CRASH INVOLVED OCCUPANT COUNT PREDICTION

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ABSTRACT

Current vehicles don't evaluate the number of occupants in a crash. Automatic Crash Notification systems (ACN) (i.e. OnStar, eCall) require crash dataset. This dataset includes information to support a crash severity evaluation (i.e. Advanced Automatic Crash Notification & Injury Severity Prediction). AACN & ISP support the emergency response by triggering rapidly the proper medical response.

However, to this date, one valuable piece of information is still missing: the occupancy. The occupancy number would enable an emergency response with the proper magnitude. In the post-crash notification systems, a proposed feature is named Occupant Count Prediction or OCP.

With OCP, PSAPs (Public Service Answering Points) would obtain a predicted occupant count allowing them to tailor the emergency response magnitude to the actual crash. Ambulances or ERTs would be dispatched when/where needed, in the correct numbers, thereby increasing efficiency.

This paper identifies several formulas to quantify OCP. It is also discussed an array of sensors which could be used as input into those OCP formulas. The analysis includes the accuracy of several sensor combinations and demonstrates a relationship between the number of sensors and the prediction accuracy.

GIDAS is used for validating, or predicting the accuracy of, an Occupant Count Prediction algorithm. For most OCP formulas, the accuracy is above 94%. The accuracy gets upward of 99% in vehicle fully equipped with sensors. However with the current ubiquitous equipment in today's typical vehicle we can predict with 97.6% accuracy the occupant count OCP.

OBJECTIVE

This paper discusses a potential new feature for ACN systems. The OCP (Occupant Count Prediction) would supply a prediction of occupancy in a crashed vehicle. This feature leverages a few typical sensors inside the vehicle. Several variants of sensor combination and OCP formulas are proposed. GIDAS is used to evaluate the field accuracy of OCP predictions.

METHOD

This paper describes several steps. The first is to process the GIDAS database to obtain a field description of the vehicles, the number of occupants and their belt usage. The second step is to identify a set of vehicle sensors and their output. The third step is to identify several formulas using combinations of sensors to predict the number of occupants. The fourth, and last step, is to compare the predictions with the actual number of occupants and gauge the accuracy of each sensor set and formula.

OCCUPANT DATA

The GIDAS database contains a large number of accident cases. The dataset is filtered for cases with passenger vehicles, resulting in a set of 21315 accident cases. For the purpose of this analysis, only cars with up to 5 seating positions are considered.

Some accidents cases contain more than one vehicle. Looking at these independently, the number of individual vehicles represented is 29876. Processing further down to the number of occupants, this accident set contains 43448 passengers. GIDAS is considered to be a good sample of the accident field.

The occupancy distribution breakdown is given in Table 1.

Table 1. Occupant set position distribution

Total number of occupants	43448	100%
Driver	29852	69%
Passenger	8906	20%
Rear Left	1933	4%
Rear Right	2392	6%
Rear Center	365	1%

For each passenger, these 6 types of parameters are extracted:

1. Position in vehicle
2. Belt usage
3. Age, Age group
4. Size, estimated size
5. Weight, estimated weight
6. Gender (inclusive pregnancy)

Note on the weight: in GIDAS the weight is given but also an estimated weight. Going forward the "weight" is understood as the smaller of the 2 weights.

SENSORS DESCRIPTION

In this paper, only 2 types of vehicle sensors are considered:

1. Buckle sensor
2. Occupant detection sensors.

The Buckle sensor is the common ubiquitous sensor. For the evaluations below, this sensor is assumed to supply the information to the algorithm that the occupant is belted when the occupant is identified as belted in the GIDAS files.

The Occupant detection sensors are also quite common nowadays. There are 2 main types: the advanced occupant sensing (capable of differentiating between persons and child seats) and the simpler contact-strip used mainly to cut off belt warnings when seats are empty.

IMPLICIT DRIVER PRESENCE

In most if not all vehicles, the driver seat is not equipped with an occupant detection system, because it is assumed the driver is always present in the vehicle. In the next steps, some the proposed algorithms will also use the same logic and assume a driver presence.

OCCUPANT AND VEHICLE DATA PROCESSING

The first step in this processing is the occupants' set from GIDAS. Every occupant file is processed to obtain his position in the car, his belt usage, age, weight, etc.

The OCP's goal is to provide an accurate count of the persons present inside the vehicle. The persons may be present, but they need to be counted.

Buckle sensor
The buckle sensor returns the information of belt usage. For the OCP, the buckle sensor's output is used as a surrogate measure of presence:

Belt used = Occupant counted

If the belt parameter is unknown or NA, then the output is considered as "not buckled", and therefore the occupant is not counted.

Occupant detection sensor
The Occupant detection sensor provides a direct information of presence. The occupant's weight is the main characteristic driving the sensor output. It is assumed that the sensor would provide a confirmation of presence if the person's weight is above 15kg. Unfortunately, in some GIDAS accident cases, the weight is unknown or undocumented. In this case, the age of the person is used as a surrogate. In the absence of weight data, a positive detection is assumed when the person is 7 years old or older. If weight, age, age group are all unknown, then size, or estimated size, and pregnancy status were used to qualify the person into the adult/non-child age group.

The parameters used in this order:

Weight or estimated weight	(>=15kg)
Age or estimated age	(>=7y)
Age group	(>=6-12y)
Size or estimated size	(>=150cm)
Pregnancy	(yes)

If all of the above parameters are unknown, as a conservative measure, the occupant will be considered undetected by the occupant detection system. Precisely, 1210 occupants remain without any information supporting a determination for the occupant sensor.

641 of 1210 are actually belted.
23 of 1210 are actually unbelted.
545 of 1210 have an unknown belt status
1 of 1210 as an NA belt status.

The 641 belted occupants with unknown detection potential may be captured by the buckle sensor when used by the algorithms.

Occupant detectable = Occupant counted

If the above parameters driving detection are unknown or NA, then the occupant is considered as "undetected", and therefore the occupant is not counted.

SENSORS COMBINATIONS

Vehicles can be equipped differently with sensors. The objective is to consider a few relevant sensor combinations and apply some logical variants.

The Buckle sensors, the occupants' sensors, and the implicit driver presence are combined in these 7 variations Vx:

V1: Belt sensors on every seats only
V2: Driver + belt sensors
V3: Occupant detection sensors on every seats only
V4: Driver + occupant detection sensors
V5: Belt and weight sensors on every seat
V6: Driver + belt & occupant detection sensors
V7: Driver + Passenger Belt & Detection + belt sensors in the rear

The objective for V2, V4, and V6 is to determine if the "implicit driver" increases the accuracy of the OCP.

V6 is designed to be the most comprehensive sensor combination with the implicit driver. It is expected to be the most accurate

The risk of over counting existing here exclusively because of the implicit driver. In some rare cases, a vehicle in involved in an accident without a driver. The formulas with an implicit driver will provide an over count by one.

The risk of under-counting exists also. It is driven by 2 factors:

1. Unbelted occupants
2. Undetected occupants

The lack of information on the 545 of 1210 occupants identified above as unbelted with unknown weight/age will appear as undercounted if they are not drivers and cover by the implicit driver.

OCP CALCULATIONS

The previous steps are laying the ground work at the occupant level. The buckle sensor output and the occupant detection output are defined. The seating positions are known, which allows processing an implicit driver as well.

For the OCP, the evaluation needs to get back to the vehicle level. In a spreadsheet, every vehicle will have for every position 3 sensor outputs:

1. Buckle sensor
2. Occupant detection sensor
3. Both combined (with a Boolean “OR”)

Furthermore, every vehicle will have the 7 variations of sensors calculated

Example of formula for V7: Driver + Passenger Belt & Detection + belt sensors in the rear

OCP(V7)= 1+
PassengerBuckle(OR)PassengerDectection + RearLeftBuckle +RearCenterBuckle + RearRightBuckle

COMPARISON OF OCP WITH REAL OCCUPANCY

The results summary for the OCP evaluations is in Table 2. It also includes details about the number of cases with over- and undercounting occurs and by which amount.

In Table 3, the % of correct prediction is calculated, as well as % of over and under-predictions.

Table 2: OCP results

Total number of Occupants = 43448	V1 buckle	V2 Driver + Buckles	V3 Occ. Detection	V4 Driver + Occupant Detection	V5 Buckle & Occupant Detection	V6 Driver + Buckle & Occupant Detection	V7 Driver +Pass. Buckle & Detection + Rear Belts
OCP result	36533	41210	42683	42848	43272	43378	42496
Diff. to occupancy	6915	2238	765	600	176	70	952
% diff.	15.9%	5.2%	1.8%	1.4%	0.4%	0.2%	2.2%
Over counting by 1	0	15	0	22	0	24	20
Correct Prediction	24556	28169	29226	29320	29727	29770	29169
Under Counting by 1	4143	1306	557	459	130	74	464
Under Counting by 2	884	243	75	63	12	4	161
Under Counting by 3	192	111	15	11	6	4	62
Under Counting by 4	77	32	2	1	1	0	0
Under Counting by 5	24	0	1	0	0	0	0

Table 3: OCP results, % of over, under and correct predictions

Number of Veh. = 29876	V1	V2	V3	V4	V5	V6	V7
Over-predict	0.00%	0.05%	0.00%	0.07%	0.00%	0.08%	0.07%
Correct	82.2%	94.3%	97.8%	98.1%	99.5%	99.6%	97.6%
Under-predict	17.8%	5.7%	2.2%	1.8%	0.5%	0.3%	2.3%

CONCLUSIONS

It is possible to use GIDAS for predicting, or validating, the accuracy of an Occupant Count Prediction algorithm. Most formulas have an accuracy above 94%. The accuracy gets up to 99.6% in vehicle fully equipped with sensors. However with a typical equipment in today’s vehicle (buckle sensors on all seats and a front passenger detection) we can predict with 97.6% accuracy the occupant count.