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Piotr ALEKSANDROWICZ

University of Science and Technology, Institute of Automation and Transport,
Machine Maintenance Department
Al. prof. S. Kaliskiego 7, 85-796 Bydgoszcz, Poland
Corresponding author. E-mail: p.aleksandrowicz@utp.edu.pl

VERIFICATION OF MOTOR VEHICLE POST ACCIDENT INSURANCE CLAIMS

Summary. Use of a vehicle involves a risk of collision and, consequently, high costs of post-accident repairs. Therefore, if there is no insurance cover and the repair must be paid by the vehicle owner, some of them choose to file fraudulent insurance claims as the damage can be very difficult to verify. Payments of undue damages pose a major social and economic problem. This article deals with these problems and puts forward a proposition of insurance claim verification by means of a new research method to increase the efficiency of detection and elimination of such claims. This new method requires division of the damage-verification process into static analysis (S), dynamic analysis (D) and analysis of characteristic damage (C). The obtained results show that insurance companies have had problems with selection of appropriate research methods to verify the insurance claims. Application of the proposed new method allows to reduce payments of undue damages and the costs of court proceedings.

1. INTRODUCTION

Road traffic poses a risk of road accidents and collisions. According to statistical data, as many as 32 760 accidents and 436 469 road collisions were reported in Poland in 2017 [1]. This translates to almost half a million undesirable road events. It must be noted that the above-given number of collisions corresponds to the number of such events reported to the police. In Poland, collisions do not need to be reported to the police and involvement of the police makes it difficult to fake damage. In turn, reports of the Polish Insurance Chamber (PIU) show that each year, insurance companies cover traffic damage in the amount of 1 700 000 PLN from the obligatory third-party liability insurance and voluntary comprehensive cover insurance, hence, a few times more than the number of reported events. PIU data also show that the phenomenon of insurance fraud poses a major threat. In 2017, in Poland, the number of third-party liability insurance offences claimed by the motor vehicle owners was 8 700 for the sum of 30 000 000 € to cover the costs of post-accident repairs. The actual scale of this phenomenon is not known, however. According to PIU, the number of undetected frauds is high [2]. This is a serious social and economic problem and it does not apply to Poland alone. Traffic insurance frauds are also reported in other European Union countries, discussed in work [3], which addresses the phenomenon in Germany and Czechoslovakia. The literature does not provide any comprehensive method for the verification of auto insurance claims to support decision-making. The authors usually deal with some selected issues, whereas practice and research results indicate that there is a need to introduce changes and develop a new approach to the problem. Such an approach is provided by the proposed verification method.

The first of the procedures to be used for verification is the static method (S). It involves comparing the geometric dimensions of the vehicle damage, and establishing, on this basis, whether they are

consistent or not. To compare the geometric consistence of the damage zones, it is necessary to use verification procedures that are adequate to the obtained data. For example, in work [4], a comparison of the geometric consistence of the vehicle damage by means of transparent super-positioning is presented. This kind of procedure involves overlapping scaled images. One of them must have decreased transparency to make visible the vehicle damage recorded in the other photograph. In the above-mentioned work, a comparison is performed of a collision of a passenger car and a truck. In motor vehicle claims, photographs do not always enable an appropriate transparent superposition. Most frequently, photographs of the indicated perpetrator's vehicle are not available, which limits application of this method. To compare the damage, apart from photographs, vector-based shapes of the vehicles can be used. These are graphically presented silhouettes of vehicles accurately representing the shapes of vehicles' bodies and they are in the same scale. They can be obtained from commercial online data or a CD record. A comparison of the real objects involved in an accident with the damaged elements of the vehicles also provides good results. In practice, however, this kind of comparison is even more limited as the vehicle of the indicated perpetrator is usually in a different location than the vehicle of the claimant or is no longer available, or its damaged elements have been removed. Below, the assessment procedures most frequently used for the static damage comparison method, involving scaled photographs, Fig. 1a, and vector-based silhouettes, Fig. 1b, are presented. However, to provide the possibility of using a combination of procedures of S analysis, a video was made as well [5]. It needs to be stressed that S analysis does confirm possible contact between vehicles, but does not confirm the reported circumstances.

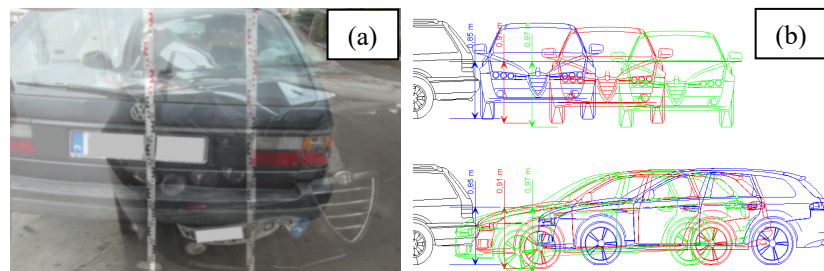


Fig. 1. Transparent superposition of damaged vehicles on the basis of scaled photographs (a), a comparison of damage zones on the basis of vector-based silhouettes (b)

The second assessment procedure is dynamic analysis (**D**). It uses simulation programs for road accident reconstruction. Verification with the use of this procedure involves time–space relations, collision and post-collision positions depending on the available input data. However, selection of a simulation program should be based on the purpose of modeling and the range of available data. Simulation programs by the finite elements method (FEM) are not used to verify accidents for traffic insurance claims, although they offer accurate calculations, for example, LS-DYNA program, presented in work [6]. It was used for an experimental simulation of a passenger car collision with a fence wall and, then, the results and deformations of elements were compared with those obtained from the simulation. In turn, study [7] presents deformations of a passenger car caused by hitting a wall to prove that the engine chamber cover frame structure needs to be replaced to improve the safety of the vehicle users. FEM programs require very efficient computers and uploading of a lot of material and geometric data. In traffic claims, there are no such data and insurance companies do not employ specialists who can operate such programs. However, programs used for modeling collisions in the Multi Body System (MBS) convention are commonly used by experts and employees of insurance companies. They do not require much computing like FEM programs. They do not set high requirements for introduction of input data either. These programs include PC-Crash, Virtual Crash and V-SIM. PC-Crash enables modeling of different kinds of events, which are discussed, among others, in work [8]. In turn, [9] presents the simulation results of a comparison of a small coverage head-on crash performed by means of Virtual Crash program. The authors provided a rollover of a vehicle like in the recorded test.

In Poland, however, the V-SIM code, which is applied in the SDC assessment method, is commonly used. It models the car motion as a motion of a solid body with 10 freedom degrees. Modeling is performed with the use of two systems of coordinates, the first one being a global system. This system of coordinates shows the current position of the simulated objects and the designed arrangement of the environmental elements. The axes of the system coordinates are marked x , y , z . Axis z is directed upwards and the position of the system start is established by the program operator. The second system is associated with the simulated object and its axes are marked x' , y' , z' . This is a system that determines external forces acting on the simulated object. The center of the system is in the middle of the vehicle curb weight. Axis x' is oriented in the direction of the vehicle natural motion, whereas axis z' is vertically oriented upward of the unloaded vehicle. The position of the vehicle curb weight center is determined by radial vector r_c , which is presented below, Fig. 2.

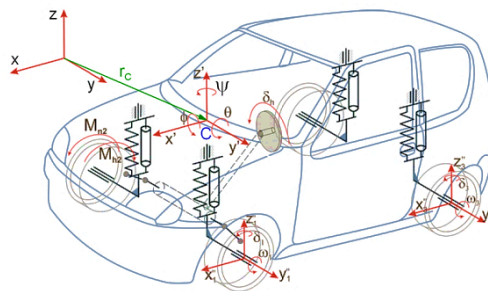


Fig. 2. Model of vehicle with co-ordinate systems [11]

V-SIM program offers two tire models: HSRI developed by the Dugoff team and TM-easy for the newest tires as well as a kinematic model of an independent suspension of wheels whose deflection is determined separately for each wheel that is described in work [10]. The vehicle model included stiffness of suspension of a progressive nature and different damping values for the shock absorber compression and stretching as well as stiffness of control arms, whereas the vehicle steering system is modeled according to Ackerman rules. The program enables to change the vehicle curb weight, arrangement of cargo and passengers and the definition of the major inertia moments. The model of the braking system includes optionally a corrector of braking forces with parametrically given characteristics and provides the possibility of ABS system operation. The power transmission system has clutch models and transmission of the drive onto one of the vehicle axels whose number is three. The program also includes aerodynamic resistance of the body. Moreover, it provides the possibility of modeling the performance of tasks such as acceleration with an option for a driver to simulate change of pressure on the gas pedal, turning the steering wheel left, use of the main brake to change pressure on the brake pedal, blocking the wheel and dropping tire pressure to simulate an increase in the wheel movement resistance caused, for instance, by deformations of the body and a punctured tire.

However, using programs that perform calculations in MBS convention poses some problems because it uses simplified models of contact between the simulated objects. In work [11], contact models of V-SIM4 programs are discussed. It is necessary that the program user should choose a model to match the analyzed collision. It applies mostly to the cases when incompatible vehicles collide. Acceptance of a default 2D detection model for collisions of such vehicles, which detects a collision based on the object shape projection onto the ground, does not reflect the actual circumstances of a collision well. Sensitivity of the obtained results to input data is important for SDC analysis because the information about traffic claims is not complete and characterized by uncertainty.

Below, there are differences in the vehicle stopping position, in Fig. 3a, according to the driver's relation and, in Fig. 3b, according to the damage assessment. Simulation calculations have been carried out by means of the above-characterized program V-SIM4 - version 4.0.20. According to the dynamic analysis, in the analyzed case, hitting a tree, as declared by the driver, was not possible as before changing the direction of travel, the vehicle had already gone past the indicated obstacle. However, the findings from the vehicle deformation revealed that hitting a tree would be possible, but

for different speed values and a different distance of the vehicle from the obstacle at the moment of making a decision to pull up and turn left onto the road side compared to the information included in the claim. Dynamic analysis allows to verify whether a collision occurred in the described circumstances or not. To make the possibility of the use of analysis D more clear, a video was made [12].

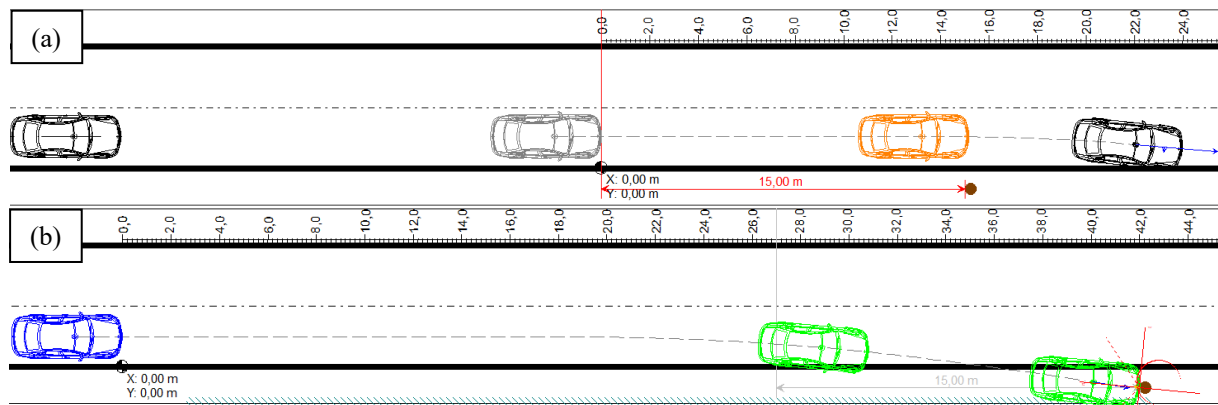


Fig. 3. Positions of a vehicle in time according to the data given by the driver (a), positions of the vehicle in time and space and impacts established on the basis of its damage (b)

As mentioned above, the modeling results should be treated with caution, especially in cases where the initial data are used for calculations but are not determined on the basis of a real experiment. The issue of sensitivity of a simulated collision pattern to initial conditions was also investigated in work [13, 14], whose authors searched for the most probable pattern of a collision using the method of Monte Carlo.

The literature review indicates that experimental verification of V-SIM program applied in the SDC method for a dynamic analysis is really used.

The results of tests of a head-on collision of a passenger car with a rigid barrier for 40 % overlap, with the use of this program, are presented in work [15]. The authors show the possibilities of using the program default parameter change to obtain appropriate simulation results. This information can be supportive for experts, specialists and insurance agents in performing a dynamic analysis of a claim by the SDC method. However, simulation of a right-angle passenger car collision in V-SIM program is presented in works [16, 17]. The authors confirmed the sensitivity of the collision circumstances to the input data introduced by the program operator to the simulation.

The marks of the crash left on the road and the vehicle bodies during their contact provide data to be analyzed for damage by the third of the proposed methods, that is, verification of characteristic damage (C). For example, in work [18], a perpendicular crash is analyzed including the deformations of bodies and characteristic damage to the vehicle door up to the towing device. In turn, in work [19], the formation of characteristic marks, paint scratches and paint marks left on each of the vehicles involved in the collision is discussed. In work [20], marks of paint accumulation and its characteristic wave shape are analyzed. This work also includes practical examples of this verification method application and calculations of the relative speed of the colliding cars. The best verification results of damage characteristics are obtained on the basis of inspection of the real object. It allows to thoroughly inspect the vehicle-damaged zones and collect samples of, e.g., the paint or tree bark, for further comparative analysis of the indicated obstacle or the perpetrator's vehicle. In practice, verification of claims is usually carried out on the basis of images. The most common marks documented in photographs include accumulation of paint, pieces of bark from a tree trunk or concrete from a pole. Below, there are exemplary marks in the form of paint accumulation on the damaged side of the vehicle, Fig. 4b. However, it needs to be emphasized that C analysis provides information only about the possible contact of vehicles, but does not prove that it occurred in circumstances described by the claimant. To become familiarized with the possibilities to apply C analysis and the kinds of marks detected on the collision site, a video was recorded [21].



Fig. 4. Characteristic marks in the form of paint accumulation on a vehicle of the claimant (a) and pieces of paint impacted into a tree trunk - indicated obstacle (b)

In this study, a new complex approach has been proposed - a static, dynamic analysis and an analysis of characteristic damage - for verification of the vehicle damage as well as a decision process along with a supportive program. This new approach to SDC convention allows to identify and eliminate fake damage. A video was recorded to show a practical application of the proposed method supporting the decision process by a developed program [22].

2. VERIFICATION PROCESS BY SDC METHOD

To provide the effectiveness of verification and detection of fake insurance claims, the process of SDC analysis covers all the stages: from filing the claim to making a final decision. The SDC method supports the decision process using a developed program [23]. The assessment method is shown below in the form of a block scheme Fig. 5.

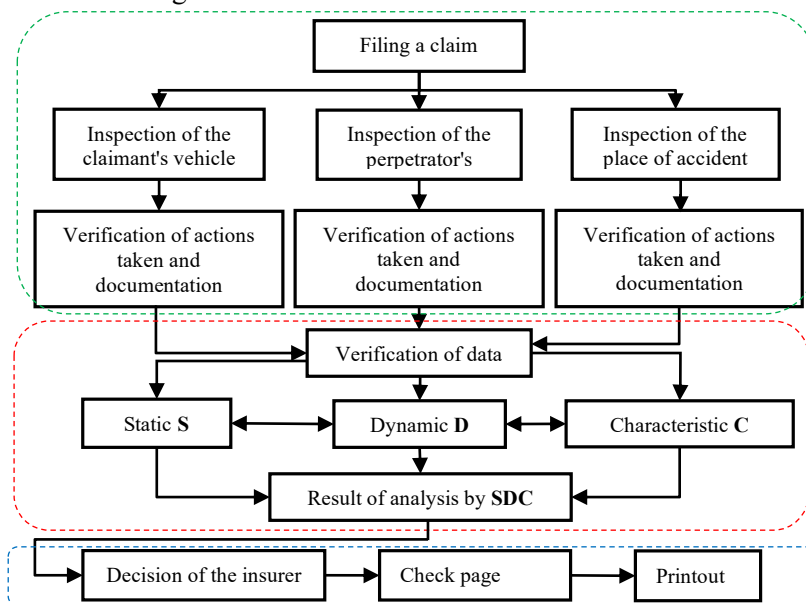


Fig. 5. Verification by the SDC method used in the process of claim settlement

The presented assessment method includes three levels (stages) of the claim settlement process:

1. filing an insurance claim and commencement of settling procedures and verification of collected documentation,
2. verification: static (S), dynamic (D), vehicle and obstacle characteristic damage (C), implemented depending on the available data that are used to provide the result by the SDC method and

3. decision of the insurance company with reference to the input data and S, D, C analysis results.

2.1. Level one – filing a claim and initial data

At this level, the actions to be taken for the claim settlement involve analyses of the input data. They also have equivalents in the spaces for choice of dialogue windows of the developed program. These actions and data connected with the damaged vehicle, perpetrator and the site of collision include the following:

- inspection (confirms inspection),
- marks caused by collision with another vehicle (indicates disclosure of vehicle post-collision marks),
- marks caused by hitting an obstacle (indicates disclosure of vehicle marks caused by hitting an obstacle),
- non contact claim (for a vehicle of the indicated damage perpetrator who did not collide with the claimant's vehicle, although improper behavior of the perpetrator created a threat that led to the claimant's vehicle damage),
- accumulation (indicates detection of accumulation of e.g. paint, organic substances and others),
- representation of shapes (indicates detection of characteristic damage in the form of representation of shapes on contacting surfaces during collision),
- body deformation measurements (confirm measurements of geometric deformations of bodies of the claimant's vehicle),
- situational sketch dimensioned with an obstacle (confirms preparation of technical documentation in the form of a sketch prepared during inspection of the indicated place of damage),
- measurements of damage sites (confirm geometric measurements of damage sites for static analysis and characteristic damage) and
- photographs (confirm taking photographs).

2.2. Level two - results of collision verification with the use of S, D, C procedures

The second level of the process involves reviewing the damage verification by the SDC method. Each of the procedures that are presented below may give a positive or a negative outcome. The program operator's task involves marking the obtained results of S, D and C procedures:

Static verification (S):

- real objects (means performance of an analysis on the basis of real objects' presentation),
- transparent (means performance of an analysis on the basis of transparent superposition),
- images and vector based (means performance of an analysis on the basis of comparison of a scaled image with a vector-based silhouette),
- vector silhouettes (means performance of an analysis on the basis of juxtaposition of vector silhouettes).

Dynamic verification (D):

- time/space reconstruction (means performance of an analysis on the basis of physical evidence),
- time/space declared (means performance of an analysis on the basis of parameters provided by the victim),
- simulation (means an analysis based on the expert's estimated parameters),
- no data (means that a lack of data makes it impossible to carry out a dynamic analysis).

Verification of characteristic damage (C):

- accumulation (means that accumulation on the surfaces in contact during the collision was found),

- representation of damage (means that representation of characteristic shapes was found on the surfaces in contact during the collision),
- copying (means that damage unrelated to the claim was revealed),
- no data (means that a lack of data makes it impossible to carry out an analysis of characteristic damage).

2.3. Level three – decision of insurer and supervisor

The last level of the verification process has been provided with the possibility of generation of a report including the insurer's decision and control card documenting all choices made by the verifier using SDC program. The user can print these documents or export them in an Excel file to be stored in an electronic form.

3. CASE STUDY – OWN RESEARCH

For the purpose of studying the effect of input data and S, D and C analyses on the correctness of the decision to refuse a damage claim, 94 cases of claims turned down by an insurance company were analyzed. Negative results meant that the decision of an insurance company was right, which accounted for only 30.9% of all the considered claims, whereas, in the remaining, positively considered cases, the decisions were wrong.

Group I - factors connected with the inspection of the claimant's vehicle. The inspection was carried out in all 94 cases and the following facts were reported:

- marks of an impact with another vehicle,
- marks of an impact with an indicated obstacle,
- accumulation in the vehicle bodies,
- representation of characteristic shapes,
- performance of measurements of vehicle damage,
- localization of the vehicle body damage,
- taking photographs of the vehicle.

Group II - factors connected with an inspection of the perpetrator's vehicle. It was carried out in 71 cases and the following was reported:

- marks of an impact with another vehicle,
- occurrence of non-contact damage,
- accumulation on the vehicle body,
- representation of characteristic shapes,
- measuring deformation of the vehicle damage,
- measuring the sites of the vehicle body damage,
- taking photographs of the damage.

Group III - factors connected with an inspection of the indicated site of collision. It was performed in 48 cases and the following facts were reported:

- marks of the impact on an indicated obstacle,
- marks caused by a road collision,
- accumulation on an indicated obstacle,
- representation of characteristic shapes,
- drawing a situational sketch of the site of the impact with an obstacle,
- measuring the location of damage,
- taking photographs at the site of the accident.

In terms of the statistic verification factors (they were reported in all 94 cases), positive or negative results were also obtained according to one of the following procedures:

- comparison of real objects involved in the accident,
- transparent superposition of the damaged objects,
- comparison of the photograph and the vector-based silhouette of the damaged objects,
- comparison of the damaged objects with the use of their vector-based silhouettes.

Among the factors involved in the dynamic verification (data were collected from 72 cases), six results were possible, that is, a positive or negative outcome in the procedures:

- time/space – reconstruction,
- time/space – declared,
- simulation.

Regarding the factors that are involved in characteristic damage, 79 observations were available, which included the following:

- accumulation on the vehicle,
- representation of characteristic damage shapes,
- copying damage from another claim unrelated to the filed claim.

3.1. Accepted statistical methods

An accuracy test of Fisher is a statistical test that makes it possible to analyze the independence of two groups characterized in frequency tables with dimensions 2×2 . As compared to the χ^2 test, being applied in similar cases, the calculated p -value is accurate and does not require fulfillment of the condition of sample size [24].

Logistic regression – A regression model, which uses observation of independent variables for estimation of chances for a binary independent variable to assume one of the values (assumes two values: 0 or 1), is used. If p stands for the result probability to be 1, then the probability of 0 result is equal to $1-p$, whereas the chance is a ratio of these probabilities $\frac{p}{1-p}$. An indicator of the model adjustment is an information criterion of Akaike (AIC). It is used for comparison of models differing in terms of independent variables [25].

Value 0.05 was accepted as the level of significance. All calculations and diagrams were performed with the use of statistic packet R version 3.4.0.

3.1.1. Independent tests

The research involved the performance of statistical tests for the collected data to verify the hypothesis of lack of impact of particular factors on the correctness of the final decision of the Insurance Company (IC).

Below, results are presented that allowed to reject this hypothesis. If accumulation was found on the claimant's vehicle, a correct decision was made in 44.4 % of the cases.

However, when no accumulation was found, wrong decisions were more frequent, which accounted for 77.6 % of cases, Fig. 6. The statistical significance of this difference was confirmed by the Fisher test, for which the p -value was 0.038.

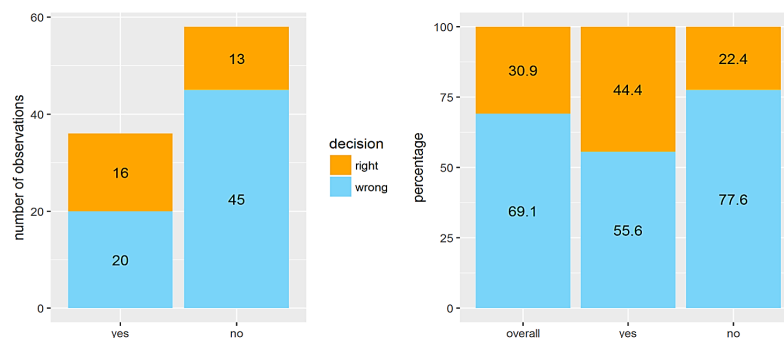


Fig. 6. Decisions of IC depending on the occurrence of accumulations on the claimant's vehicle body

P -value < 0.001 in the Fisher test shows that measurements of damage location on the claimant's vehicle body were statistically significant, a positive influence on the correctness of IC decisions that is presented below, Fig. 7.

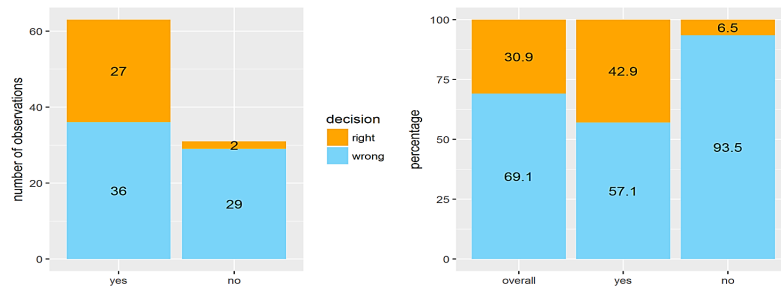


Fig. 7. IC decisions depending on measurements of damage location on the claimant's vehicle body

Correct decisions were made more often when an inspection of the place of collision was carried out. The differences found were statistically significant, which was confirmed by the Fisher test (p -value = 0.026), Fig. 8.

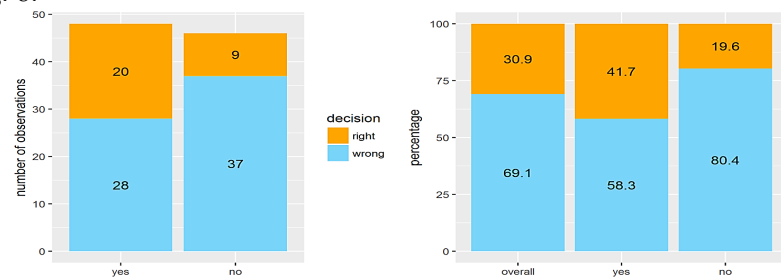


Fig. 8. IC decisions depending on the inspection of the indicated site of accident

The calculations show that, at the significance level of 0.05, it was necessary to reject the hypothesis that measurements of damage location on the obstacle did not affect the correctness of the insurance company decision. The right decision was taken significantly more often if such a measurement was performed. This is confirmed by p -value = 0.031 obtained in the Fisher test, Fig. 9.

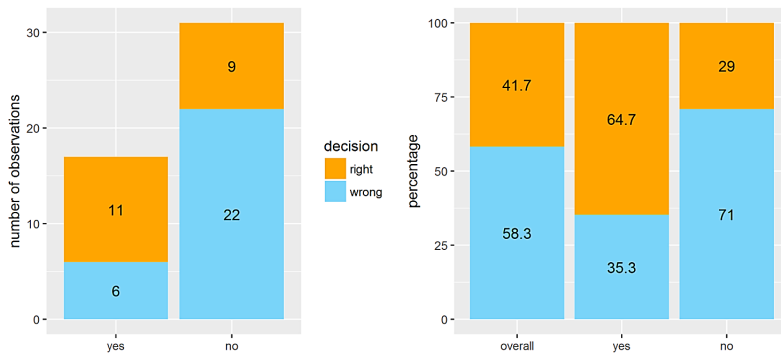


Fig. 9. Decision of IC depending on the performance of measurements of damage location on the indicated obstacle

The research also shows that the insurance company did not make any wrong decision when a negative result was reported in one of the static verification procedures. P -value <0.001 in the Fisher test indicates that the disproportions are not random in character, Fig. 10.

Obtainment of a positive result in the time–space procedure of the dynamic analysis involved making only inappropriate decisions by IC. The statistical significance of this factor was confirmed by p -value = 0.007, which was obtained in the Fisher test, Fig. 11.

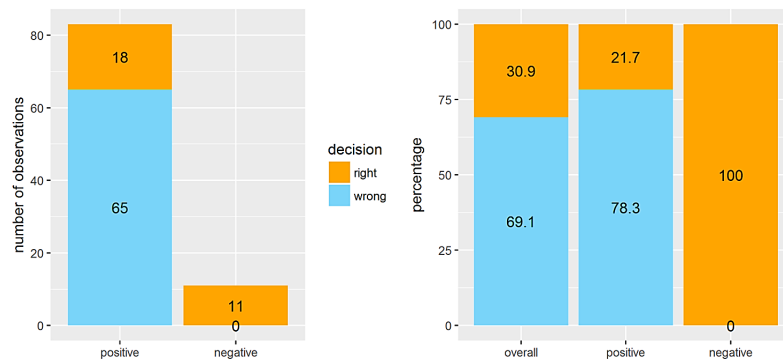


Fig. 10. Decisions of IC depending on the static verification analysis S

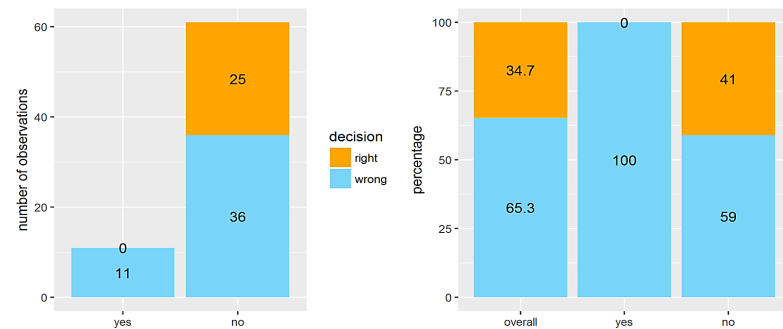


Fig. 11. Decisions of IC depending on the positive result of time/space-declared D analysis positive result

The tests have proven that a negative result obtained in the same procedure implied that the decision taken by IC was right. Thus, the hypothesis about a lack of differences between the groups had to be rejected at the level of significance 0.05 because p -value < 0.001 was obtained in the Fisher test, Fig. 12.

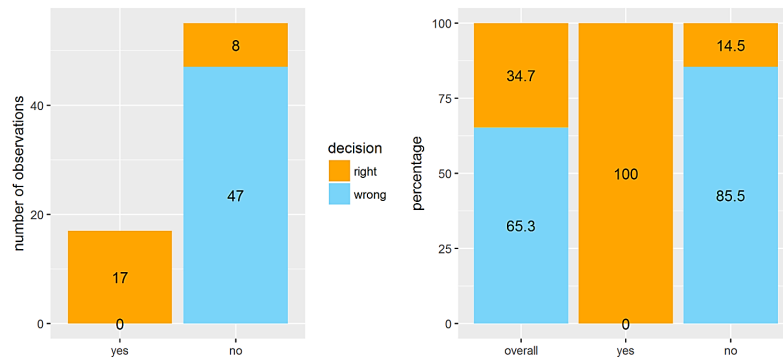


Fig. 12. Decisions of IC depending on a negative result of the time-space procedure – declared analyses D

It was found that disproportions could also be observed in considering positive results of the simulation procedure. Correct decisions were taken significantly more often when no positive result was obtained in this category, which was confirmed by the Fisher test because it provided p -value < 0.001 , Fig. 13.

However, obtainment of a negative result of the simulation procedure indicated no wrong decisions. According to Fisher test p -value = 0.001, the comparable groups differed from each other in this respect, Fig. 14.

3.1.2. Logistic regression

The above calculations were performed separately for the impact of each factor on the correctness of the decision. Logistic regression allows to take into consideration a higher number of parameters.

The goal of application of logistic regression was to model the probability of success. In the analyzed case, a success is defined as the right decision made by the insurance company by observing the remaining variables. In choosing a model, the number of independent variables was limited and matched so that the possible lack of data could not additionally decrease the number of observations. Taking into consideration the AIC information criterion, a model was chosen that included such factors as performance of measurements of the vehicle damage location and inspection of the indicated place of damage. Table 1 shows the coefficients of a logistic regression model marked (*), those that are significantly different from zero. A chance denotes a ratio of success probability (taking a right decision by IC) to failure probability (taking a wrong decision by IC). However, a value in this column is calculated by raising the natural logarithm base (number e) to power equal to the coefficient value. In turn, in the last columns of the table, end values for 95 % of confidence intervals, that is, intervals with 95 % probability, including the value of chance, are presented.

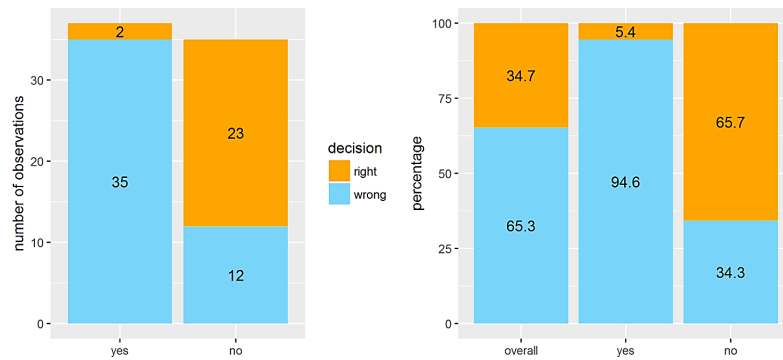


Fig. 13. Decisions of IC depending on the positive result of analysis D simulation procedure

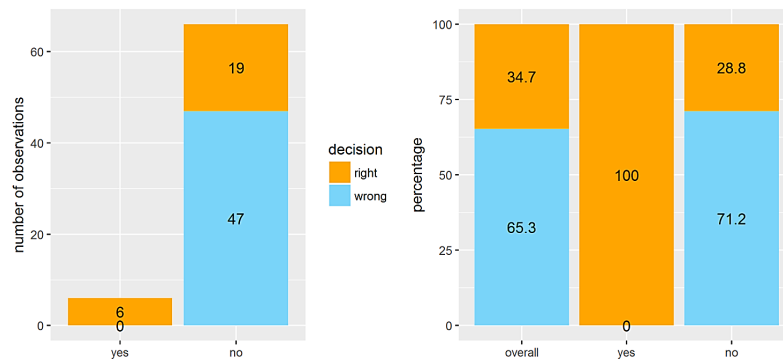


Fig. 14. Decisions of IC depending on a negative result of simulation in the D analysis procedure

The form of the model can be expressed by the following formula:

$$\ln\left(\frac{p(x_1, x_2)}{1-p(x_1, x_2)}\right) = -3.045 + 2.25x_1 + 0.839x_2 \tag{1}$$

where:

$x_1 = \begin{cases} 1, & \text{when a measurement of the damaged claimant's vehicle localization is done,} \\ 0, & \text{otherwise,} \end{cases}$

$x_2 = \begin{cases} 1, & \text{when inspection of the damage site is done,} \\ 0, & \text{otherwise,} \end{cases}$

$p(x_1, x_2)$ - probability of making the right decision by IC.

Chance for absolute expression 0.048 means that in the logistic regression model, the ratio of success probability to the probability of failure is just like if measurements of the damage location were not performed for the damaged vehicle or inspection of the accident site was not carried out.

However, fulfillment of any of these conditions was associated with an increase in a chance for success by, respectively, 9.491 and 2.313 times. In turn, based on an assumption that the location of damage sustained by the claimant's vehicle and inspection of the collision site were carried out, the chance of taking the right decision was $0.048 \times 9.491 \times 2.313 \approx 1$, and the probability of success was approximately 50 %. The above regression model was used for the calculation of the probability of taking the right decision on the basis of observations. Based on these values, it was possible to create a classifier that, for a given observation, determined whether a given decision would be positive depending on whether the probability of this event is higher than a certain established level (the so-called cut-off level). Sensitivity, which is a ratio of the number of properly classified decisions to the number of all correct decisions as well as specificity, that is, a ratio of the number of properly classified decisions to the number of all wrong decisions, can be calculated for a classifier with a given cut-off level. Both these values are presented below, for two different cutoff levels Fig. 15, on a ROC curve [26].

Table 1

Coefficients of the logistic regression model

	coefficient	chance	2.5%	97.5%
Free word	-3.045*	0.048	0.007	0.176
Measurement of the claimant's vehicle damage location	2.25*	9.491	2.498	62.444
Inspection of the damage site	0.839	2.313	0.875	6.411

One of the methods for the assessment of the classifier quality is to calculate the field beneath ROC, which, in the analyzed case, provided a result equal to 0.744. The most effective classifiers reach values close to 1. The regular shape of the obtained curve is the result of a simpler shape of the logistic regression, in which two binary variables are independent variables. A set of calculated probability values can then consist of four values. The value of probabilities equal to 41.1% corresponds to the cut-off level for which the sensitivity and specificity are the highest. The sensitivity for such a classifier would be 65.5% and the specificity would be 72.3%. The positive predictive value (PPR), that is, the percentage of actual, appropriate decisions out of all decisions qualified as appropriate would be 51.4%. The negative predictive value (NPR - percentage of erroneous decisions out of all decisions qualified to be wrong) would be equal to 82.5%.

4. CONCLUSIONS

The research shows that each time, wrong decisions were made when:

- the result of the dynamic procedure time/space – declared was positive.

The research also shows that all the decisions of IC were right when:

- the result of one of the static damage verification procedures was negative,
- the result of the dynamic procedure time/space – declared was negative,
- the result of the dynamic simulation procedure was negative.

As the research shows, input data have a significant influence on correctness of the decision. The results of the research show that the right decisions prevailed when:

- measurements of damage location on the body of the claimant's vehicle were performed,
- measurements of damage location on the indicated obstacle were performed on the accident site,
- inspection of the indicated place of damage occurrence was performed,
- accumulations were found on the claimant's vehicle body,
- a positive result for dynamic procedure simulation was not reported.

An attempt has been made to create a logistic regression model that would allow to estimate the probability of undertaking right decisions on the basis of the values of the remaining variables. On the basis of the results of the research a model has been built that includes two factors:

- performance of measurements of the victim's vehicle body damage location,
- performance of inspection of the indicated site of accident.

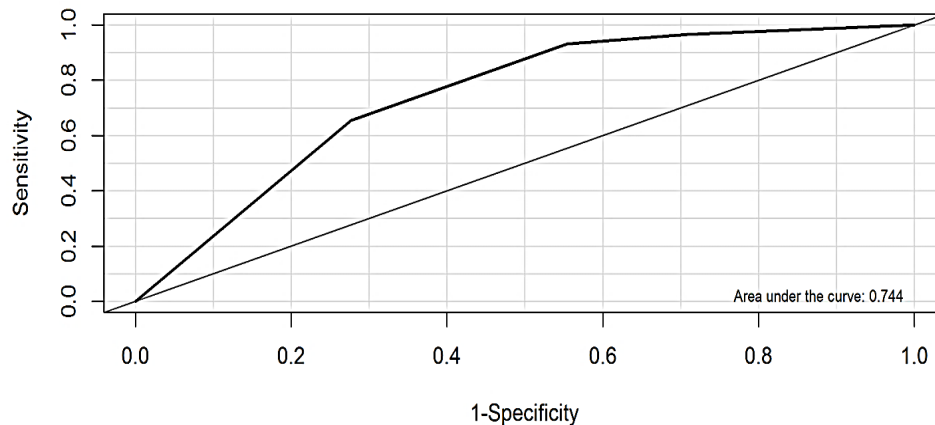


Fig. 15. ROC Curve for logistic regression model

The test results indicate that settlement of each claim must involve measurement of the claimant's vehicle damage and identification of its characteristic damage and inspection of the incident site as well as measurement of the location of impact marks on the obstacle. These data, along with application of the SDC method, will contribute to successful detection of fraudulent claims and will increase the number of correct decisions. Moreover, the research shows that insurance companies have difficulties in using simulation programs for D analysis based on data provided by participants of the collision. To settle the insurance claims, the insurance company should take advantage of its own resources. Therefore, actions need to be taken to provide insurance employees with specialist training courses because it is necessary to model collisions correctly in simulation programs. This issue is described, for example, in the works of [27, 28] based on the PC-Crash program. Otherwise, experts or external agencies should be hired to perform these kinds of analyses. The proposed program offers decision variants to support the process of damage claims verification using the SDC method operated by Microsoft Excel.

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