

CREATION AND VALIDATION OF INJURY SEVERITY PREDICTION MODELS FOR THE IMPLEMENTATION IN ADVANCED ECALL SYSTEMS

Angela Schubert, Thomas Unger, Henrik Liers - Verkehrsunfallforschung an der TU Dresden GmbH (VUFO)

Prof. Dr. Christian Kleber - Universitätsklinikum Leipzig and Dresden

Dr. Michael Hetz - Universitätsklinikum Leipzig

Prof. Dr. Klaus-Dieter Schaser - Universitätsklinikum Dresden

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Agenda

Motivation

Introduction to traffic accident research at VUFO

Development of a diagnostic tool for clinical rescue

Perspectives

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Road safety goals

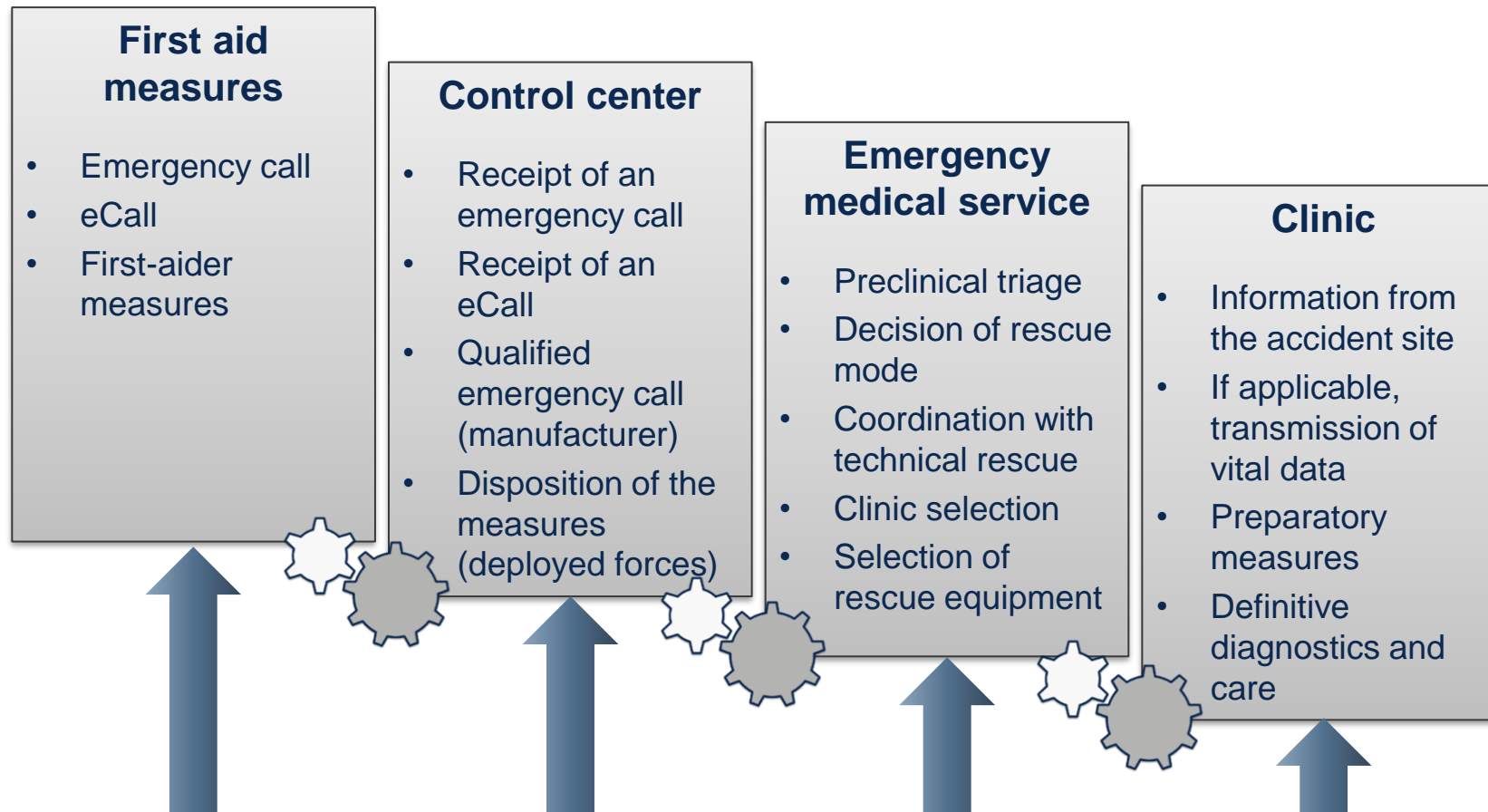
- **Primary:** Minimizing the number of fatalities and serious injuries in accidents
- Optimizations in vehicle safety focus mainly on seriously injured persons
- **Germany 2021: 323.129 injured persons, thereof 2.562 killed and 55.137 seriously injured (DESTATIS)**
- To achieve further improvements, all fields of traffic safety must be optimized
 - Primary safety (high potential - currently area with most progress)
 - Secondary safety (already at a high level)
 - Tertiary safety (optimizations underway, even greater interdisciplinarity desirable)



Motivation and approach:

Improvement of diagnostics in rescue services through software-based injury probability estimation

Phases of rescue in traffic accidents



- Rescue system thrives on interdisciplinarity
- The earlier qualified information is available, the better the care/transport can be coordinated

**Potential of a diagnostic tool:
Improve the quality of information & interlocking of disciplines → Save valuable time**

Agenda

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Introduction to traffic accident research at VUFO

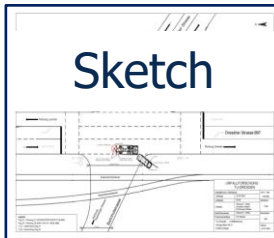
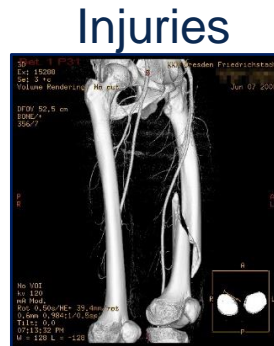
Development of a diagnostic tool for clinical rescue

Perspectives

Introduction to traffic accident research at VUFO

Accident investigation on the spot – the GIDAS project

Information

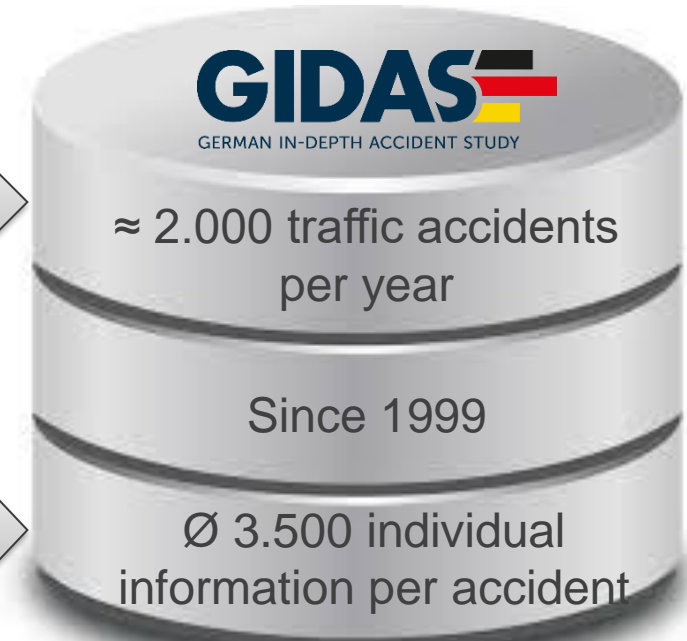


Reconstruction of the accident with PC Crash®



Each GIDAS accident is reconstructed from the critical situation to the final position of the parties involved

Database



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Procedure & Methodology

Which injuries are relevant?

Focus to serious injuries with an indication for an emergency doctor

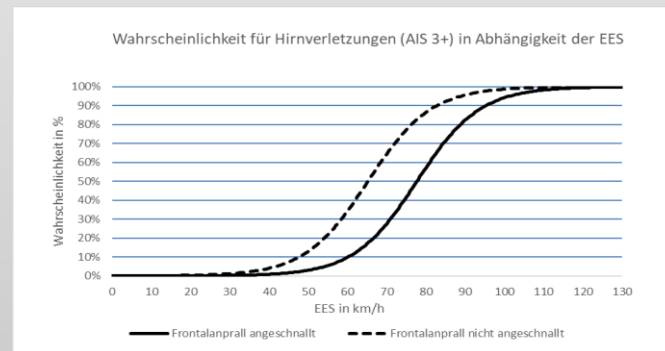
What affects the severity of an injury?

Identify influencing variables for the prediction of injuries

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Statistical Models for classification

Create injury risk functions with influencing parameters of traffic accidents in GIDAS to predict probable injuries



Presence of the injury?

No

Yes

Development of a prototype user interface

Based on the predictions, an exemplary diagnostic tool is created for the control centre, rescue service and clinic in order to improve the rescue chain

Form fields: Vor Ort: NEF, RTW, RTH, Feuer, Feuer2, THW; Weiteres Rettungsmittel anfordern: NEF; Inzidenz 1; Kind; Schock; ISS > 15; Intubation; Techn. Rett.

Verletzungsmuster:

| sehr wahrscheinlich | wahrscheinlich |
|---------------------------|---|
| LWS-Verletzungen | Abdominale Verletzung |
| Mittelgeschädelverletzung | Augenverletzung |
| Zahnverletzung | Beckenverletzungen |
| | HWS-Verletzungen |
| | Hand-/Pneumothorax |
| | SHT/Kopfverletzung |
| | Thoraxverletzung |
| | Verletzung Bauchwand/Organe intraabdominell |

Weitere Informationen:

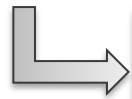
Zielklinik Soll: Füge weitere Fachabteilung hinzu: AUG, SYN, HCH, HMG, HCH, HAU, GUC, UNO, UTO

Legenbericht senden, Eingabekorrektur

Creation of Masterdataset

**GIDAS-Dataset(12/2020) passenger car occupants with collision:
n = 78.844 persons**

Known information on injury severity (AIS15) and location of the injury



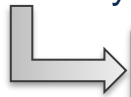
n = 76.136 persons
thereof 40.751 uninjured, 35.385 injured with 86.764 single injuries

Only front row of seats of passenger cars, known information on DV and EES in the collision process of the most severe collision in the accident. Underride and incapacity are excluded. Front airbag installed. Burns are excluded.



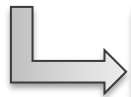
n = 27.142 persons

Only passenger cars with year of market introduction from 2000 upwards



n = 13.944 persons

Independent variables used must not have unknowns



n = 11.683 persons
thereof 6.398 uninjured, 5.285 injured with 11.736 single injuries

Model development

Which injuries are relevant?

Focus to serious injuries with an indication for an emergency doctor

Elaboration of a revised categorisation system for the classification of injuries resulting from a passenger car accident:

- Focus to at least serious injuries (AIS15 3-6)
- Orientation guide:
 - Medical dissertation of Heinz Brehme *
 - German trauma registry
 - Emergency doctor indication catalogue
 - S3-Guideline Polytrauma
- Aim: Subdividing injuries from a tactical point of view according to:
 - criteria that are relevant for prehospital patient care
 - dispositional issues (target hospital)



- Main categories
- Subcategories
- Intubation
- ISS15 > 15
- Entrapment in the vehicle
- Child
- Geriatric patient

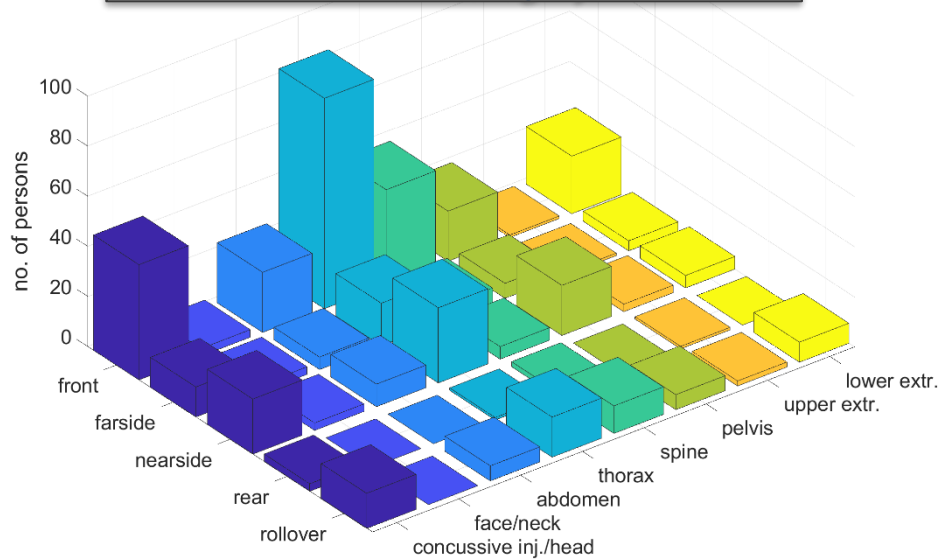
* Brehme, H: Schwere (AIS 3+) Verletzungen von PKW-Frontinsassen (Medizinische Dissertationsschrift)

Model development

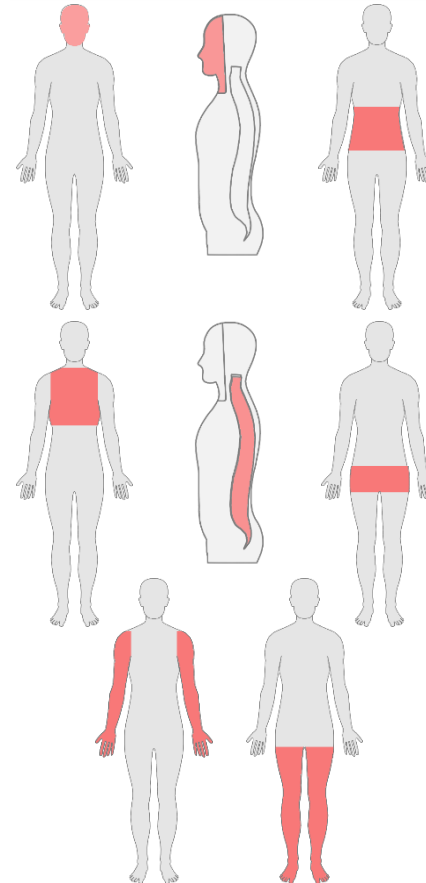
Which injuries are relevant?

Focus to serious injuries with an indication for an emergency doctor

No. of persons with at least one injury in main category



Main categories according to body region



- Main categories
- Subcategories
- Intubation
- ISS15 > 15
- Entrapment in the vehicle
- Child
- Geriatric patient

n = 214 persons with 460 injuries in a defined main category (812 single injuries)

Model development

What affects the severity of an injury?

Identify influencing variables for the prediction of injuries

Influencing variables for the prediction of injuries:

- few, clear parameters
- immediately acquirable at the accident site
- proven influence on accident outcome
- only basics of the technical investigation

Direction of impact and seating position:

- Front
- Farside
- Nearside
- Rear
- Rollover

Impact side and seating position result in different injury kinematics → Creation of an injury risk function for each of the groups

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EES or DV - Value

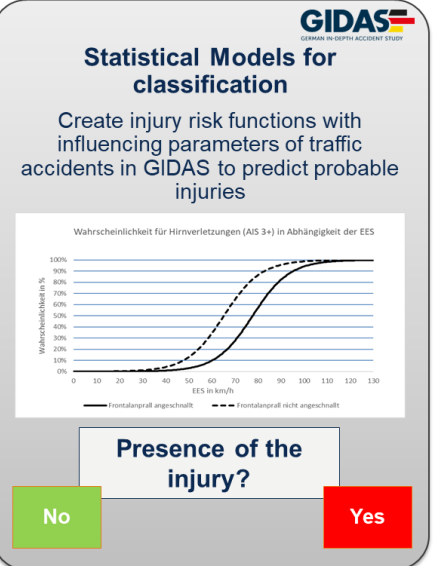
Age of patient

Seat belt usage

Vehicle class

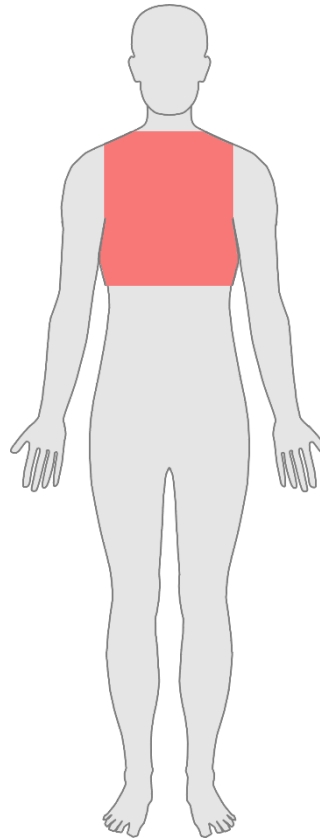
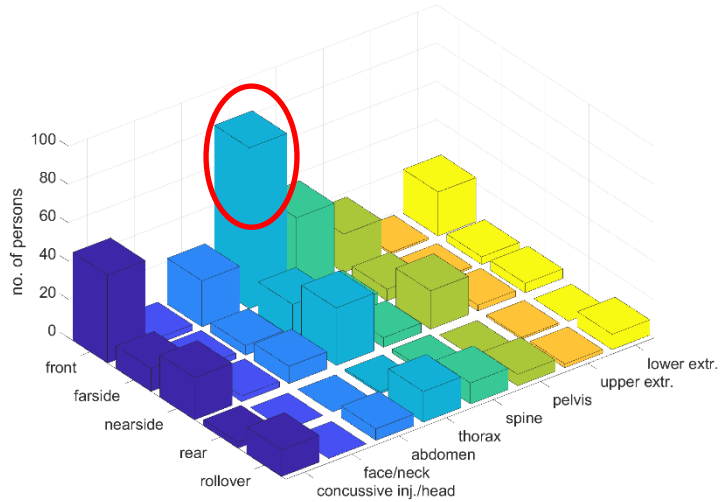
Passenger compartment

Airbag activation



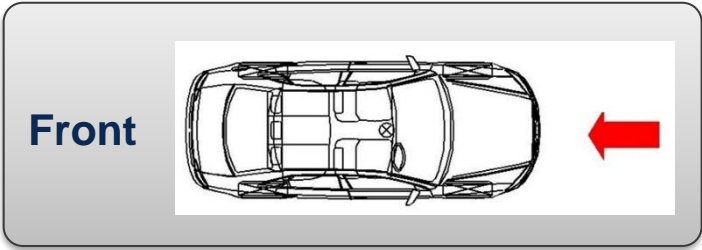
Exemplary Analysis

For the main category of thorax injuries for frontal impact



Frontal impact: n = 82 persons with at least one injury in main category thorax

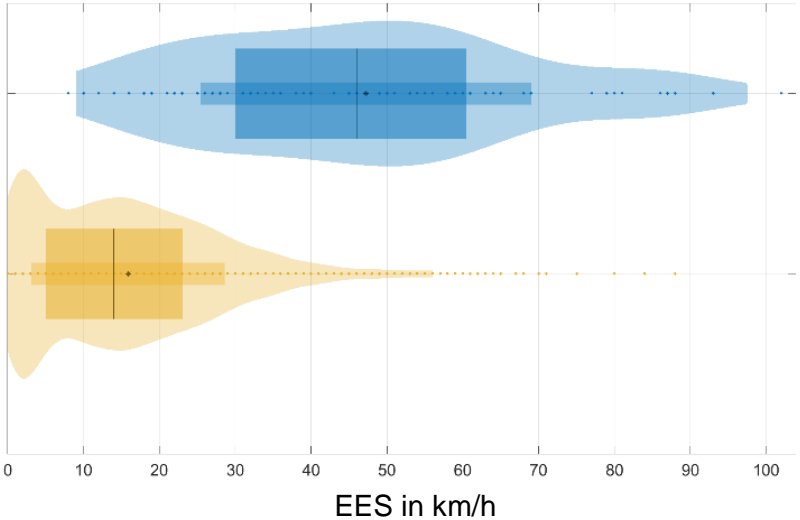
Energy Equivalent Speed (EES) as independent variable



Thorax injuries for front impacts

Persons with specific injury

Persons without specific injury



Model development

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Statistical Models for classification

Create injury risk functions with influencing parameters of traffic accidents in GIDAS to predict probable injuries

Wahrscheinlichkeit für Hirnverletzungen (AIS 3+) in Abhängigkeit der EES

Presence of the injury?

No Yes

Creation of injury risk functions based on the master data set

→ Used for classification of a serious injury in a specific body region for a given accident

Logistic Regression

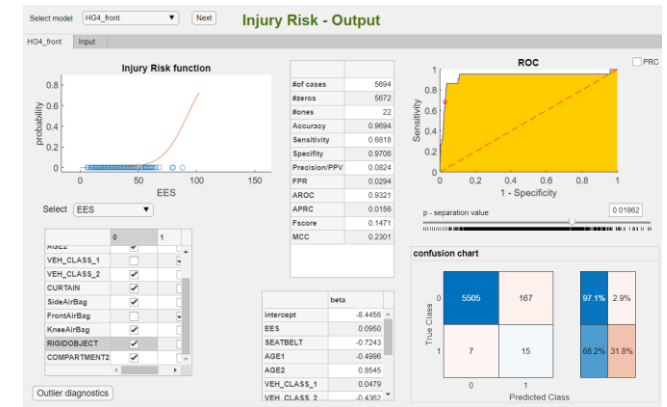
RUSboost

5-Fold Cross-Validation

Analysis of classification results and statistical values

→ Model selection → Log. Regression

→ Selection of suitable classification threshold



Creation of a final model on the entire master dataset

External Validation with EUSKA data

Exemplary classification results

Classification of Thorax injuries for front impacts
for standard classification threshold of 0,5

| True Class | Predicted Class | | | |
|------------|-----------------|--------|--------|-------|
| | 0 | 1 | | |
| 0 | 5.493 | 8 | 99,9 % | 0,1 % |
| 1 | 73 | 9 | 11 % | 89 % |
| | 98,7 % | 52,9 % | | |
| | 1,3 % | 47,1 % | | |

Highly unbalanced dataset:
the class of interest accounts for
only 1.5% of the dataset

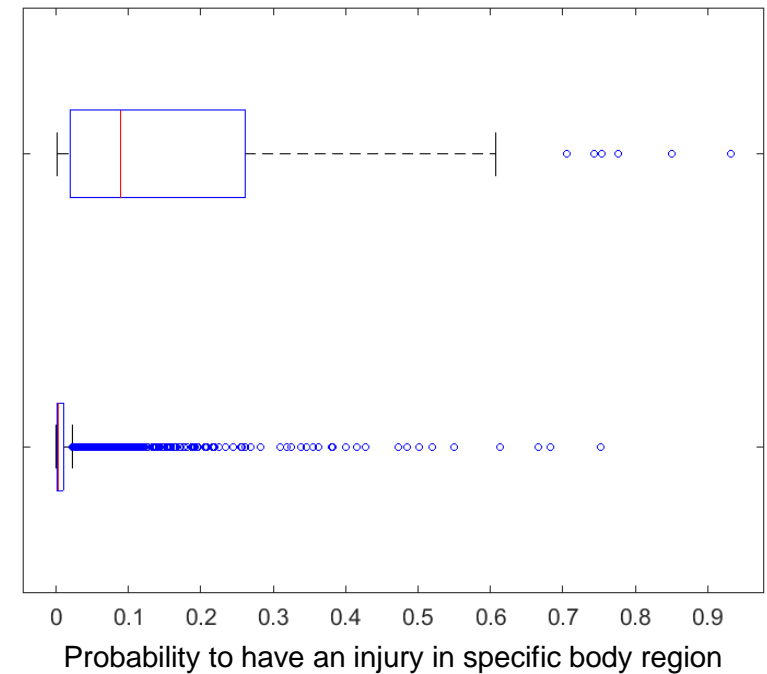


Probabilities from the model separated
according to actual occurrence of the injury

Thorax injuries for front impacts

Persons with
specific injury

Persons
without
specific injury



Exemplary classification results

Classification of Thorax injuries for front impacts
for optimized classification threshold

| True Class | Predicted Class | | | |
|------------|-----------------|--------|--------|--------|
| | 0 | 1 | | |
| 0 | 4.953 | 548 | 90 % | 10 % |
| 1 | 22 | 60 | 73,2 % | 26,8 % |
| | 99,6 % | 9,9 % | | |
| | 0,4 % | 90,1 % | | |

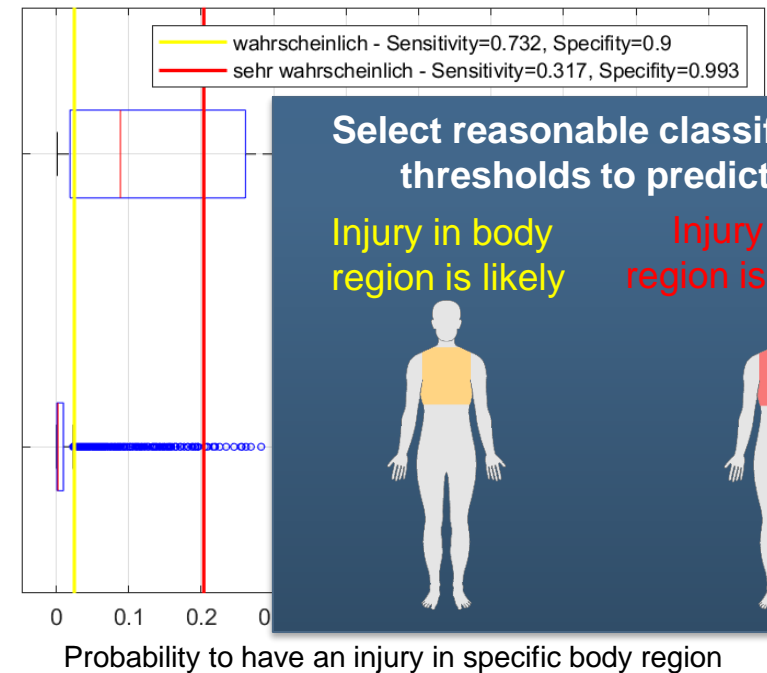


Persons with specific injury

Persons without specific injury

Classification method for user interface

Thorax injuries for front impacts



Select reasonable classification thresholds to predict, if:

Injury in body region is likely

Injury in body region is very likely



Development of a prototype user interface

Creation of a diagnostic tool and integration of the predictions from the injury risk functions

**Ecall
or phone call**



Control center



**Emergency
medical service**



Clinic

Diagnoseeol Eingabe

Anspruchrichtung: Front, Heck, links, rechts, Überschiag, unbekannt

Anzahl Insassen: 2

Fahrerklasse: K, M, C, G, L

Fahrerstatus: unbekannt, unbekannt

Fahrerstatus betroffen: Ja, Nein

Unterfahren: Ja, Nein

Starker Anprallgegner: Ja, Nein

EES in km/h: 60

GPS Koordinaten: D: 51.04952, L: 13.74063

Lebensbericht

Lebelle

Alarmierungsvorschlag: NEF, RTW, RTH, Feuer, Feuer2, THW

Alarmiert: unterwegs, Vor Ort

Anzahl Verletzte: 2, Anzahl Fahrzeuge: 2

YMAS Status: weitere Verursachung des Totals ist die Verknüpfung mit der Lebensrisikofunktion

Rückmeldung Einsatzstelle: B: 51.0495, L: 13.7409

Zielklinik Soll: Inzasse 1, Inzasse 2

Lebensbericht senden, Eingabekorrektur

Retungsfeld

Vor Ort: NEF, RTW, RTH, Feuer, Feuer2, THW

Weiteres Rettungsmittel anfordern: RTH

Inzasse 2: 15.5 > 15, Intubation, Techn. Rett.

Verletzungsmuster: sehr wahrscheinlich, wahrscheinlich, Abdominale Verletzung, Beckenverletzungen, Verletzung der unteren Extremität

Weitere Informationen: instabil

Zielklinik Soll: AUG, SCH, STN, NCH, NKG, NEN, NEE, NDC, LND, DCH

Lebensbericht senden, Eingabekorrektur

Klinik

Info/Update RD-NA, Verletzungsmuster, Zielklinik Soll, Ankunft

Verletzte: 1, 2

Verletzungsmuster: sehr wahrscheinlich, wahrscheinlich, Beckenverletzungen, Verletzung der unteren Extremität

Zielklinik Soll: AUG, SCH, STN, NCH, NKG, NEN, NEE, NDC, LND, DCH

Ankunft: in 00:00, in 00:00

Diagnoseeol Eingabe

Lebensbericht senden, Eingabekorrektur

**Corrective input
possible**

Diagnoseeol Eingabe

Lebensbericht senden, Eingabekorrektur

**Corrective input
possible**

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Perspectives and further activities

Goal: Development of a viable diagnostic aid for further optimization of the rescue chain

- Coming soon: Trial period on rescue helicopters in Dresden with operation of the prototype user interface on tablets
- The prototype user interface is no approved medical device
→ Desirable after end of project: award to a medical device company and conversion to an approved medical device
- Further development of solutions and trial implementation in pilot regions
 - Involvement of rescue control centres, fire brigade schools, rescue associations, fire brigades
 - Integration of the trauma network DGU
 - Involvement of suppliers and OEMs, industry partners



THANK YOU FOR YOUR ATTENTION!

Angela Schubert

Data analysis and simulation

Angela.Schubert@vufo.de

Tel.: +49 351 43 89 89 29