

NAOMI: iNformation Application fOr relatives of patients adMitted to the ICU

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Abstract. A hospitalization at the Intensive Care Unit (ICU) is a stressful event for both patients and family members. As such, they are often confused and worried about the condition of the patient. To support the verbal communication between the medical staff on the one hand and the ICU patients and their relatives on the other hand, this demo presents the NAOMI platform. NAOMI allows doctors to upload medical brochures, which are then automatically annotated with appropriate clinical terms. By monitoring the pathology, symptoms and treatment plan of the patients and matching them on these annotations, NAOMI will then provide the appropriate paragraphs from these brochures to patients and their relatives. As such, they always get personalized and appropriate information about the condition of the patient.

Keywords: Intensive Care Unit · Patient Information System · Semantic brochure annotation · SNOMED

1 Introduction

The Intensive Care Unit (ICU) of Ghent University Hospital is responsible for the treatment of patients with acute, life-threatening disorders. The patient is constantly monitored by a team of doctors and nurses. During the hospitalization, the patient's relatives experience a lot of stress. The medical staff of the Ghent University Hospital tries to comfort and support the family members by offering specific information about the patients situation. Currently, this is being performed verbally, supported by paper brochures. However, during this stressful period the family members tend to forget the given information. The given brochures, which are also available on-line, are created for broad categories of pathologies, to ensure usability for a large group of patients. Consequently, the brochures contain a plethora of information that is not applicable to the

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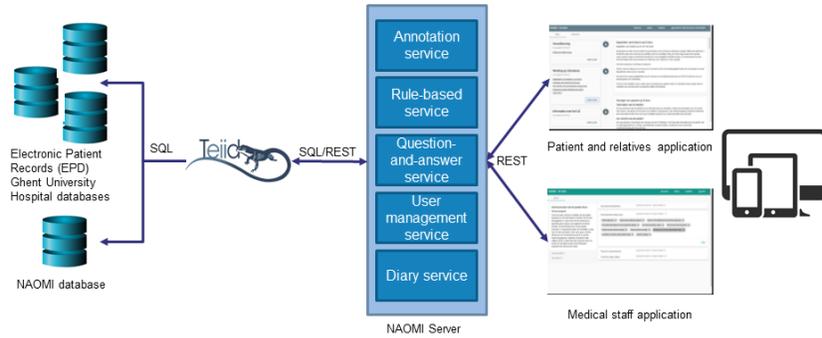


Fig. 1. Architecture of the NAOMI platform

particular patient’s condition. As such, the family members tend to be drowned in non-specific and detail information. To enrich their knowledge about the patient’s pathology, they then tend to search the Web for more information, e.g., using Symptom Checker³. This often leads to misconceptions and more worry because the found material is not personalized and contains too much information that does not apply to the specific situation or treatment of the patient.

To counter these issues, we have designed a patient information system, called NAOMI, to support communication between the medical staff and the patient’s relatives about the patient’s condition. NAOMI allows the medical staff to upload brochures. These are semi-automatically annotated according to pre-defined, fine-grained categories. When a patient is admitted to the ICU or his/her condition is updated in the electronic patient record (EPD) of the hospital, his/her pathology and/or symptoms are automatically mapped on these annotations. As such, only relevant sections of the brochures are provided as information to the relatives. In this way, NAOMI provides a source of information that is personalized to the patients current condition. Moreover, to support the verbal communication, NAOMI also contains a question-and-answer service, allowing the medical staff to inquire about the (medical) history and lifestyle of the patient, and a diary, enabling the patient and relatives to share text and pictures with each other.

2 NAOMI Architecture

The high-level architecture of NAOMI is shown in Figure 1. The various components are highlighted below.

Annotation service: The annotation service provides the functionality to semi-automatically annotate the various paragraphs of the uploaded brochures according to fine-grained categories. First the text is pre-processed by:

- identifying the different paragraphs,

³ <https://patient.info/symptom-checker>

- performing tokenization that splits up the paragraph in single tokens consisting of 1 or more words that have joint meaning, e.g., non invasive ventilation,
- normalizing the text to remove capitalization and superfluous characters, e.g., punctuation and numbers,
- performing lemmatization to transform each word to its stem,
- removing stop words, and
- translating the remaining words to English.

To identify the labels for the paragraphs, a medical ontology is used, namely the SNOMED CT (Systematized Nomenclature of Medicine - Clinical Terms) ontology⁴. It represents a collection of medical concepts in a hierarchy, where each one of them is described by fixed medical terms. The tokens that remain after the pre-processing are looked up in the SNOMED terms by using Stardog⁵ and SPARQL. The most frequent occurring medical terms from SNOMED are used to label the paragraph. The brochure and its labels are stored in the database in a tree-based manner. The root is the title of the brochure. Each child of this root represents either a paragraph or a subtitle. Paragraphs below a subtitle are added as children of this subtitle node. As such the structure of the document is reflected in the shape of the tree, i.e., the more subtitles, the deeper the tree. A parent node also receives the labels of its children and the most frequent ones are used to label this parent (i.e. title). As such, the root contains all the most important labels that categorize this brochure and all the relevant paragraphs and titles can easily be identified that are linked to a particular term.

Rule-based service: The rule-based service, implemented using the Easy Rules system⁶, is used to map the pathology, symptoms and treatment plans of the patient on the annotation categories. These rules are incepted and curated by the medical staff of Ghent University Hospital. This ensures that only the paragraphs of the brochures are selected and shown that are relevant for this particular patient's condition. An example of a Rule is: IF ICDS score > 4 AND ETT Tube present THEN linked categories are "invasive ventilation", "non-invasive ventilation", "sedation", "fixation", "tracheal cannula".

Information retrieval and storage: The platform connects to existing databases of Ghent University Hospital through the use of a data virtualisation system, namely jBoss Teiid⁷. From these database, the necessary information about the patient is retrieved, e.g., his/her pathology, symptoms and current treatment. A dedicated database for NAOMI was also set-up, which contains, for example, the uploaded brochures and its annotations, account information of the users (e.g. the relatives) and the questionnaires of the medical staff towards the relatives.

Web applications: Two web application were developed in Angular, one for the medical staff and one for the patient and his/her relatives.

⁴ <http://www.snomed.org/>

⁵ <https://www.stardog.com/>

⁶ <https://github.com/j-easy/easy-rules>

⁷ <https://docs.jboss.org/author/display/teiidexamples/What+is+Teiid>

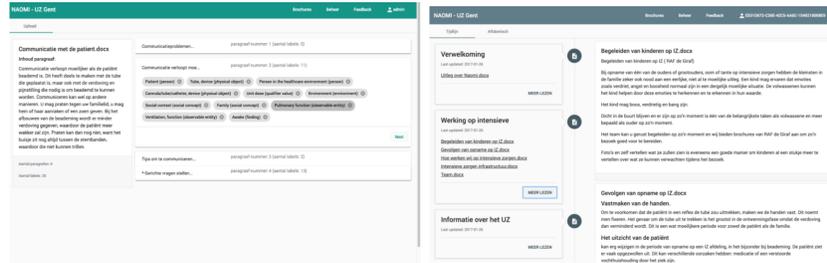


Fig. 2. The Web applications for a) the medical staff, and b) the patients & relatives

- *Medical staff application:* As shown in Figure 2a, this web application allows to upload and annotate brochures. When a new brochure is uploaded, the different paragraphs are automatically annotated with medical categories by the *Annotation service*. The paragraphs and their annotations are then shown to the medical staff, who can then decline wrong or unnecessary labels. When the staff member accepts the remaining annotations, the annotated brochure is stored in the NAOMI database. The application also allows to manage the *Question-and-answer service* of the patient and relatives web application, e.g., add new questionnaires. Finally, the medical staff can manage the different accounts of patients and relatives through the *User management service*, e.g., change access rights or link relatives to patients.
- *Patient and relatives application:* As visualized in Figure 2b, this application allows the family members to retrieve information about the condition of the patient in a comprehensible manner. This content is displayed both in a timeline and in alphabetical order. It also uses the *Question-and-answer service* to provide functionality in which the medical staff can ask questions to the relatives. This supports verbal communication about the lifestyle and (medical) history of the patient. A *Diary service* is foreseen allowing the patient and the relatives to write texts and upload pictures chronicling his/her stay at the ICU as well as events happening in the lives of the relatives. The patient has the added ability to control the access rights of the family members to his/her information through the *User management service*.

3 Demonstrator

The demo will allow the visitors to operate both designed web applications. First, they will log in as a medical staff member. They will be able to choose from a number of provided brochures to upload into the platform. Next, they will use the first web application to semi-automatically annotate this brochure. Second, they will log in as a family member of a given patient, who has a pathology linked to the brochure they just annotated. They will then see how the second web application automatically fetches the parts of the brochure that are relevant for this patient. The two videos at the following link give an idea of the functionality of both web applications: <https://www.youtube.com/playlist?list=PLFnSuWuVjOrFwVYp4o1d0bekLVYaq8n9J>.