ENVISION – Improvement of intensive care of COVID-19 patients with artificial intelligence

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Abstract

The Envision project aims at developing artificial intelligence-based tools for supporting the treatment of critically ill COVID-19 patients in the intensive care unit. Twelve European hospitals participate in the collection of patient data for the development and validation of the artificial intelligence tools. Ten potential use cases have been identified as development targets. Data analysis and results from expert interviews are applied to define the clinically most relevant parameters and functional use cases to be used in providing decision support for the clinicians in the intensive care units for this patient group. The resulting artificial intelligence-based tool may be beneficial in the management of the next similar epidemics, as well.

Keywords: COVID-19, artificial intelligence, intensive care

Introduction

The COVID-19 epidemic broke out during 2019-2020 with serious consequences all over the world. This viral disorder is generally characterized by high fever, cough, dyspnea, chills, persistent tremor, muscle pain, headache, sore throat, and a loss of taste and/or smell [1]. More severe consequences include coagulopathy associated symptoms like blood coagulation, thrombosis, acute respiratory distress syndrome, and kidney failure which can lead to death if even the intensive care treatment cannot help. When the European Union realized the importance of this epidemic, it, among other things, reserved funding for projects to study the disease and help in its management [2]. The Envision project (12/2020-7/2022) [3], coordinated by the Goethe University Frankfurt am Main, Germany is one of these projects. The main focus of the Envision project is to improve the intensive care of the COVID-19 patients by supporting it with artificial intelligence (AI). This paper explains how the Envision project plans to develop AI based tools to help the intensive care unit (ICU) personnel to treat patients and to reduce the mortality rates.

Material and methods

The use of AI is based on the creation of a model which contains the knowledge to conduct one or more given tasks. The model is typically created by training an algorithm with a large amount of training data from representative real-world examples (the so-called data-driven approach, including neural networks) [4]. An alternative is to form the model with rules obtained from the experts of the field (rule-based approach, including expert systems) [5]. The data-driven approach is often preferred when sufficient amounts of training data are available and explicit rules are difficult to formulate (like in the cases of new diseases for which no or little experience has been gained) or need dynamic updating as more data and knowledge about the problem is becoming available over time (like is gained during the pandemic).

The Envision project consortium includes twelve hospitals across Europe [6]. The role of these hospitals is three-fold: First, they provide use cases where AI could be applied. Second, they provide the training data for the AI models to be created and third, they will validate the AI system which is to be created as a result from training. The project aims at recording data from more than 200 COVID-19 patients in the ICU. These three phases should be completed in 20 months, by the end of the project in the end of July 2022.

To proceed in the system development, a number of use cases need to be defined where AI could be of assistance. These use cases define the goal for the AI system and the inputs which the AI system uses to output the desired results. In the early stage of the project, it is not yet known exactly what the most significant inputs to the system are. The potentially most significant inputs are obtained with an exploratory study which connects the outcomes of the patients to the input variables and determines their relative significance. The list of initial variables consists of the general demographic variables of the patients such as age, gender, length, weight, known previous diseases and around seventy measurement variables collected during the patients' stay in the ICU.

A central tool in the collection of the patient data is the Sandman.ICU system [7] being developed by the company App@work [8]. The tool is based on a previous anaesthesia documentation tool, Sandman.MD, of the same company. Sandman.ICU obtains the ICU measurements automatically from the measurement system but the required demographic data and the annotations and medications need to be entered manually by the personnel using a tablet computer, according to the instructions of the project protocol. According to the plan, the AI module will be integrated to the Sandman.ICU system when it has been developed, tested and validated successfully.

The participating hospitals receive the Sandman.ICU system, the necessary tablet computers, a compatible patient data collection device and training for the use of the system. The hospitals then collect COVID-19 patient data for the use of the project, preferably as much as possible. An important step in the patient data transfer from the recording hospitals to the AI method development groups is its anonymization. The patient data needs to be anonymized so thoroughly that it is impossible for the recipients of the data to find out the true personality of the patient. This is required by the European General Data Protection Regulation [9] when the data processing environment does not fulfil the secure data processing criteria which is practically very difficult to implement in such a multinational research project as Envision. The anonymization process is performed by one of the project partners which receives all

the patient data. A sufficiently large set of patient cases is collected, and the preliminary quality check is performed to each one of the recordings. The acceptable recordings are then de-identified. The age of the subject is altered slightly to hide the origin. The anonymization software assigns new case numbers to the patient files without a link to the original case and a new patient data set is then available for development.

The recording and collection of patient data requires an ethical approval in each participating hospital. The project's approach to this is to prepare the required documentation in the coordinating hospital first. After the ethical approval, the other participating hospitals can use the documentation, adapted to their environment for their own application processes.

Results

At the time of writing, the Envision project has developed ten use cases for the application of AI in the care of the COVID-19 patients in the ICU. The use cases are described as patient cases which inspire the researchers to ask additional questions to refine the use case into an implementable prototype. This refinement requires collaboration and joint meetings of the AI development team and the ICU expert clinicians who can answer the questions of the AI developers. Some of the use cases may be solely based on the collected patient data but some may incorporate expert knowledge in the model, as well.

The first use cases are related to anticoagulation in COVID-19. The AI system is expected to be able to predict which patients are at particularly high risk for thromboembolic complications and then suggest a suitable dosage of anticoagulants for each patient.

Another use case is related to the prone position of the COVID-19 patients in the ICU. It is known that the prone position offers some improvement in the oxygenation of the patients but the optimal intervals in prone position are not yet known. The exploratory study with the body position and patient outcome data may offer a possibility to suggest the best observed solution.

Additional use cases are related to the optimal use of extracorporeal membrane oxygenator treatment, guideline-based ventilation, dexamethasone medication recommendation and infection prediction. Somewhat different use cases include the suggestion of the inclusion of a difficult patient case into an experimental treatment study and the computer-based monitoring of the changes in treatment guidelines in some recognized treatment guideline sources.

Discussion

The Envision project aims at taking all the possible benefits of AI into the treatment of the critically ill COVID-19 patients. Some of the presented use cases may turn out to be too difficult to implement into a clinically acceptable, working system in this short timeframe but some may fulfil the expectations, too. Only the accumulation of sufficiently large data sets will show us what will be feasible and what not. If the number of potentially relevant variables grows too high in a case, it may be impossible to collect a sufficiently large data set in a reasonable amount of time.

Even if some use cases turn out to be implementable in practice, the methods need to be validated in the hospitals. This will cause some delays to their adoption in clinical practice. Additional delays will be caused by the requirements of the medical device regulation in the European Union [10]. The quality system, risk management,

usability testing and system development life cycle requirements of the regulation mean that the design of a commercially deliverable medical device has to be started from the beginning when a working research prototype has been developed and found acceptable. This may mean that some of the benefits of the project can be exploited only in the next epidemic due to all these delays. The delays can, however, be shortened with the parallel development of the processes, device design, and documentation required by the regulations while the validation of the methods is still going on. Still, the last gaps in the medical device design can only be completed after developed AI methods have reached acceptable performance.

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Conflict of interest statement

The authors are researchers in the project that is described here but they have no conflicts of interests with the producers of the equipment or producers of the data used in this study.

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