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Image Processing Based Severity and Cost Prediction of Damages in the Vehicle Body: A Computational Intelligence Approach

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***Abstract*— Vehicle damage detection is one of the important prime activities in the insurance and vehicle rental industries. These kinds of systems are widely used by the driver and also by the insurance company to identify the damage of a vehicle once an accident happens and in order to detect and determine a suitable appraisal as per the damage and for vehicle rental companies to assign the damage of a vehicle to a guilty customer. The core technique of this system is object recognition. However, object recognition and classification being perplexing research ranges, the reliability of a project of this nature lies in the feature selection and extraction mechanisms. This paper presents a novel approach to measure the vehicle body damage severity and to make a cost prediction using 2D images. Thus, once a vehicle body damages, the driver does not have to wait until the insurance company calculates the appraisal, instead he himself can get a brief idea as to how much it will cost to recover the damage. Once an image is uploaded, the system processes the image and identifies the dent. Next, it is classified into the relevant severity class also considering the features of the vehicle like the make, model and the year of manufacture. Afterward, the severity generated as per damage image is mapped with the cost rules, which are constructed based on the properties of the vehicle such as the make, model and the year of manufacture. Finally, the user gets notified with a damage severity class and an average cost from which the damage can be recovered.**

Keywords—Vehicle Damage Detection; Cost and Severity Prediction; Rule based expert systems; SIFT

I. INTRODUCTION

More than 27000 motor accidents take place in the world per annum [1]. In most of these accidents, the drivers or the insurance policy holders have to spend a massive amount of time to get the damage caused to the vehicle estimated. Even though the modern technology is advanced enough to let the driver detect his own vehicle's damage, the related existing products crave for further advancement regarding features. The approach below tries to address the further enhancements.

At present, as soon as a vehicle meets with an accident and a damage is caused to the vehicle, the driver or the insurance policy holder contacts the insurance company and waits for their arrival to the place of the accident. Once the relevant personnel arrive, a traditional approach is followed and the appraisal is calculated. However, frequently the appraisal amount provided by the insurance companies are not sufficient to recover the damage caused. Though there are ways of appealing for the past amount of appraisal, that too is a long procedure. Also sometimes the manual damage detectives can omit some damages or be partial to some parties when the damages are assessed. The damage which is assessed not being presented to the user in an interactive manner too is a very severe problem. Recognition of minor vehicle body damages in a scenario of frequently changing drivers, such as in the car rental or car sharing businesses is too important. [1]

Once a vehicle faces an accident, the priority of the driver or the insurance policy holder is to contrive the severity of the damage as soon as possible, then the approximate cost to recover the damage.

II. VEHICLE DAMAGES AND DAMAGE CLAIMING

A vehicle damage can also be recognized as a deformation in a vehicle, the deformations of interest are dings and dents, where dings are surface deformations which protrude from the surface and dents are depressions into the surface [2].

The number of vehicle damages increases day by day with the increase of the usage of vehicles. There is no universal classification of vehicle damages. A damage can be recognized as a deformation in a vehicle, the deformations of interest are dings and dents, where dings are surface deformations which protrude from the surface and dents are depressions into the surface [2]. According to *Libertymutual.com*, the classification of damages are as follows.

- Minor Damage - scratches, scrapes or dings. For example, a cracked headlight or small dent in your hood.
- Moderate Damage - large dents in the hood, fender or door of your car. If the doors won't open, or if airbags have deployed, you likely have a moderate amount of damage to your car.
- Severe Damage - very heavy damage. These type of damages includes broken axles and bent or twisted

frames. In a severe damage situation, air bags have almost always deployed.

RAC motor company categorizes the damages into four different categories. This categorization is mainly based on the ability of a vehicle to re appear on the road. Though a vehicle damage is classified into one of the above-specified categories, the process of claiming an appraisal is the most important part of assessing a damage.

Once the severity of a damage is identified, the damage is classified to either of these classes. The class of the damage is the key to get an idea of the condition of the vehicle which met with an accident.

Being acknowledged about the damage and its severity of the damage is very important in the damage claiming process. When one has an idea about the damage which has happened to one's vehicle, it is convenient for all the parties who are involved in the damage claiming process (ideally the insurer and the policy holder). Even though the policy holder or the driver has an idea about the severity of the damage, at times, it is important, and the above-mentioned parties are anticipating, to know the cost which it takes to recover the damage.

According to Rethunk, an automobile image processing researcher, "Having an algorithm work under lab conditions or on known images is one thing; developing a system that is accurate and robust for 'natural' images such as cars seen on a parking lot would likely require a team working for several years. In addition to the core problem of creating the algorithm, there are numerous other engineering difficulties."[3]

III. PROPOSED SOLUTION

The proposed system predicts only minor damages which are scratches, scrapes and dings only in the vehicle body. Once a damage image is uploaded to the system, the relevant damage is identified, extracting local features of it to determine the type of the damage caused to the relevant vehicle. The illustration below (Fig1) gives a brief idea about the flow of the proposed approach.

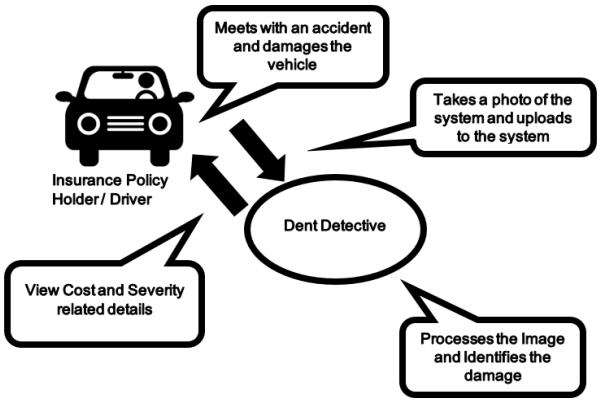

Fig 1 The flow of the proposed solution

Dent Detective is designed to solve the above-described problem using computational intelligence with the usage of 2D images of the damage. Once a vehicle meets with an accident, it is obvious to have at least a small damage. So when any kind of damage occurred to a vehicle, the driver's or the vehicle owner's concerns are, knowing how severe the damage is and to know the approximate cost that will take to repair the damaged component(s). The proposed solution will allow the user to upload an image of the damage. The system will accept the vehicle details of the uploaded damage image. Once the relevant details are uploaded, the image is processed and the severity of the damage will be output along with an average cost prediction as per the damage.

Thus once a vehicle's body damages, the driver does not have to wait until the insurance company calculates the appraisal, he himself can get a brief idea as to how much it will cost to recover the damage. Once an image is uploaded, the image's local features are extracted and classified into the damage classes which were addressed before. Afterwards, the severity generated as per damage image is mapped with the cost rules, which are constructed based on the properties of the vehicle such as the make, model and the year of manufacture. Finally, the user gets notified with a damage severity class and an average cost with which the damage can be recovered.

A. Feature Extraction

Initially, having uploaded the damage image, the local features of the damage image should be extracted. The methodology used for this purpose is SIFT (Scale Invariant Feature Extraction). SIFT, a distinctive feature extraction methodology, which is capable of extracting distinctive features from an image that is invariant of scale and such factors. The main reason for choosing this methodology is the invariance for scale and the angle which the image is taken. The images uploaded by the user cannot be expected to be necessarily of similar angles. They can be of different sizes, different viewpoints and depths. Therefore, the scale of the image changes and matters. Thus the need of an algorithm which is invariant to scale arises. The goal of this method is to extract invariant features of an image and then compare them with corresponding parts of another image taken from a different angle.

The founder of this algorithm, David G. Lowe has clearly defined four main steps that an image should go through when the features are extracted using SIFT. The following illustration is a representation of the defined steps.

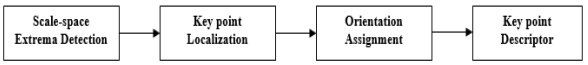

Fig 2 The steps in SIFT

The SIFT algorithm has very high accuracy comparatively, has distinctiveness because of the usage of a larger database of images, and can generate many features considering even a smaller area. Moreover, the efficiency is almost real-time.

B. *Feature Description*

Having identified the local features of the damage image, the necessity of storing and describing the features arises. The Bag of Visual words algorithm which is inspired by the Bag of words algorithm used for text analysis in documents was used in this approach.

Bag of Visual Words uses a dictionary of visual code words which are generated by the extracted local damage features present in the damage images. When a new key point is extracted from an input image, it will be assigned to a nearest key point in the dictionary, so an output of this stage is a histogram of assigned key points in an input image to nearest key points in the dictionary [4]. Having identified and described the features related to each of the damages, the image was classified according to the hence identified features.

C. *Severity Class Classification*

The image classification step has a huge importance in the process of image processing. It is very nice to have a "pretty picture" or an image, showing a magnitude of colors illustrating various features of the underlying terrain, but it is quite useless unless it helps to know what the colors mean [5].

Image classification is the procedure which divides the images into classes taking various features into consideration. To identify the features occurring in an image is the main objective of image classification. The approach which is used in this research to classify the images based on the identified features is Support Vector Machine (SVM).

The extracted features are used to train the SVM, with a training set of data which contain images of different vehicle types. The images are classified into three of the classes mentioned above, namely scratches, scrapes and dings. The following illustration depicts the functionality of the classification module.

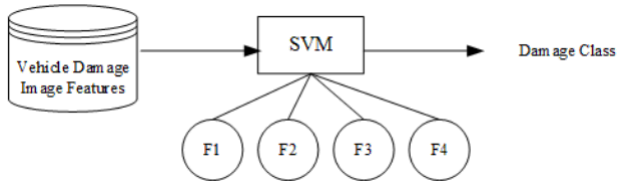

Fig 3 What happens in the classification module

Vehicle damage images are fed into the SVM and the extracted features, marked as F1, F2, F3 and F4. The SVM module gives the damage class which indicates the severity of the damage. The damage severity can be defined in a desired scale, ideally as a numerical score which also has a description of the condition of the severity for a better understanding of the severity of the damage caused.

D. *Cost Rule System*

Rule based systems are commonly called event processing systems and are used to analyze events in real-time to extract useful information that enhances value for the stakeholders [6]. Since no one can provide human experts for classification purposes, automated classification methods can quickly classify large volumes of data into detailed categories [7].

The severity classes produced by the classification module is then mapped to the costs in order to output the user an approximate cost which is based on the severity and the type of the vehicle. Cost rules are conditional statements which take several parameters like the severity of the damage and the type of the vehicle, year of manufacture, (vehicle make and model for further accurate results)

In a rule based expert system, the knowledge base is a set of rules. Rules are a collection of rules about some specific subject area that invariably uses the same pieces of evidence to imply several different hypotheses [8].

In a rule-based inference system, the rules are typically of the form

If E_1 and E_2 and . . . And E_n
Then H

where E_i (i = l …. n) is the i^{th} piece of evidence and H is a hypothesis suggested by the evidence [8].

The following table shows an overview of the cost rule arrangement.

TABLE 1 THE PARTS OF THE COST RULE SYSTEM

Data	Conditions	Rules
Vehicle Type Vehicle Make Vehicle Model Year of Manufacture	Equal, Greater than, Less than	If the severity is = <amount> AND If the Make = <Make> AND If the Model = <Model> AND If the Vehicle Type = <VehicleType>

Once these data are input and the conditions are considered, based on them the rules are imposed and satisfied. Hence the relevant cost is produced.

IV. EVALUATION AND RESULTS

The proposed solution uses the uploaded damage image of the car body and produces the results in the form of damage severity. The following illustration shows the steps by which the image input is transformed into the form of a quantitative output.

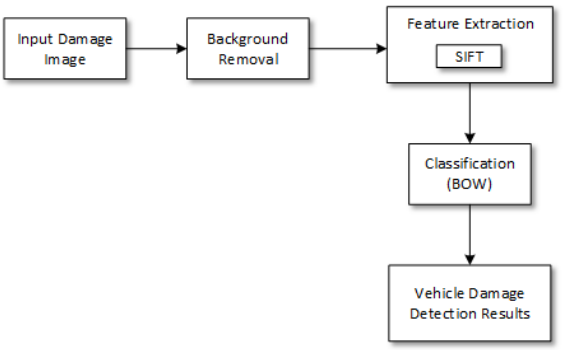

Fig 4 The Technical Flow of the system

After the severity of the damage is produced, then it is mapped to the cost rules which are shown in TABLE 1. The

hence produced results are cross validated with a real-world estimator affiliated to an insurance company. The produced results by the 'Dent Detective' system highly resemble the cost evaluation given by the estimator. However, the accuracy of the system depends on the number of training images used. The more relevant and reliable the damage images are the more is the accuracy of the output. The above fact proves that choosing training and testing data for a research of this nature is critical in an image processing based research project of this caliber. Furthermore, the choice of algorithms also plays a vital role in this research because the conditions of lighting, the distance of the camera to the vehicle, and the angle at which the damage image is taken affect the accuracy of the output. The enhancements of accuracy, performance and functionality are discussed in the future work section below.

V. CONCLUSION

Vehicle damages are often seen in the modern world due to the immense usage of vehicles. The drivers or the vehicle owners should spend a considerable amount of time on finding the severity of the damage and the cost to recover the damage according to the existing approaches. This paper suggests a methodology where a user can upload multiple images of a damage in the body of a vehicle and to calculate the severity and the cost of the damage based on the properties of the vehicle. Though similar applications for this research problem exists, no solution with all features mentioned above exist. The cost and the severity prediction are the unique features of this study. Features like user appeal and the administrators (vehicle insurance companies and vehicle rental companies) being able to update the severities and the cost rules to match the company customers, but they will be implemented in the future.

This research suggests a novel approach to address the problem of identifying vehicle body damages and predicting the severity and the cost. Initially, the damage image's features are extracted, then, a dictionary of code words is created using the Bag of Visual words algorithm. Next the extracted features are taken into consideration and are classified into severity classes. Based on the severities of the damages, they are given an approximate cost utilizing a rule based engine.

VI. FUTURE WORK

The current system calculates the damage type, the severity and the cost as per the damage, only taking the vehicle type into consideration. Therefore, the cost prediction given by the system is not very specific to a single vehicle. To improve the accuracy of the cost and to be more particular to a single vehicle, the make, model, color and the year of manufacture will be taken into consideration. Additionally, as an advancement of the internal operations of the application, the automatic detection of the above-mentioned details, vehicle make, model, color and the year of manufacture can be added. By adding the above stated advancements, the suggested approach is expected to be more reliable and accurate.

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