PREDICTION OF SEVERE INJURIES FOR THE OPTIMIZATION OF THE PRE-CLINICAL RESCUE PERIOD OF CAR OCCUPANTS

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ABSTRACT

The number of injured car occupants decreases constantly. Nevertheless, they account for nearly 50% of all fatalities and about 44% of all seriously injured persons in German traffic accidents. Further reductions of casualties require multiple efforts in all parts of traffic safety. In this paper a detailed analysis of the important pre-hospital rescue phase was done.

The basis for future improvements is the knowledge about injury causation of car occupants in combination with other corresponding influence factors. For that reason more than 1.200 severe (AIS3+) injuries of frontal car occupants were analyzed. For the most relevant injuries of car occupants multivariate analysis models were created to predict the probability of these injuries in a real crash scenario. In addition to the collision severity different influence factors like impact direction, seat belt usage, age of the occupant, and gender were analyzed.

Furthermore, the models were checked regarding the goodness of fit and all results all results were checked concerning their robustness. The prediction models were created on the basis of 5.000 car accidents. Afterwards, the models were validated using 4.000 different car accidents.

The prediction of the probability of severe injuries could be used for different applications in the field of traffic safety. One possibility is the implementation of the models in a tool for the on-the-spot diagnosis. The background for the development of such applications is the fact, that there are only limited diagnostic possibilities available at the accident scene. Nevertheless, the rescue forces have to make essential decisions like the alerting of the necessary medical experts, appropriate treatment, the type of transportation and the choice of an adequate hospital. These decisions quite often decide between life and death or influence the long-term effects of injured persons. At his point, indications of expectable injuries could help enormously.

To enable even persons with limited technical knowledge to use the tool, a procedure was developed that facilitates the assumption of the given crash severity.

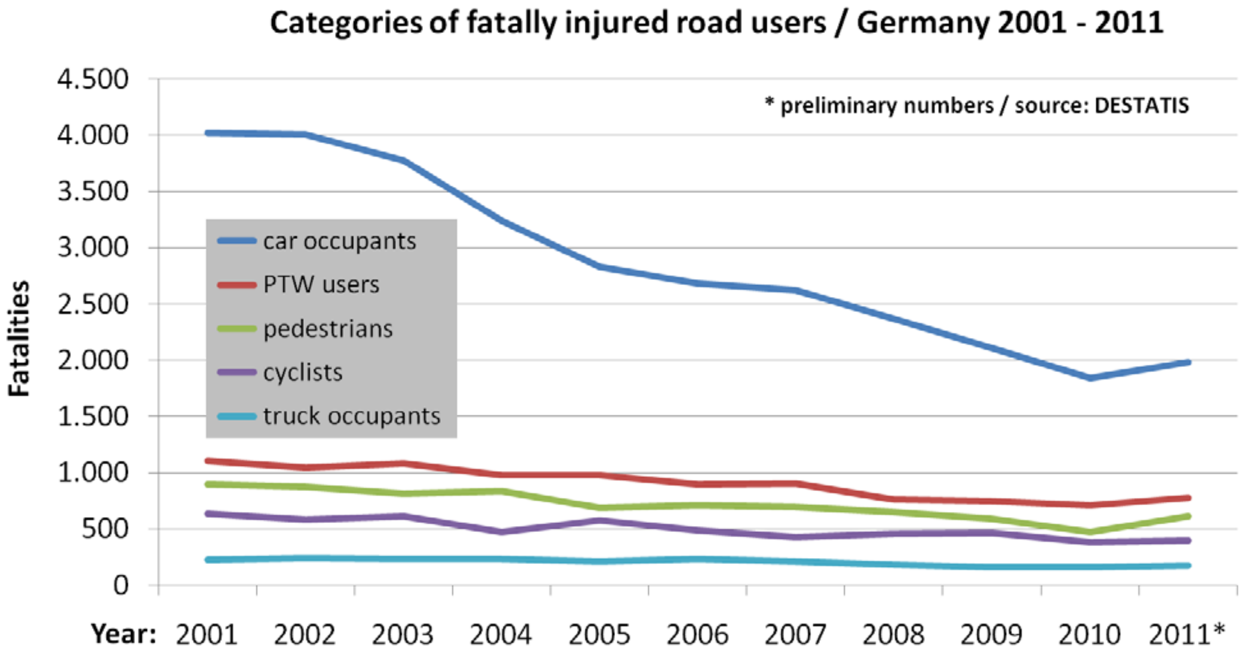
Another important possibility for the application of the prediction models is the use for the qualification of information sent by e-call systems.

INTRODUCTION

First results of the development of a software tool for emergency diagnostics were shown in 2008 at ESAR conference from Mr. Brehme. Since then, the diagnostic models were used by more than 100 different employees of the accident research unit in Dresden to test the applicability of the tool at the scene. After the reconstruction of all accidents in these years (2007 to 2010), it is now possible to validate the predicted injuries with the actually sustained injuries of all car occupants. The paper shows the validation process as well as the further potential of the tool.

MOTIVATION

In Germany, the numbers of fatally and seriously injured occupants is decreasing generally since many years (picture 1). Nevertheless in 2011 compared to 2010 the number of fatally injured occupants increases by 7,8%, the number of seriously injured occupants increases by 6,8%. Every second fatally injured person in German traffic accidents is a car occupant.



picture 1 – Fatally injured road users, Germany 2001 - 2011

The global target is the decrease of fatally and seriously injured casualties in road traffic accidents; in particular the reduction of injured car occupants.
Therefore achievements in different fields are necessary, for instance in:

- secondary safety (already on high level),
- primary safety (increasing importance),
- driver education and qualification,
- infrastructure and
- rescue medicine.

Especially in rescue medicine there are often difficulties in severe car accidents, e.g.:

- occupants are frequently not accessible for medical examination,
- slight but impressive injuries may distract attention away from severe (e.g. internal) injuries,
- the absence of diagnostic measures and
- delayed symptoms and so-called „talk and die“ situations.

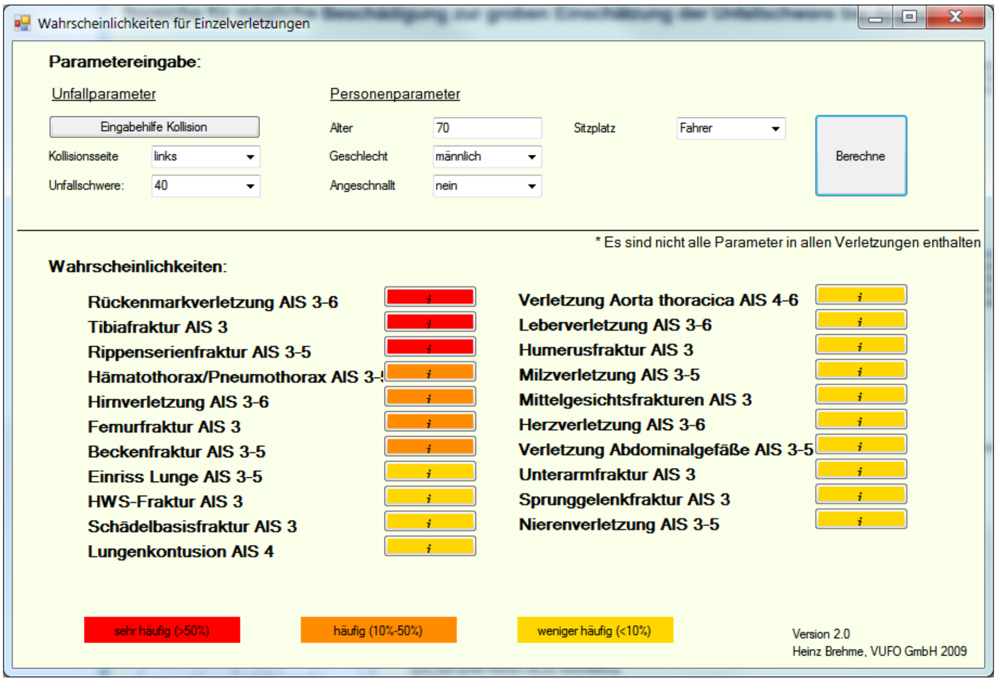
A typical rescue scene is shown in picture 2. Especially accidents where persons are jammed in the car are challenging for the rescue forces.

picture 2 – Rescue of a tucked car occupant

Despite all that different decisions that are essential for survival have to be made, concerning:

- necessary rescue forces
- urgent measures / advanced cardiac life support
- transportation
- adequate hospital

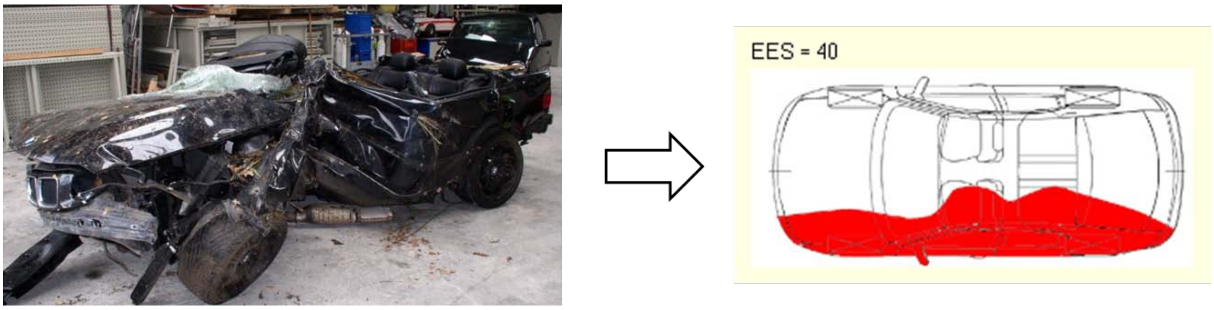
The VUFO diagnosis tool (picture 3) could possibly help to find the right decisions.



picture 3 – Diagnosis tool

VALIDATION METHOD

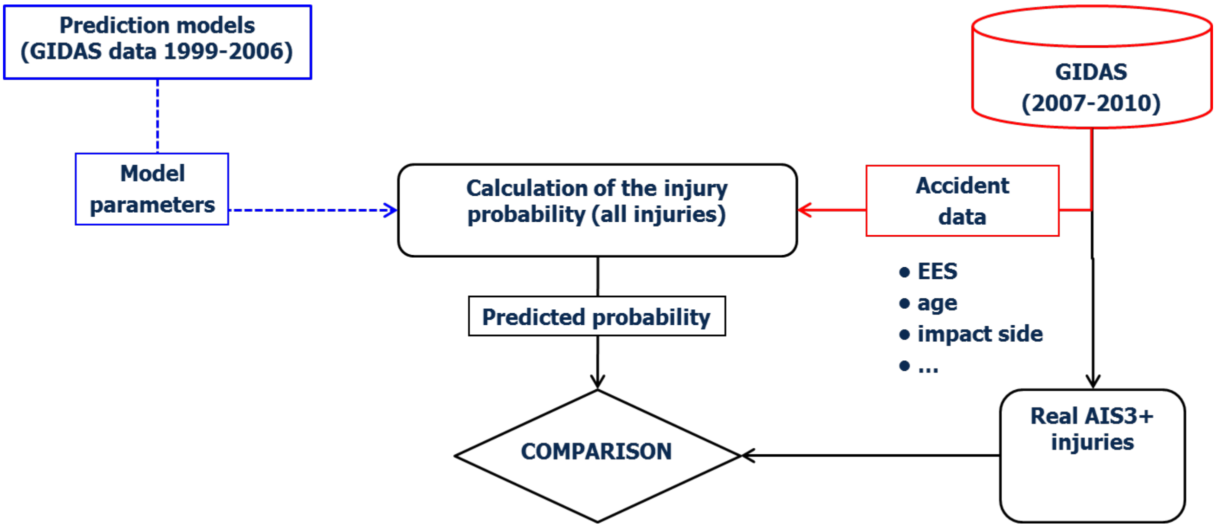
A first important step was the validation of the Energy Equivalent Speed (EES) estimation by laymen at the accident site. As shown in picture 4, the EES was estimated by a comparison of deformation depth and pictures with given EES values.



picture 4 – EES estimation

Independent from the EES estimation of laymen at the accident site every accident in GIDAS is reconstructed. After the reconstruction the estimated EES by the laymen and the reconstructed EES by the reconstruction engineer could be compared.

For the validation of the diagnosis tool (picture 3) the following method was used (picture 5).

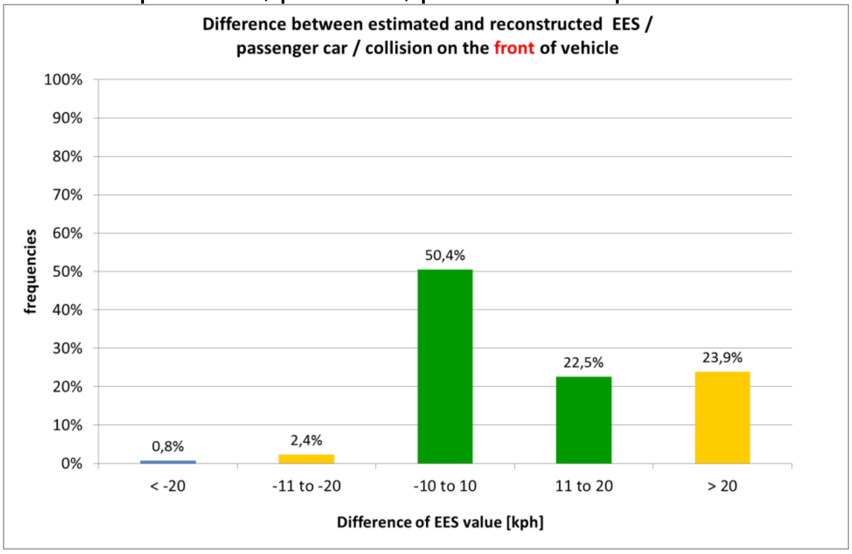


picture 5 – Validation method

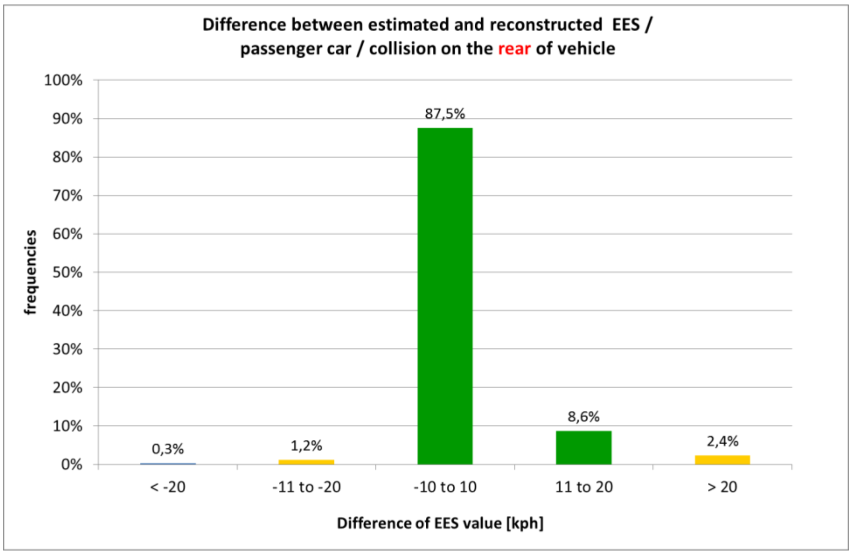
In this second step the models were validated using recent data out of GIDAS. The prediction models of the diagnosis tool base on GIDAS data from 1999 to 2006. With these models the probability of severe injuries in GIDAS accidents from 2007 to 2010 could be calculated and compared with the actually sustained injuries (picture 5). This was done for all injuries listed in the diagnosis model separately.

RESULTS OF THE VALIDATION PROCESS

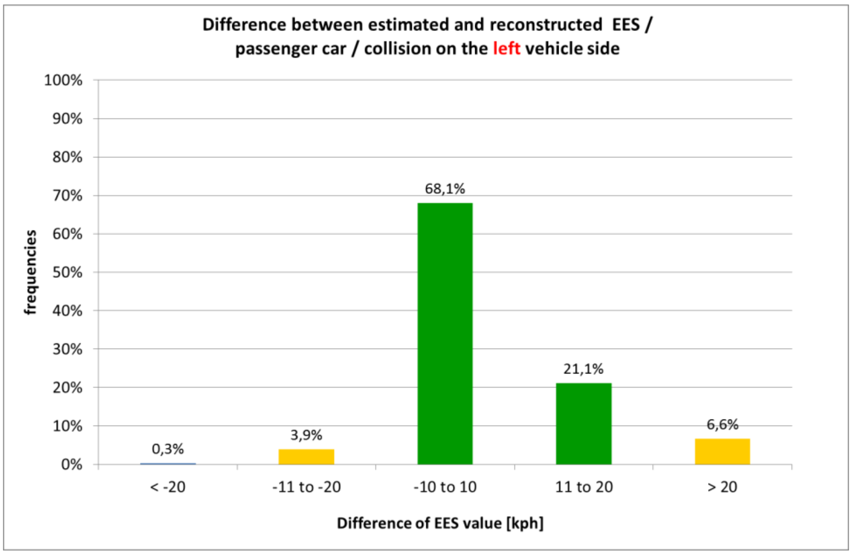
The results of the comparison between estimated and reconstructed EES were shown in picture 6, picture 7, picture 8 and picture 9.



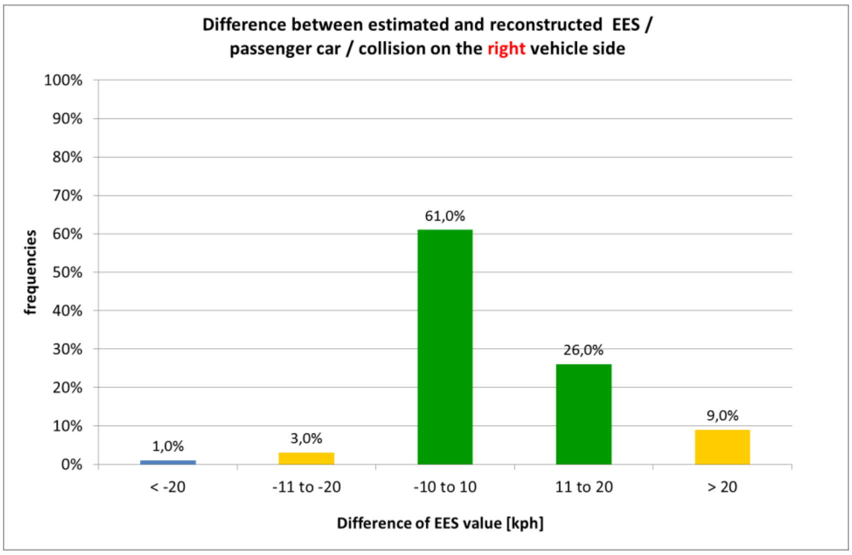
picture 6 – Difference between estimated and reconstructed EES on the front



picture 7 – Difference between estimated and reconstructed EES on the rear



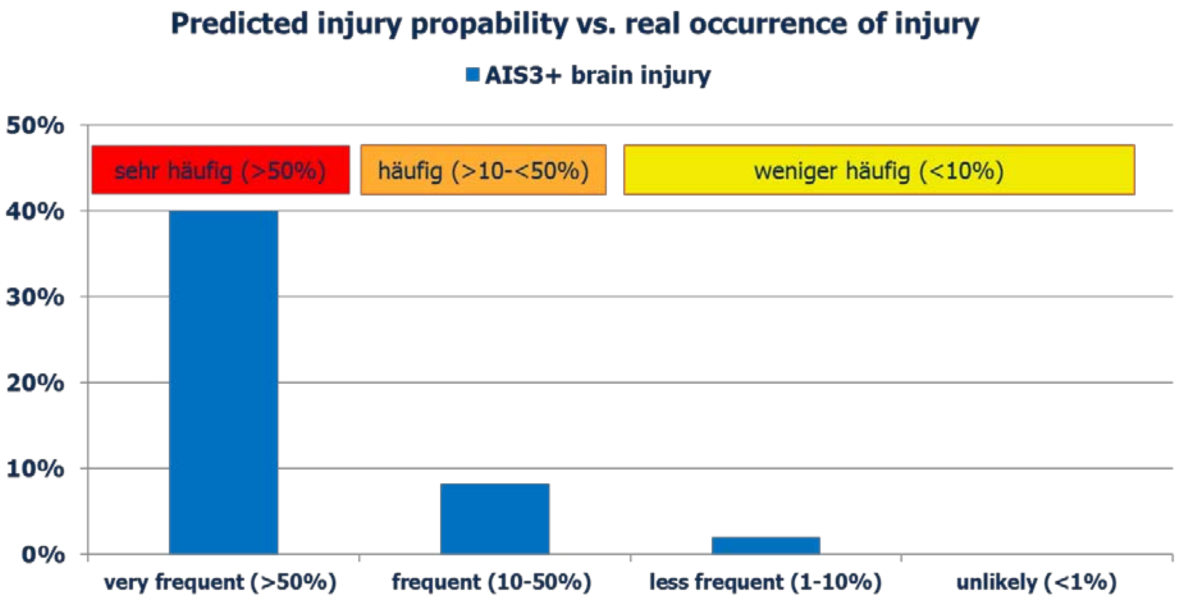
picture 8 – Difference between estimated and reconstructed EES on the left side



picture 9 – Difference between estimated and reconstructed EES on the right side

It can be seen in all pictures that there is a small overestimation of the EES from the laymen at the accident site. Nevertheless the variance of the EES estimation is for all impact sides mostly between +/- 10 kph. The small overestimation of EES leads to slightly higher prediction probabilities (higher injury severity), which is still better than an underestimation. Further activities will concentrate on the optimization of the EES pictures and the analysis of single cases. There are some good reasons to assume, that the accuracy of EES estimation could be further optimized.

In the second step, the predicted injury probability was compared to the actual occurrence of injuries. Therefore the real EES value from the reconstruction engineer was used to find out the differences based on the model. In picture 10 the comparison for brain injuries (AIS3+) is shown.



picture 10 – Validation of brain injury prediction

It could be stated for brain injuries, that the prediction of the group “injury occurrence very often (>50%)” was true in reality in 40% of the cases. In the group “often (>10-<50%)” in reality about 8% of the injuries occurred.
All models seem to be too conservative. By taking the average of all models into account, between 25% and 50% of the occupants in the prediction group “very often (>50%)” actually sustained an AIS3+ injury. Occupants with prediction probabilities between 10% and 50% (group “often”) showed between 5% and 15% real occurrence of the predicted AIS3+ injuries.

DISCUSSION AND CONCLUSION

The developed diagnosis tool can be handled on the accident scene from any person.
The effects of such a diagnostic tool are:

- the optimization of the rescue chain (choice of appropriate rescue forces),
- better diagnoses due to indications on certain (e.g. internal) injuries,
- the choice of an adequate clinic,
- the prevention of later relocation,
- the optimization of the use of available rescue forces,

In general, model modifications are possible and useful. Further parameters like the vehicle age or the impact point can be implemented.

The prediction models can alternatively be used in eCall systems for qualifying the emergency call.

The validation showed that the tool can be easily handled at the accident scene. Furthermore, the models showed good predictions of AIS3+ injures. Prediction probabilities above 50% often indicated actual injuries. The models are currently still too pessimistic, which results from two facts:

- The models based on an older dataset with old vehicles (GIDAS 1999-2006) whilst the validation was done with more modern vehicles (GIDAS 2007-2010) so that improvements in the field of passive safety lead to biases,
- the boundary value within logistic regression was 0.5 (could be decreased)

Therefore it is suggested to create prediction models for severe (AIS3+) injuries with current datasets.

For all four impact sides the EES estimation is rather good and tends to an overestimation. The given images lead to 50 to 88% correct estimations. The best assessment could be found for rear end collisions and the worst for frontal collisions. One possible reason in frontal crashes is that the damages (e.g. folded bonnet) exceed the real deformation and thus, lead to higher estimations of the EES value. The images should therefore be revised or differentiated for different vehicle ages. Nevertheless a rough estimation of the crash severity on the basis of images is feasible even for laymen.