PhD Thesis Proposal

Title:

Fuzzy detection of events in a BAN using multi-parameter evaluation

Summary:

Healthcare is evolving to a patient centred paradigm. The extant architecture addressing health will not be able to cope with the increasing costs of providing for a growing population (in terms of raw number, people affected by diseases and senior citizens). A change to a more preventive system instead of a reacting one is warranted.

Body Area Networks [1] are in the middle of this change, as they provide the user-focused monitoring and actuating that can lead to a system that detects anomalies sooner, with the possibility even of preventing such anomalies. These networks comprise sensors that collect information (physiological or other body related, ex.: location) and actuators that give actuate on the body (administering drugs, changing sound track, etc.). The communication network between these devices and a usual central node forms the BAN.

A BAN's advantage is its heterogeneous monitoring capabilities that when correlated can provide a very rich set of information. For this it needs a centralized view of the available resources so that all the applications using the BAN can share them and the possible correlation from the different information sources. This last point is the crux of this proposal.

There are several physiologic formulas that enable deriving new information. An example of correlation of different sensing information is determining Cardiac Output (CO) from Heart Rate (HR) and Stroke Volume (SV). As described by Sun et al. [2] it is expressed by $CO = SV \times HR$. There are other examples, including insulin sensitivity (see Keener and Sneyd [4]) from blood glucose, blood insulin and glucose intake. These are direct applications of formulae, where a middleware for BANs could derive new information from existing one. From the example we could derive CO from an electro cardiac reader for SV and a HR reader. These formulae based models could be part of a middleware that provides applications with an abstraction that provides information, either assessing sensors directly or correlating existing ones [3].

But one should define models beyond formulae. There are scenarios where even with the current parameters it is not possible to ascertain an outcome. This goes beyond the information as a quantitative value (Blood Pressure (BP) = 113/77 mmHg) to a more qualitative reasoning ("user is having an arrhythmia with 97% probability"). In this respect modules that handle fuzzy knowledge or qualitative reasoning are of interest. As an example, Otero et al. [5] use a model that relates several physiological variables over time to provide more accurate alarms in ICU. The model is defined by a network of fuzzy constraints between a set of points that describe the temporal evolution of the measured variables. Another noteworthy aspect of the work is that they provide a tool for clinicians to define the network and the variables to watch. Qualitative reasoning as described by Forbus [6] allows defining the relationships in qualitative terms and qualitative thresholds that a system can then interpret to infer some meaning.

Sugeno and Yasukawa [7] propose the combination of both fields to provide fuzzy logic based qualitative models.

Objectives:

The objective of this thesis is to research how to derive recommendations and/or detections based on uncertainty and incomplete information in physiological human models. It will involve researching in medical bibliography for defining basic requirements for the models. A model for a specific condition based on the overall architecture should be defined to serve as a demonstration of the results.

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Bibliography

[1] Benoît Latré, Bart Braem, Ingrid Moerman, Chris Blondia, and Piet Demeester. “A survey on wireless body area networks.” Wireless Networks, 17:1–18, 2011. ISSN 1022-0038.

[2] J.X. Sun, A.T. Reisner, M. Saeed, and R.G. Mark. “Estimating cardiac output from arterial blood pressure waveforms: a critical evaluation using the MIMIC II database”. In Computers, in Cardiology, 2005, pages 295 –298, September 2005. doi:10.1109/CIC.2005.1588095

[3] Pedro Brandão; "Modelling correlations for Body Sensor Network information", Proc International Conf. on Body Area Networks - BodyNets, Oslo, Norway, Vol. , pp. 1 - 1, September, 2012.

[4] James Keener and James Sneyd. Mathematical physiology II: Systems physiology, volume 8/2 of Interdisciplinary Applied Mathematics. Springer Verlag, 2nd edition, 2009. ISBN 978-0-387-79387-0.

[5] Abraham Otero, Paulo Félix, Senén Barro, and Francisco Palacios. “Addressing the flaws of current critical alarms: a fuzzy constraint satisfaction approach. Artificial Intelligence in Medicine, 47(3):219 – 238, 2009. ISSN 0933-3657. doi: 10.1016/j.artmed.2009.08.002.

[6] K.D. Forbus. Qualitative reasoning. In Allen B . Tucker, editor, Intelligent Systems, Computer Science Handbook, chapter VII. Chapman and Hall/CRC, 2nd edition, June 2004. doi:10.1201/9780203494455.sec7.

[7] M. Sugeno and T. Yasukawa. A fuzzy-logic-based approach to qualitative modelling. Fuzzy Systems, IEEE Transactions on, 1(1):7, Feb 1993. ISSN 1063-6706. doi:10.1109/TFUZZ.1993.390281.