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Towards Prediction of Injuries in Traffic Accidents

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Abstract. For people involved in road traffic accidents, the time necessary to respond is crucial and it is hard to discern, which persons in which cars most urgently need help. To plan the rescue operation before arriving at the scene, digital information regarding the severity of the accident is vital. Our framework aims to transmit available data from the in-car sensors and to simulate the forces enacted on occupants using injury models. To avoid data security and privacy issues, we install low-cost hardware in the car for aggregation and preprocessing. Our framework can be retrofitted to existing cars and therefore could extend the benefits to a wide range of people

Keywords. Injury prediction, Traffic accident simulation, Framework

1. Introduction

Road traffic crashes are one of the leading causes of death for children and young adults. The World Health Organization (WHO) estimates 1.3 million fatalities globally each year [1]. Sanchez-Mangas et al. have shown that a fast response to traffic accidents is vital to increase the chances of survival [2]. Accordingly, governments regulate the methods of emergency calls. Modern approaches such as eCall and Next Generation 112 focus on the automatic response to crashes, removing the necessity for the error-prone intervention by a person or the time-consuming dialogue with the dispatcher [3,4]. Such protocols also include further data to support the planning and execution of the emergency response mission. Since traffic accidents often involve multiple vehicles [5], it is furthermore crucial to provide information to the emergency responding team, which assists them in the reconstruction of the accident and prediction of the resulting injuries. This would enable them to provide the fastest aid to the persons most in need and therefore would lead to the best outcome.

Instead of relying on custom solutions, which would take time to permeate the markets and also exclude the vast amount of existing cars, we utilize existing sensors build-in cars and their recording and communicating facilities. The Controller Area Network (CAN) is a wired vehicle bus architecture. Since 1986, it is the standard in automotive

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engineering. The CAN bus interconnects the various sensors and actors within the vehicle and its communication protocol provides error correction. Modern cars feature a variety of sensors, which as identified by Deserno et al. could be crucial for the prediction of injuries [6]. Through the extraction of this data via an interface and subsequent semantic mapping, crash-related information could be obtained for existing cars indifferent of model and manufacturer.

Data broadcasting can be integrated into the International Standard Accident Number (ISAN), which provides the semantically interoperable information exchange between automatic systems of the emergency alerting, responding, and curing instances [7]. Tri et al. used the BeamNG physics engine to virtually reconstruct road accidents [8]. The observed forces acting on the simulated passengers can be applied to human injury models, to produce a comprehensive representation of the possible state of each person involved [9]. In this paper, we suggest a framework for information merging, visualizing, and presenting to aid the rescue personnel's decision-making process prior to the arrival of the rescue team at the accident site.

2. Methods

2.1. Data extraction

Our method depends on the reliable extraction of relevant data from the CAN-bus. This requires the design of an interface for data processing and semantic mapping. Sudarshan et al. [10] utilize the Raspberry Pi and PiCan2 to interface the CAN bus of vehicles. The Raspberry Pi can perform simple computing and interpretation of the provided CAN-bus data in real-time and functions as an extendable hub. To extract the data model and manufacture-independently, we use a look-up table for each car model locally on the Raspberry Pi. The mapping of different sensors and sampling rates to the specified data fields is required for the subsequent simulation. To capture all relevant data, the Raspberry Pi continuously reads information from the CAN bus in a certain time frame. The reporting of a crash (alerting) is handled by the eCall system or, if no eCall exists in a vehicle, the alerting is triggered by the deployment of the airbags. Once our system detects an event, the Raspberry Pi gathers the data frame prior to and all frames during the event. The Raspberry Pi then establishes a connection with the ISAN network, encodes the data for transmission, and submits the data payload.

2.2. Data transmission

Figure 1 illustrates the communication of the individual components of our framework. First, the crash is registered and then the encoded crash data is sent via the ISAN protocol. The data is received by the ISAN system handling verification, encryption, and decryption of data. In the following step, the data is relayed to the simulation server that executes the physical simulation and applies the injury model. The so generated data then gets visualized on the server and can be accessed via an authentication process. The simulated data for the occurred accident is referenced by the data linking process provided in the ISAN specifications [7].

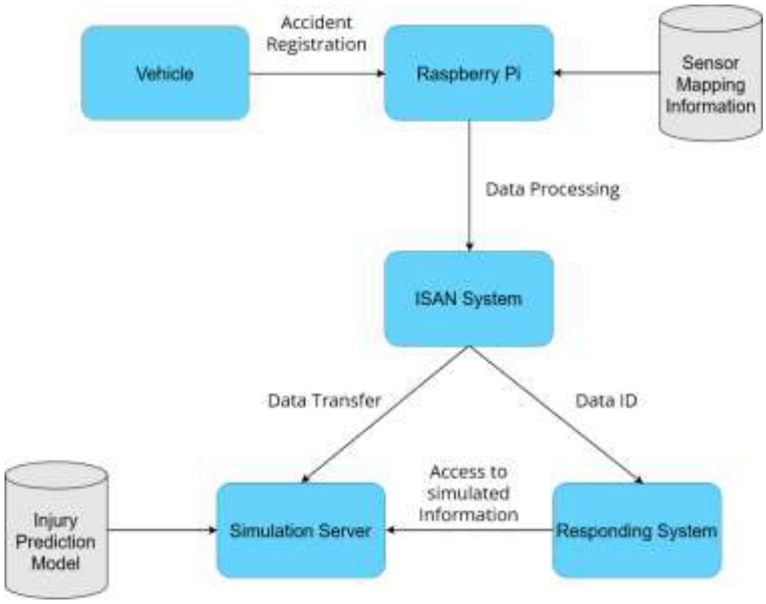

Figure 1. Overview of the proposed framework**.**

2.3. Injury prediction and visualization

To gauge the extent of the injuries inflicted, we use the received data to simulate the physical forces acting on the passengers of the involved vehicles. To implement this, the received data on the simulation server creates a simulation instance for the recorded accident, linking the incoming data of each vehicle by spatial and temporal proximity and assigning a unique identifier of the crash to each car and passenger. For each car within the instance, we run a simulation based on the reported data using a yet-to-be-specified physics engine. The vehicle model used in the simulation is a stand-in model based on the reported vehicle class. If the number of occupants is not provided, we assume full occupancy for the simulation and highlight non-verified passengers with flags accordingly. To execute the physical simulation, we apply the registered forces to the stand-in vehicle in which we place a virtual ragdoll dummy on all occupied seats to capture the impact and forces acting on the passengers. For the design of the ragdoll multiple variants, accommodating the different sexes and statures can be used. Depending on the simulation load of the server, multiple instances of the simulation can be run to generate data for the different dummies. Following the simulation of the experienced forces, a human injury model will be utilized to translate the applied forces into the resulting injuries.

3. Results

The prior steps culminate in a system, which provides the information for the identification of the persons most affected by the accident. To make the data accessible we suggest the following visualization.

Figure 2. Left: Real-time render of BeamNG.drive with dummy placed on driver seat **Right:** Visualization of a possible representation of forces enacted on dummy during crash.

First, provide an overview of the entire scene of the accident with all cars involved. This will be implemented, by using the stand-in vehicles and the transmitted GPS location. A tier system, assigning colors to the severity of the simulated injuries will be employed to visualize the vehicles with passengers in critical condition. Selecting a vehicle then provides a view of all occupants represented by the corresponding 3D dummy. As shown in Figure 2, a heat map of the experienced forces can be assigned as a texture, and selecting a dummy produces the list of assumed injuries derived from the injury model.

4. Discussion

The here proposed framework for the prediction of road traffic accidents could provide a scale-able and cost-efficient approach to visualize existing sensor information collected even by older vehicles. The use of a Raspberry Pi for the local aggregation and semantic encoding allows for an undemanding extension with further sensors in the future. With this, we achieved our set goal for the accessibility of our framework, which could be particularly interesting for developing countries, which exhibit heightened numbers of car accidents [1]. Our suggested framework builds on the previously established research, that demonstrated the validity of the reconstruction of accidents using a state-of-the-art physics engines [8] and the accurate prediction of injuries through human finite element models (FEMs) [9,11]. While information not recorded by the sensors prohibits a perfect reconstruction of the accident, the integration of auxiliary technologies, like wearables could alleviate the issue. We expect the system to provide information to emergency response teams, from previously unused sensors, which can function as a lower bound for injury prediction and could reduce the mortality of persons involved in road traffic accidents. Going forward, future works need to implement and validate the herein-proposed components of the framework. This includes the design of the real-time semantic processing, encoding, and transmission of the data locally in the car. The incorporation of the communication process within the existing ISAN framework. The implementation of the simulation server, encompassing the inclusion of an appropriate physics engine that allows for the extraction of the relevant data. Lastly, all produced information needs to be accessible in an intelligible format, which allows for a hierarchical overview of the whole scene, starting with vehicles and ending with the detailed injuries afflicted on a single passenger.

Following the creation of a prototype, the practicalities of the framework can be further examined. Hardware requirements can be specified and scale-ability regarding the number and complexity of simulations could be evaluated. Existing databases, such as the Crash Injury Research and Engineering Network (CIREN) which have been employed by Golman et al. to test the injury prediction of FEMs[11], could be utilized to test the injury prediction process. Expanding on this approach, the proposed visualization of information could be scrutinized. Finally, it needs to be tested, whether the provided information leads to an improvement in the decision making process and has a measurable impact on the outcome of rescue missions.

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