\mu_s = \mu_s - \sigma_s / 2$ (6)
- $\sigma_S = \sigma_s = \sigma_s / 2$ (7)
- $P_S = P_s = P_s / 2$ (8)

  If ($|\mu_{s'} - \mu_{s''}| < \mu_{threshold}$ and $|\sigma_{s'} - \sigma_{s''}| < \sigma_{threshold2}$) then merge component s'' into s' and delete component s''. Here $\sigma_{threshold2} <= \sigma_{threshod}$

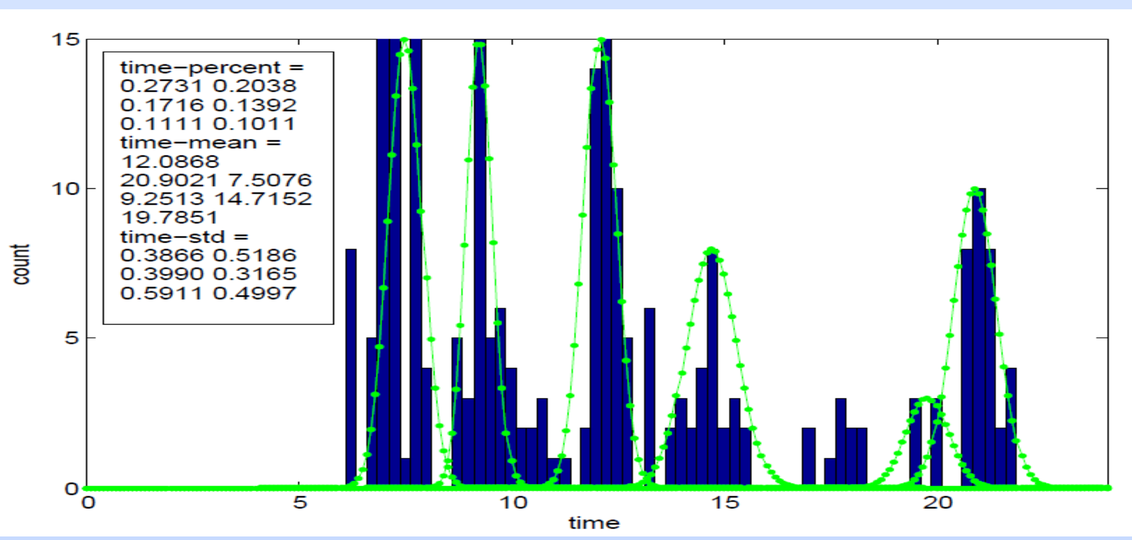
- $\mu_{s'} = (\mu_{s'} * P_{s'} + \mu_{s''} * P_{s''}) / (P_{s'} + P_{s''})$ (9)
- $\sigma_{s'} = \max(\sigma_{s'}, \sigma_{s''})$ (10)
- $P_{s'} = P_{s'} + P_{s''}$ (11)
- $P(s) = P(s) / \sum P(s)$ (12)

- Repeat with all new values.

Result and Conclusion:



X axis of Figure is count of the data in one months, there are about 258 count in the data set. Y axis of Fig. 1 is the time points of each data. The interval is from 0 to 24.



X axis of Figure is the time axis from 0 to 24 hours in one day, the Y axis is the count of how many time points gathered in each time interval. From the Figure we can see that there are mainly 6 time points that the user takes tablets: in the morning about 7.5, 9.25, at noon 12.09, 14.72, and at evening 19.79, 20.9. The probability that at these time points the user takes tablets are 20.38%, 17.16%, 27.31%, 13.92%, 11.11%, and 17.16%. The data gathered from one month, the standard deviations for each time points: 0.4, 0.32, 0.39, 0.59, 0.5 and 0.52.
Gaussian Mixture Model and the split-merge algorithm is a powerful tool for unsupervised learning .The stable life style of the user is the basic of a useful learning result.

Project Implementation:

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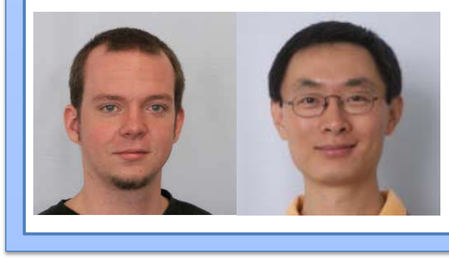

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