Developed Prototype of Artificial Intelligence Techniques to Determine the Probability of Survival in Trauma Injuries

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Abstract

Determining the probability or likelihood of survival in trauma injuries is important for triage, setting treatment priorities and research and management audit. The existing methods for this purpose have shortcomings that necessitate further development. In this study, an artificial intelligence method called fuzzy inference system (FIS) for determining the likelihood of survival in trauma injuries is being designed and evaluated. FIS is able to model complex and imprecise data in an accurate and manageable manner. The mapping between its inputs (i.e. injury information) and output (i.e. Probability of survival) is performed by a set of conditional IF-THEN rules contained in its knowledge base. The accuracy of the FIS primarily depends on the design of its knowledge base. The required knowledge base is being designed by carrying out a detailed statistical analysis of the trauma injury profiles contained in a large data base of injury cases made available to the study by a collaborating institution, Trauma and Audit Research Network (TARN).

Currently an initial prototype of the FIS system has been developed. The aim is to finalize its design and compare its performance against the existing methods of determining the probability of survival in trauma injuries.
من خلال مجموعة من قواعد على هيئة IF-THEN المشروطة الواردة في قاعدة المعرفة الخاصة بها. فئة FIS تعتمد على قاعدة المعرفة الخاصة بالدرجة الأولى على تصميم قاعدة المعرفة الخاصة بها. يتم تصميم قاعدة المعرفة المطلوبة من خلال إجراء تحليل إحصائي مفصل لبيانات إصابة الجسدية الواردة معتمداً على قاعدة بيانات تحتوي على عدد كبير من حالات الإصابة التي تم توفيرها للدراسة من قبل المؤسسة التعاونية. تسمى شبكة أبحاث الصدمات والراجعة في بريطانيا (TARN).

في هذه الدراسة تم تطوير نموذج أولي ونظام ذكي لتحديد احتمالية البقاء على قيد الحياة ومقارنة أدائه مع الطرق المستخدمة الحالية.
Introduction

Assessing the severity of a trauma injury in a hospital’s emergency department (ED) is challenging due to diversity of injury types, individual's vulnerabilities (e.g. very young or old aged groups), large number of possible physiological measures (e.g. heart rate, temperature, blood pressure, respiration rate etc) and complexity of anatomical assessments (e.g. evaluating a head injury). Early intervention in many medical and traumatic conditions can improve survival outcome and reduce disabilities [1][2].

The extent of injury severity could be classified as nominal, ordinal or interval [2]. The majority characterisations of an injury severity are in nominal scales where verbal classifications are used to describe injury. They are valuables in simplifying communication between parties. Ordinal approaches use a positive entire numbers to provide a score to an injury severity. Several groupings such as fractures and many neurosurgical, orthopaedic and common injury classifications fall into this type. Interval scales likewise give numbers however there is an implicit probability of some reliability in the intervals between the numbers [3].

A number of trauma injury severity scoring systems were reported that are intend to accurately and consistently quantify injuries by considering measurable or observable status of the patient's medical conditions. The main benefits of trauma scoring systems are [2]:

Triage: This sets priorities to treat patients.

Prognostic evaluation: This enables predication and management of injury outcomes.

Research and audit management: These compare patient groups on injury outcomes and examines the effects of treatments.

Trauma assessment scoring methods can be grouped as anatomical, physiological and combined. Anatomical scoring systems characterise the extent of anatomical disruption weighted by the importance of injury site [2]. Physiological scoring systems are based on haematological, neurological and respiratory abnormalities. They afford robust mechanisms to forecast mortality [2]; however they have limitation in identifying the implication of the injury sites.
Combined anatomical and physiological scoring systems attempt to deal with the limitations of the anatomical and physiological scoring systems to better indicate the probability of survival.

Studies to develop better approaches to assess trauma injuries are ongoing. The primary aim of this research is to design and develop a system to determine probability or likelihood of survival following a trauma injury. Techniques that are considered are: expert systems, neural networks and fuzzy logic. Expert system encapsulates the knowledge of a domain expert in problem solving. Neural networks (neural computing) have the ability to learn from example cases. Fuzzy logic allows reasoning through contextual processing [4].

Abbreviated Injury Scale (AIS) was developed in the mid-1960s for tracking injury in automotive and aircraft crashes, since that time it has become one of an international scoring system for a variety of traumatic injuries [5]. The first AIS injury coding dictionary was developed In 1975-1976 [6]. In recent years, several versions of AIS have been developed as AIS-2015. This considers the most recent version which completely revised the spinal injury codes and allowed the coding of associated soft tissue injury [7]. AIS used to classify more than 2000 injury description in nine body parts (head, neck, face, thorax, spine, abdomen, upper limbs, lower limbs, and external) [8]. In an ordinal scale between 1 (minor injury) and 6 (maximum injury, possibly mortal) range, is allocated to each injury.

The Glasgow Coma Scale (GCS) was introduced in 1974. It was developed to standardise assessment of a patient's level of consciousness (LOC). It is relatively simple to apply and is used in a variety of medical assessment cases such as determining urgency of care and for neurological examinations. Its scale is 3 to 15 obtained by evaluating eye opening, verbal and motor behaviours [9]. This study is on based on an anatomical trauma injury scoring systems called Abbreviated Injury Scale (AIS) and a physiological scoring system called Glasgow Coma Scale (GCS).

These are popular methods in trauma injury assessment due to their relative accuracy and ease of implementation. The development of the method required access to the Trauma Assessment and Research Network (TARN) data base. The developed method is being
compared with the conventional methods of determining probability of survival in trauma injuries.

**Experimental Method**

The work is in collaboration with Trauma Audit and Research Network (TARN). The data analysis investigated the number, Age, Gender, injury types of trauma cases, used in the study. There were about 10% more males than females and 97% of the injuries were in the blunt category and the rest, penetrating type. A blunt traumatic injury is caused by the application of mechanical force to the body or when the body strikes a surface in which the skin is not penetrated.

A penetrating traumatic injury is caused when a sharp object such as knife penetrates the body. The proportion of cases that survived (lived after the trauma) was 93.3% and the remaining cases not survivor (died) as shown Table 1.

**Table 1 Overview of all injury trauma cases.**

<table>
<thead>
<tr>
<th>Gender (%)</th>
<th>Mean Age (years) (standard deviation)</th>
<th>Injury outcome</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>26098 (54.7%)</td>
<td>60.7 (24.8)</td>
<td>44499</td>
</tr>
<tr>
<td>Female</td>
<td>21604 (45.3%)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figures 1 and 2 show the distributions (histograms) indicating the effect of age on the individuals surviving and not surviving in trauma [10]. The age distribution for survived cases shows peaks at 20, 60 and 80 years but for those that did not survive, there is a single dominant peak at about 90 years. The peaks in the distribution of cases that survived do not infer that more injuries occur at those ages but there are more subjects with those ages in the analysed data.
Figure 1 Age distribution of individuals surviving

Figure 2 Age distribution of individuals not surviving
The TARN database has divided into two sets Training set and test set. The Training set contained approximately 2/3 of the cases (number = 174900) and the validation data set contained the remaining 1/3 subjects (number = 159000).

Fig. 3 shows the schematic diagram of proposed trauma injury assessment system to determine Probability of survival. A detailed statistical analysis of the TARN data base was been carried out to establish the interrelationships between trauma injury scores and outcomes (patient surviving or not). This led to mapping of the trauma injury scores and associated outcomes through knowledge representation means, primarily a set of IF-THEN rules. Fuzzy Inference system (FIS) was used to perform inferencing, whereby existing coded knowledge (from the data base) and injury scores of a current case are processed to derive a survival Probability. Fig.4 shows the FIS system whereby the input is fuzzified to allow textual processing and then defuzzified to provide a number for the probability of survival.

Figure 3. Operation of developed fuzzy logic system to determine probability of survival.
Results and Discussion

The developed FIS system is currently in a prototype form and its design is not yet finalised. The main challenge has been the development of a knowledge base that accurately maps the trauma injury information to survival outcome. The detailed statistical analysis carried out on the TARN data based helped with this process as it indicated the significance of injury parameters in probability or likelihood of trauma injury outcome. Fig.5 shows a user interface developed for the purpose of the study. It receives the trauma injury details and by using the FIS indicate the probability of the survival. The plan is complete the design and of the system and evaluate it against the exist methods.

Figure 4. Fuzzy inference system to determine likelihood of survival.
Conclusions

New approaches to determining the manner in which the abbreviated Injury System (AIS) code and probability (or likelihood) of survival (Ps) are derived are proposed. These may speed up the process of generating the AIS code and may make determining Ps more accurate. The proposed methods are based on artificial intelligence techniques and primarily fuzzy logic techniques.

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