Sheffield Hallam University

Fuzzy logic to determine the likelihood of survival for trauma injury patients

SALEH, Mohammed, SAATCHI, Reza <http://orcid.org/0000-0002-2266-0187> and BURKE, Derek

Available from Sheffield Hallam University Research Archive (SHURA) at:

https://shura.shu.ac.uk/15934/

This document is the Accepted Version [AM]

Citation:

SALEH, Mohammed, SAATCHI, Reza and BURKE, Derek (2017). Fuzzy logic to determine the likelihood of survival for trauma injury patients. In: CUDD, Peter and DE WITTE, Luc, (eds.) Harnessing the power of technology to improve lives. Studies in Health Technology and Informatics (242). IOS Press, 385-388. [Book Section]

Copyright and re-use policy

See http://shura.shu.ac.uk/information.html

Sheffield Hallam University Research Archive
http://shura.shu.ac.uk

Fuzzy Logic to Determine the Likelihood of Survival for Trauma Injury Patients

Mohammed SALEH [a], Reza SAATCHI [a,1], Fiona LECKY [b] and DEREK BURKE [c]
[a] *Sheffield Hallam University, Sheffield, UK,* [b] *Sheffield University, Sheffield, UK,*
[c] *Sheffield Children's Hospital, Sheffield, UK.*

Abstract.. A system to determine the likelihood of survival for trauma injury patients is being developed. It uses a fuzzy logic approach that can model complex processes without reliance on sophisticated mathematical formulations and may have the potential to be more accurate than the existing approaches. The outline operation of the system that is currently in a prototype stage is described.

Keywords. trauma injury assessment, fuzzy logic, trauma injury scoring system

1. Introduction

Trauma injury is an important cause of death and disability [1] and survival of a severely injured person depends on the specialised care delivered in a timely manner. A number of trauma injury severity scoring systems were reported that are intended to accurately and consistently quantify injuries by considering a measurable or observable status of the patient's medical conditions. Trauma injury scoring systems can be beneficial for [2]: (i) Triage: this helps with setting priorities to treat patients. (ii) Prognostic evaluation: this supports predication and management of injury outcomes. (iii) Research and evaluation: this facilitates comparison of patient groups on trauma injury outcomes and helps with examination of the effects of treatments.

Trauma assessment scoring methods can be classed as anatomical, physiological and combined [3][4]. The primary aim of this study is to develop and evaluate a system that determines the probability or likelihood of survival for trauma injuries. Fuzzy logic allows reasoning through linguistic processing [5]. It thus facilitates complex data models without reliance on sophisticated mathematical models. In this paper an outline operation of a prototype fuzzy logic based system to determine the likelihood of survival is reported. An anatomical injury scoring system called Abbreviated Injury Scale (AIS) [6] and a physiological scoring system called Glasgow Coma Scale (GCS) [3] are used due to their popularity and relative accuracy. In the following sections two existing approaches to determine the probability of survival are briefly explained, the concept of fuzzy logic is introduced, methodology followed to develop the new method of determining the likelihood of survival is explained and the results are presented.

[1] Corresponding Author, Department of Engineering and Mathematics, Sheffield Hallam University, City Campus, Sheaf Building, Howard Street, Sheffield S1 1WB, UK, E-mail: r.saatchi@shu.ac.uk.

2. Approaches to Determine Probability of Survival

Trauma and Injury Severity Score (TRISS) is a method that uses anatomical and physiological scoring systems to determine the probability of trauma survival (p_s) for adults sustaining traumatic injuries from blunt and penetrating mechanisms [7]. It is determined by

$$p_s = \frac{1}{1+e^{-b}} \quad (1)$$

where b relates age and trauma injury related parameters. TRISS however has a number of shortcomings as explained in [8]. In 2004 Trauma Audit and Research Network (TARN) [9] proposed a Probability of Survival model called Ps04. This model uses age, gender, Injury Severity Score (ISS) and Glasgow Coma Score (GCS) and intubation. In 2014, Ps14 model was introduced by incorporating Charlson Comorbidity Index (CCI) to the assess Pre-Existing Medical Conditions (PMC).

3. Fuzzy Logic

Features of fuzzy logic include its ability to map the input-output relationships using a set of IF-THEN rules, without the need for complex mathematical modellings and its flexibility to deal with inexact and uncertain information and then draw conclusions [5]. Fuzzy Inference System (FIS) is an implementation of fuzzy logic concepts that facilitates data analysis and decision making. It has four main components: fuzzifier, rules base, inference engine and defuzzifier [10]. FIS fuzzifies the real value inputs into linguistic variables using a set of input membership functions and depending on the information formulated by a set of IF-THEN rules in its knowledge base, it computes linguistic output values that are in turn are converted (i.e. defuzzified) into real value outputs using a number of output membership functions.

4. Method

The operations to determine the likelihood of survival relied on analysis of TARN database that has tens of thousands of trauma injury cases. These operations are broadly illustrated in Figure 1.

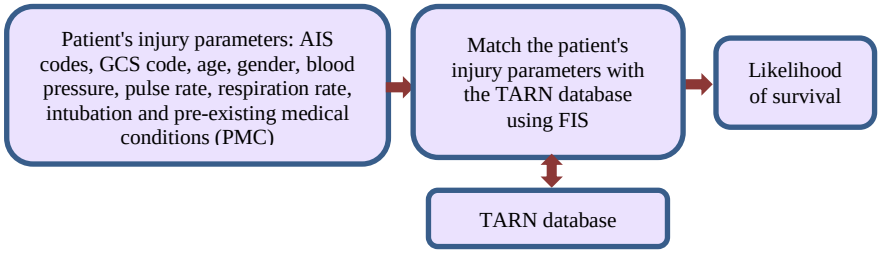

Figure 1. Fuzzy logic method to determine the likelihood of survival

The injury information for a specific patient is compared with the injury cases present in the TARN database and the closest matched injury conditions are processed by the FIS. The rules included in the knowledge base of the FIS are obtained through statistical analysis of the TARN database. The FIS interprets the injury conditions to determine the likelihood of survival. Typical rules are:

if (Head Injury is Minor) then (Injury Severity is level 1)
if (Head Injury is Severe) then (Injury Severity is level 4)
if (Chest Injury is Critical) then (Injury Severity is level 4)
if (Head Injury is Severe & Chest Injury is Critical) then (Injury Severity is level 6)

3. Results and Discussion

The example result shown in Figure 2 is an illustration of the developed prototype system's operation. The patient in this case has two injuries associated with chest and head. The AIS code for head and chest injuries are 4 and 5 respectively. AIS code 4 represents severe injury and 5 is a critical injury. The FIS system determines the degree of membership of the injury levels (i.e. 4 and 5) to a set of six membership functions labelled as *minor*, *moderate*, *serious*, *severe*, *critical* and *maximum*. The rules in the knowledge base process the determined degrees of injury memberships and by using the membership functions associated with the FIS output, the likelihood of survival (L_s) is determined. The system is currently partially developed.

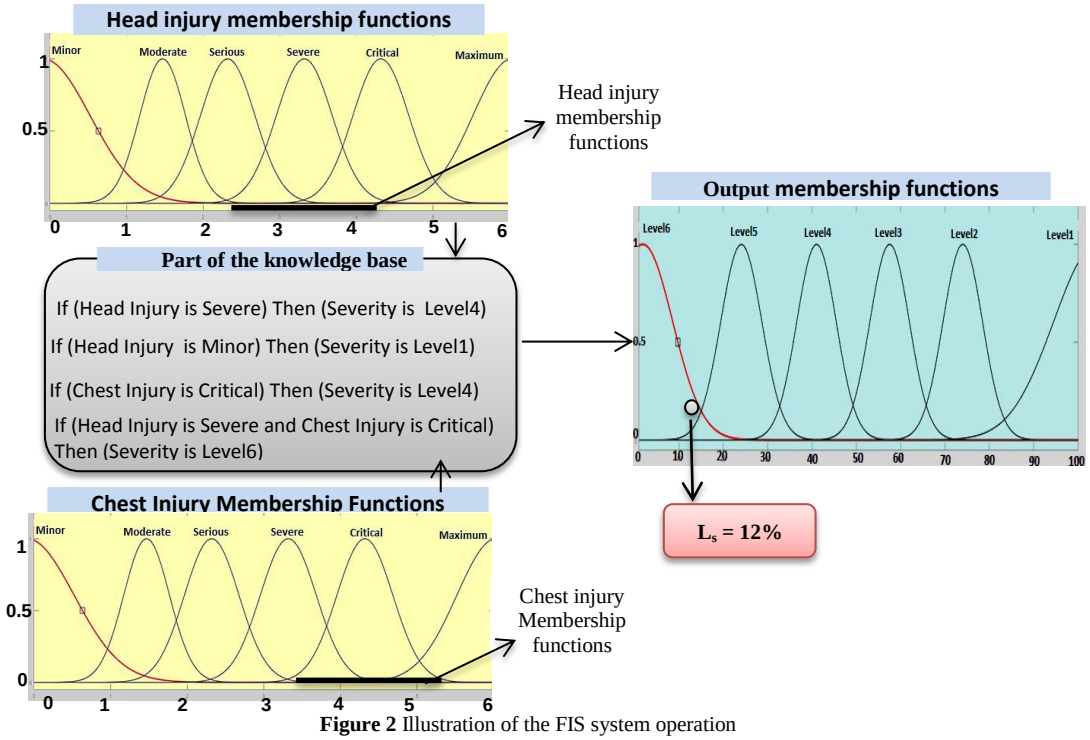

Figure 2 Illustration of the FIS system operation

5. Conclusions

A new approach to determine likelihood of survival in injury trauma cases is proposed. The method has the potential to be more accurate than existing approaches due to its flexibility and ability to model complex injuries from multi-regions of the body and to include factors such as physiological parameters, gender and age.

6. Acknowledgements

We are grateful for the ongoing support TARN has provided for the study by allowing access to their trauma injury database and for the very valuable discussions.

References

[1] R. J. Mullins, A historical perspective of trauma system development in the United States, Journal of Trauma, **47(3)** (1999), S8-14.

[2] D. H. Wisner, History and current status of trauma scoring system, Arch. of Surgery. **127(1)** (1992), 111–117.

[3] M. H. Fani-Salek, V.Y. Totten and S. A. Terezakis, Trauma scoring systems explained, EMA Emergency Medicine Australasia, **11(3)**(1999), 155-166.

[4] W. Meredith, R. Rutledge, A.F. Hansen, Field triage of trauma patients based upon the ability to follow commands, The Journal of Trauma Injury Infection and Critical Care, **38(1)** (1995), 129–134.

[5] R. R. Yager, and L. A. Zadeh, Fuzzy sets, neural networks and soft computing. John Wiley & Sons, Inc. New York, ISBN 0442016212, 1994.

[6] T. A. Gennarelli and E. Wodzin, AIS 2005: a contemporary injury scale. Injury, **37(12)** (2006), 1083-1091.

[7] P. J. Schluter, The trauma and injury severity score (TRISS) revised. Elsevier, Injury Int. J. Care Injured, **42(1)** (2011) 90-96.

[8] P. Siritongtaworn and S. Opasanon, The use of trauma score-injury severity score (TRISS) at Siriraj Hospital: How accurate is it?, Journal of the Medical Association of Thailand, **92(8)** (2009), 1016-1021.

[9] Trauma Audit and Research Network, (November 2014-last update), Improvements in the Probability of Survival Model. Available: https://www.tarn.ac.uk/Content.aspx?ca=4&c=3515 [13/04, 2015]. last accessed 17/05/2017

[10] T. J. Ross, Fuzzy logic with engineering applications, Third Edition, John Wiley and Sons, Online ISBN: 9781119994374 , 2010.