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HOW BAYESIAN ARTIFICIAL INTELLIGENCE HELP FIGHT UNCERTAINTY IN TRAUMA SURVIVAL PREDICTIONS: ANALYSIS OF CONCEPTS

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КАК БАЙЕСОВСКИЙ ИСКУССТВЕННЫЙ ИНТЕЛЛЕКТ ПОМОГАЕТ УМЕНЬШИТЬ НЕОПРЕДЕЛЕННОСТЬ В ПРОГНОЗИРОВАНИИ ВЫЖИВАНИЯ ПОСЛЕ ТРАВМ: АНАЛИЗ КОНЦЕПЦИЙ

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Artificial Intelligence (AI) allows medical practitioners to evaluate and reduce the risks of life-threatening patient outcomes. This paper analyses current concepts of Bayesian AI developed to accurately assess trauma severity. It has shown that the proposed Bayesian concept overcomes the «gold» standard used for trauma care in the US and UK emergency units. The examination has been conducted regarding prediction accuracy estimated on the largest trauma patient repository.

Keywords: trauma survival prediction, trauma severity, uncertainty estimation, Bayesian AI

Искусственный интеллект (ИИ) позволяет медицинским работникам проводить оценку жизнеугрожающих состояний пациентов и на основании учета тенденций развития болезни обеспечивает снижение риска развития патологических состояний. В статье проводится анализ новых концепций в разработке Байесовского ИИ для более точной оценки тяжести травм. Демонстрируется, что предложенные Байесовские концепции дают лучшие результаты в контексте точности прогнозирования, в сравнении с «золотым» стандартом, используемым для работы с большими травматологического профиля в травматологических центрах США и Великобритании. Анализ проводился с использованием крупнейшей базы данных по пациентам с травматическими повреждениями.

Ключевые слова: искусственный интеллект, прогноз выживания, травма, тяжесть травмы, оценка неопределенности, Байесовский ИИ

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AI – Artificial Intelligence
BMA – Bayesian methodology of Model Averaging
BDT – Bayesian Decision Trees
DT – Distress Tolerance

MSE – Mean Squared Error
NTDB – National Trauma DataBase
TRISS – Trauma and Injury Severity Score

The US NTDB is the major world collection of injured patients admitted in hospitals and emergency units that has been made available for research in Trauma Care [1, 2]. These data include information about the patient's age, gender, type and region(s) of injury(s), along with some clinical and background information about a patient's state. For each patient «alive on arrival» in a hospital it is calculated the probability of survival is by using a fundamental regression model based on TRISS. The outcome (or discharge) is alive or dead. Many researchers agree that the TRISS-based models are capable of evaluating the survival of a patient very accurately if the types and severity of the patient's injuries are typical [3]. The TRISS model has been proposed to use the

three most severe injuries a patient can obtain in nine body regions. However, in practice, there are many cases with four and more injuries, and many patients are registered with some atypical combinations of injuries. The researchers and practitioners pointed out that in such cases, the accuracy of TRISS based predictions must be improved [4]. This motivates researchers to develop and test new ways of improving the accuracy of predicting the probability of survival of patients with multiple injuries [5].

The aim of study was to analyse current concepts of Bayesian AI developed to accurately assess trauma severity.

Material and Methods. Let us analyze the NTDB statistics of injuries over 1201094 patients registered in

the NTDB as alive on arrival in hospitals and whose TRISS survival probabilities were calculated. Figure 1 shows the actual survivals and TRISS predictions versus the number of injuries. We can observe a decrease in the survival of patients with a more significant number of injuries. Remarkably, the average survival decreases from 0.98 with one injury to 0.71 with 20 injuries, while the ratio of patients with one injury decreases from 0.17 to 0.0002 with 20 injuries.

In particular (Fig.1) shows that the difference between the average TRISS predictions and the actual survival progressively increases with the number of injuries. This is typically expected – the smaller the number of cases, the larger uncertainty in predictions. We can also observe the large 1σ intervals of probabilities of survival calculated for a given number of injuries.

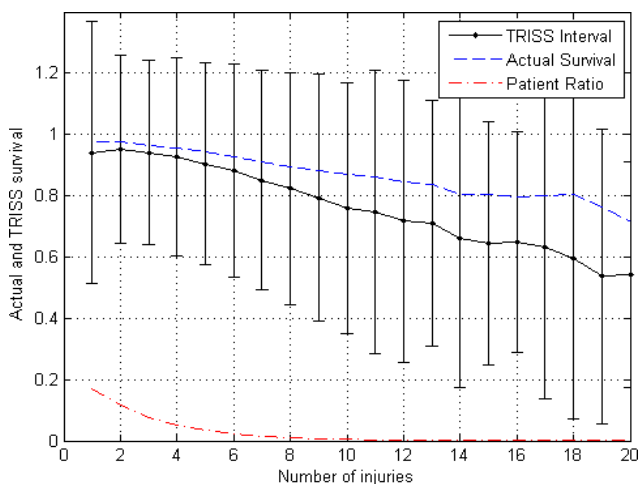


Fig. 1. TRISS predictions within 1σ intervals are depicted by the solid black line. The dashed blue line represents actual survivals. Patient ratios are the double dashed red line

We can look closer at TRISS survival predictions for patients with 11 to 15 injuries. The number of such patients is 14840.

Results and Discussion. Shows the actual survival versus TRISS predicted survival (Fig. 2). We can see that the predicted survival becomes biased in areas of lower values of the predicted survival – that is, the prediction error tends to increase for patients with lower probabilities of survival. The value of the Mean Squared Error (MSE) was 1.71.

In general, the accuracy of TRISS models can be improved by applying new model parameters and fitting those to new data. However, this approach can be practically implemented when the practitioners can appropriately set up a model structure. This assumes the knowledge of the «true» model, which in theory exists, but under many unrealistic restrictions. Thus, the practical implementation of approaching such a structure will require many attempts and efforts [6–8].

An alternative way is to use the Bayesian methodology of Model Averaging (BMA), which aims to approach the desired «true» model by averaging over multiple models. At the same time, each can be fitted well to partial data. In the conducted experiments on the NTDB, it has been found that the accuracy of predicting survival can be significantly improved by using the BMA methodology [9–11].

Within the proposed concept [12–14], Bayesian averaging has been implemented over Decision Tree models, which are known to assist clinicians with understanding how decisions are made. It has derived

14840 patients with the number of injuries 11 to 15. For training Bayesian Decision Trees (BDT), it has used 9893 patient records (2/3), and for testing 4947 (1/3) records.

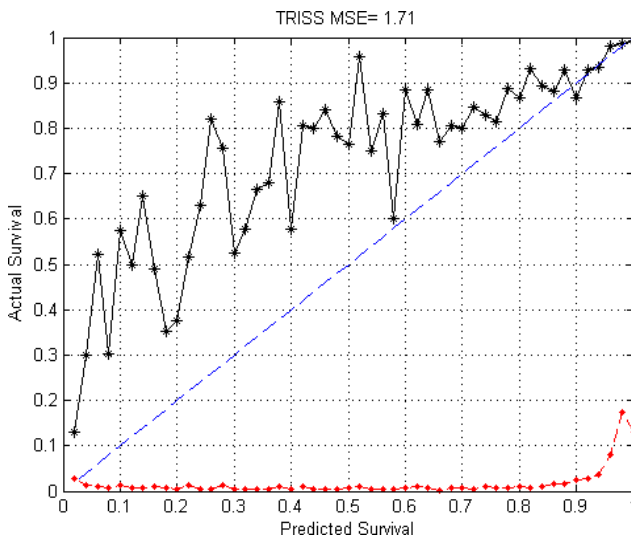


Fig. 2. Actual survival versus TRISS predicted survival is depicted as the solid black line. The red dashed line shows the patient ratio versus predicted survival

Shows the actual survival versus BDT predicted survival on the test data (Fig. 3). The same data were used to compare the accuracy with the TRISS survival. We can see that the BDT predictions are distinguishingly close to actual survival, and as a result, the value of MSE is decreased to 0.5.

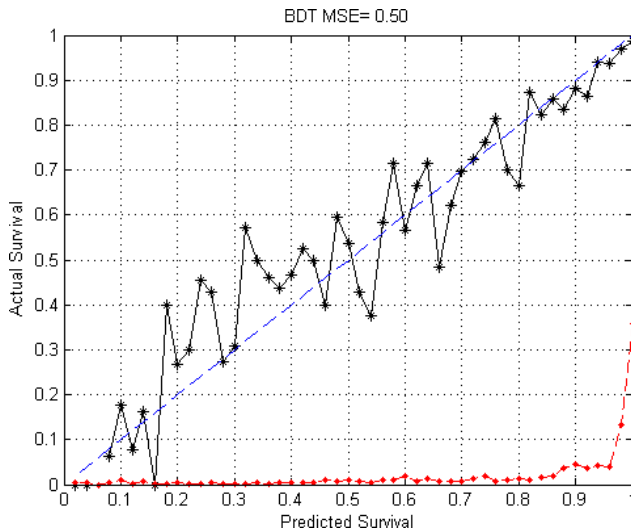


Fig. 3. Actual survival versus BDT predicted survival is depicted as the solid black line. The red dashed line shows the patient ratio versus predicted survival

Conclusion. In the future, the authors of the above concept expect to improve the BMA methodology, which is still suffering from the lack of model diversity, especially for hierarchical DT models, that results in model selection instead of model averaging. They also expect to minimize a screening test by eliminating the weakest attributes without a decrease in BMA performance. It is also important to note that using Natural Language Processing will allow practitioners to extract information about a patient's condition directly from textual protocols produced by trauma coders, and so will solve the problem of human-computer interaction.

Disclosures: The author declare no conflict of interest.

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CORRECTION OF ISCHEMIC REPERFUSION LIVER DAMAGE IN THE EXPERIMENT WITH THE USE OF ANTIOXIDANT DRUGS

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КОРРЕКЦИЯ ИШЕМИЧЕСКИ-РЕПЕРФУЗИОННОГО ПОРАЖЕНИЯ ПЕЧЕНИ В ЭКСПЕРИМЕНТЕ С ИСПОЛЬЗОВАНИЕМ АНТИОКСИДАНТНЫХ СРЕДСТВ

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The article assesses the effectiveness of correction of ischemic reperfusion damage to the liver of rats in an experiment. The study was conducted in 2 groups: the 1st group (n=15) of rats, which were intraperitoneally injected with 2 ml of physiological solution one day before the modeling of the pathological process and immediately before it; 2nd group (n=15) of rats were administered 2 ml of Remaxol and ascorbic acid 20 mg/ml with lipoic acid 3 mg/ml according to a similar scheme. Partial ischemia was simulated for 40 minutes, followed by a 3-hour reperfusion period. Lower markers of cytotoxic syndrome in rat blood plasma, higher antioxidant activity of blood plasma, and adequate prooxidant-antioxidant balance