Ill-structured medical data processing in mass casualty situations

Olga Popcova, Iulian Secrieru, Elena Guțuleac

Introduction

Ill-structured problems are those that everyone commonly faces in the everyday life. These include important social, political, economic and scientific problems.

Solving ill-structured problems usually requires the following activities:

a) problem definition, description and formalization;
b) generating possible solutions;
c) evaluation of alternative solutions, taking into account the end-user preferences;
d) implementation of the most viable solution;
e) monitoring the implementation.

Usually, solutions for ill-structured problems are rarely correct or incorrect, but they should fall within a range of acceptances. As a result, in order to be judged there are needed the stages of testing, implementation and evaluation based on the arguments. Therefore, ill-structured problems implies the need for analogical reasoning with concrete cases (precedents) and requires the justification of solutions by argument.

The medical diagnostics domain is well known as a domain with diverse and numerous ill-structured problems. Solving ill-structured problems in this domain seems to be more problematic, taking into consideration that currently information, data and knowledge specific to this domain are unstructured, fragmented and heterogeneous – which is an additional scientific challenge. This involves studying how to integrate different data sources by using the taxonomies/ontologies associated with these data sources in order to define standardized structures to ensure interoperability and consistency of stored data and knowledge.

Medical data processing in disaster response

First aid provided in mass casualty situations involves rapidly responding to emergencies, which can lead to the creation of ill-structured medical data. The chaotic and resource-constrained environment of a disaster site can make it challenging to maintain standardized medical records. Here are common issues related to ill-structured medical data in this context:

- Limited time and resources;
- Lack of access to standardized health records;
- Difficulties in consolidation of heterogeneous data;
- Limited or no internet connectivity.

These issues can be tackled by the following potential solutions:

- Digital tools or applications for mobile devices;
- Equipment solutions specifically designed for disaster response;
- Standardized templates for essential patient information, vital signs, injuries and provided healthcare;
- Offline work capabilities with possibility to synchronize data on demand;
- Voice-to-text technology to convert spoken information into structured text;
- Need to follow actual national protocols specific to disaster scenarios;
- Regular trainings of medical aid crews;
- Support via telemedicine consultations;
- Blockchain to ensure trust in the accuracy of medical records;
- Enhancement through post-disaster feedback analysis;
- Measures to protect sensitive information.

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Existing technological solutions and possible challenges

Among the basic information technologies used in medical informatics for medical data processing we can distinguish:

- Case-based reasoning;
- Machine learning models;
- Predictive analytics;
- Evidence-based guidelines;
- Reasoning based on expert's knowledge;
- Natural language processing;
- Operational research models;
- Sentiment analysis.

However, there exist factors that can even out all the benefits of the used information technologies. It happens when solutions in the medical knowledge-based systems faced challenges or did not meet expectations. Here are listed some of possible challenges:

- Lack of user-friendly interface;
- False alarms;
- Complex regulatory hurdles;
- Data bias and discrimination;
- Misalignment with clinical needs;
- Inadequate validation and testing;
- Inadequate data security;
- Overreliance on AI diagnostic tools.

Our approach in support of first-aid response in mass casualty situations

To improve the design, implementation and regulation (according to national protocols) of medical knowledge-based systems, finding a balance between technological advances, ethical considerations and needs of health professionals and patients is crucial.

In the development of computer-aided solutions to support first-aid response in mass casualty situations there exist two logical approaches: algorithmic and numerical. The numerical approach can be chosen, if developers have access to the set of precedents (real cases). We have chosen the algorithmic approach, having access to expert data and experts, which can formulate their professional knowledge in the form of decision rules.

In collaboration with a team of medical experts, we have taken kernel of the knowledge base, created for clinical sonographic diagnostic, "limiting" it to the injuries of abdominal organs (liver, pancreas, kidneys, and spleen). Also the knowledge base on the Extended Focused Assessment with Sonography in Trauma (EFAST) protocol, used for sonographic examination in case of mass casualty situations, was created.

However, the specific of mass casualty situations is that medical first-aid is focused on managing life-threatening injuries, which should be rapidly identified, and casualties condition need to be stabilized before their safe transportation to the nearest medical centres. In this regard pre-hospital triage is absolutely essential. Under time pressure and with limited resources (available healthcare personnel), a quick casualty triage based on vital signs should be done. We, in collaboration with a team of medical experts, selected basic attributes (casualty characteristics), which determine the decisions for triage based on vital signs, and applied the tabular form as the knowledge representation schema.

Also the minimum set of parameters needed for casualty registration was identified, so that the record, accompanying the casualty, contains all the information, that will enable doctors from specialized medical centres to intervene operatively in the treatment. These parameters cover all stages of the initial assessment of casualty and the organization/structuring of primary medical data. The medical record for casualty registration consists of personal data, time interval, type of injury (resulting from visual inspection of casualty), and values of basic attributes (parameters) which describe vital signs.

Moldova State University,
Vladimir Andrunachievici Institute of Mathematics and Computer Science,
str. Academiei 5, tel. 022 72 59 82
www.math.md

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