

Towards the Definition of an Intelligent Triage and Continuous Monitoring System for Hospital Emergency Departments and Clinics

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Abstract

Recent statistics have demonstrated that Emergency Departments (EDs) in Greece lack in organization and service. In most cases, patient prioritization is not automatically implemented. The main objective of this paper is to present IntelTriage, a smart triage system, that dynamically assigns priorities to patients in an ED and monitors their vital signs and location during their stay in the clinic through wearable biosensors. Initial scenarios and functional requirements are presented as preliminary results.

Keywords:

Triage, Clinical Decision Making, Wearable Electronic Devices

Introduction

Screening and monitoring of patients in Greek hospitals' EDs and clinics is poorly organized and seriously understaffed. An exception is the AHEPA General Hospital, which uses a 5-level triage system, using the ESI (Emergency Severity Index) algorithm [1]. This system provides patient priority data through monitors which then appear to the corresponding doctor, however it does not provide an evaluation based on the patient's vital signs. This paper proposes the design of a system that i) implements dynamic prioritization of patients within EDs and ii) improves the 24-h monitoring efficacy of patients in a clinic. The novelty of this approach lies in the fact that real-time screening and continuous monitoring of ESI level 3 incidents, is automated via intelligent bio-monitoring sensors and customized machine learning algorithms. In addition, through an appropriate network infrastructure, it is possible to trace the patients routes. In this way, administrative coordination between individual hospital departments is strengthened as it will be possible to extract statistical data on patient flows within the hospital. Similar attempts have been recently documented in literature [2-3].

Methods

The proposed system, the overall concept of which is shown in Figure 1, combines collecting measurements from body sensor networks, transferring them to a central point and processing these measurements to draw conclusions about the

severity of the medical incident and the appropriate notifications for the medical staff. More specifically, IntelTriage consists of the following subsystems: i) Portable Subsystem of Biosensors and Tracking Devices, ii) Medical Decision Support, iii) Interoperability, iv) Networking and v) Security.

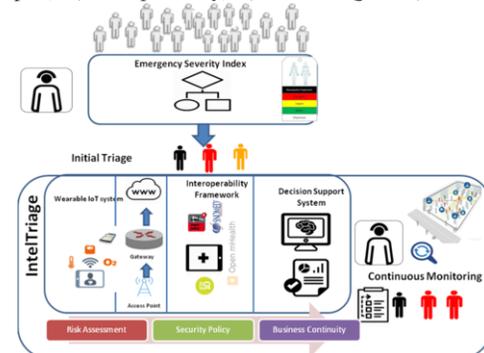


Figure 1—Conceptual diagram of IntelTriage solution

Portable Subsystem of Biosensors and Tracking Devices

The portable system consists of a Recording Platform with Body Sensors. This subsystem will gather information such as heart rate, breath rate, oxygen saturation, and transmit them to the central system database. In addition, the portable system will send beacons, which will be received from fixed 802.11 Access Points (APs).

Medical Decision Support Subsystem

Bio-parameters and Wi-Fi signals will be analyzed to assist the physician managing critical patients. The integration of machine learning algorithms and statistical models will provide dynamic monitoring of the progress of patients' health, using time series analysis and real-time changes detection, aiming at optimal triage of cases and reprioritization on the fly.

Interoperability Subsystem

While developing the monitoring, processing, and medical support subsystems, appropriate user interfaces (APIs) and RESTful Web Services will be developed to support the exchange of medical data. Based on international e-health standards, such as Health Level 7 (HL7), ICD-10 and SNOMED,

the conceptual interoperability of the end-to-end system will be ensured.

Networking Subsystem

The use of optic network in the wired section will be studied, with Bandwidth Dynamic Assignment and effective handling of the different motion priorities. The same priority system will be used for the wireless section as well. Parameters such as information priority, performance and energy consumption will be considered.

Security

Regarding data security, the key issues to address are: (a) Protection of confidentiality in the transmission, storage and processing of medical data; (b) Protecting the integrity of data (c) Availability of the data to authorized system users and (d) Detailed access control based on the need-to-know principle.

Results

Scenario

As an example of the operation of the system, the following scenario of use is provided. The patient GV enters the specially designed area of ED, where he is assigned to two nurses and one doctor. The patient has a symptom of acute appendicitis and, based on the ESI, he is categorized as Level 3 with a surgical need. The supervising physician decides to use the IntelTriage system to monitor the patient. The information received from the wearable system is available in the patient's medical records. As the patient goes through laboratory examinations, a significant increase in heart rate (> 120 / min) and respiratory rate (20% increase beyond normal) is observed. The Decision Support System then classifies the patient at Level 2, automatically alerting the medical staff about the issue and the location of the patient, in order to take appropriate actions.

Initial list of functional requirements

Based on the scenario provided by clinicians and a literature review, the initial list of functional requirements that IntelTriage shall meet are listed in Table 1.

Table 1– IntelTriage functional requirements initial list

| No | Requirement | Ref. |
|----|--|--------|
| 1 | Recording data from a biosensor device, incl. heart rate and oxygen saturation | [4] |
| 2 | Algorithmic breathing rate calculation | [5] |
| 3 | Local storage of data in the biosensor device | [6] |
| 4 | Wearable functionality in case it is out of WiFi range | [6] |
| 5 | Encoding data to be send | [7] |
| 6 | Data transmission taking into account energy consumption and data loss | [8] |
| 7 | Patient indoor location tracking | [6] |
| 8 | Automatic recognition of abnormalities in vital signs | [8] |
| 9 | Set a threshold for acceptable values of vital signs | [9] |
| 10 | Send notifications to the physician about the patient under monitoring | [9] |
| 11 | Visualization of indoor location patterns | [8][9] |

Discussion & Conclusions

This paper presents an initial attempt towards the definition of functional requirements of the main subcomponents of the IntelTriage system, a smart triage and hospital monitoring system. However, during the lifetime of the project several

new versions of functional requirements and implementation refinements will take place based on the active involvement of both clinicians and patients in small scale pilots either in the lab or the actual field of application, the ED and the clinics of the hospital. The system will be installed at the AHEPA ED and 1st Surgical Clinic premises, for a 6-10-month evaluation period. The following outcome measures are expected to be collected:

- Reaction times of nursing and medical staff when an event occurs
- Burn-out levels of nurses and doctors after a shift
- Changes in morbidity and mortality
- Level of patient satisfaction with the services provided

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