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# Research on vehicle apparent damage assessment technology based on intelligent regression calculation

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**Abstract**

Aiming at the requirements of effective assessment and accurate quantification of vehicle target apparent damage degree in war, natural disasters and other environments, this paper presents a damage assessment technique based on deep learning regression calculation. First, the image containing vehicle target is preprocessed by scale adjustment, segmentation and graying. Then, extracting and fusing the high-dimensional features of the preprocessed image through the deep convolution neural network. At last, obtaining the evaluation value of vehicle target damage degree through the fusion feature calculation of full connection regression network. In this paper, the automobile target is taken as the experimental object, and completing the relevant data collection, training and testing. The experimental results show the accuracy and effectiveness of this method for vehicle target apparent damage degree evaluation.



*Keywords:* deep learning; damage assessment; feature fusion; regression calculation

## 1. Introduction

With the development of intelligent warfare, battle damage assessment (BDA)[1] plays an important role in judging the effect of attacking targets and assisting operational decision-making. Such as vehicle target damage assessment. In addition, if we can effectively evaluate the damage degree of typical targets in natural disasters, it will also provide favorable information for our rescue. With the development of image acquisition and processing technology, the research of target damage assessment based on image is more and more extensive.

At present, there are mainly subjective evaluation method and objective evaluation method based on image[2].


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The subjective evaluation method is the manual interpretation method, which directly evaluates the target damage degree by visual target damage state. This method needs a lot of manpower. This method is greatly affected by the subjective consciousness of the judges, and it is difficult to quantify the damage degree. Objective evaluation method use algorithm to evaluate the target damage, like the change detection method[3]. As for change detection used in target damage assessment, Peng Yijin[4] compared features before and after target change by Bayesian network; Yang Qingqing et al.[5] proposed to construct the evaluation index set of characteristics before and after building damage, and defined the conversion formula to obtain the evaluation index value for building damage assessment. In addition, Wang Jisheng[6] proposed to use logistic regression model for quantitative evaluation of asphalt pavement damage condition; Gao Weiliang et al.[7] used Monte Carlo method and damage probability index method for damage assessment of ground buildings; QuWanjia[8] proposed radar damage assessment research based on D-S evidence fusion.

Aiming at the problems existing in the above-mentioned target damage assessment research, combined with the requirements of effective evaluation and accurate quantification of vehicle target damage degree. This paper proposes an intelligent regression calculation method. First of all, the original image is divided into two parts for pre-processing. Then, the features of two-way vehicle target image are extracted and fused. Finally, the fusion features are used for regression calculation, so as to obtain continuous and quantitative damage evaluation value for effective evaluation of vehicle target damage. In this paper, the automobile is taken as the target for the experiment, and the experiment shoes that the method in this paper is effective and accurate for the target damage assessment.

## 2. Process of vehicle target apparent damage assessment

In this paper, the intelligent regression calculation method is mainly used to evaluate the target damage in the visible image data of vehicle targets. The first step is pre-processing the images by scale adjustment, semantic segmentation and graying. The next step is extracting the features of the two-way pre-processed images through the convolution neural network. The extracted features are fused by expanding the dimension. The last step is calculating the characteristic regression by the full connection regression network, and the damage evaluation results are output. The overall technical scheme is shown in Fig 1.

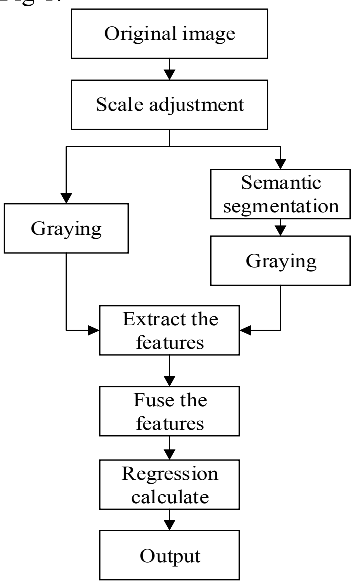



Fig. 1. Target damage assessment process

## 3. Realization of vehicle target apparent damage assessment

### *3.1. Vehicle target image preprocessing*

Image pre-processing is the basis of feature extraction and damage assessment. The main criterion of target damage assessment is the deformation degree of target. The pre-processing operations in this paper mainly include image scale adjustment, semantic segmentation and grayscale processing. Among them, the image scale adjustment is to meet the requirements of the subsequent network for the feature scale; The semantic segmentation can separate the object from the background at the pixel level, which can obtain the pure target slice better and eliminate the interference of background on the target feature extraction; Graying operation is to eliminate the interference of color information of target and background on feature analysis. In addition, in order to avoid the absolute impact of semantic segmentation on damage judgment, and to avoid losing the hidden association between target and environment. Based on the input image data, the original image data and the target slice data are generated by pre-processing to improve the robustness of the method.

For image scale adjustment, the image size is adjusted to 224×224. In order to avoid target distortion caused by image size adjustment, image aspect ratio compression is adopted in this paper. Black padding is used to fill the missing part after compression in the wide or high-scale direction to obtain the target image with predetermined size.

For semantic segmentation, this paper uses the expanded convolution network[11]. The target segmentation model is obtained by training the related target data. The model can include multiple target types, depending on the type of training data. The model can also be upgraded and updated. The trained model can be used to segment target and background permanently.

For grayscale processing, Gray function floating-point calculation is used to weight the original image and the image after semantic segmentation. As shown in formula (1). Finally, two branch data for feature extraction and calculation are obtained.

$$Gray = 0.1140 \times B + 0.5870 \times G + 0.2989 \times R \tag{1}$$

The operation and effect of image preprocessing are shown in Fig. 2.

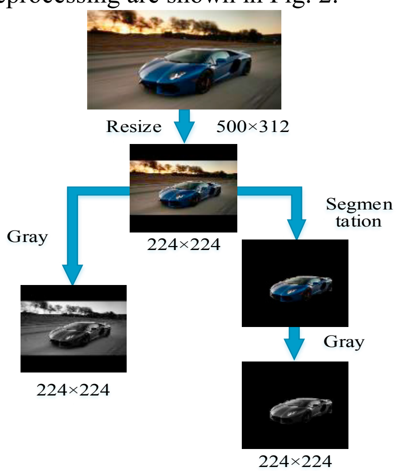



Fig. 2. Target Image Preprocessing

### *3.2. Feature extraction and fusion*

Based on the pre-processed two-way image data, the convolution neural networks is built to extract the high-dimensional features of the target. The structure of convolution neural network is shown in Fig. 3. Convolution network consists of 17 convolution layers, 5 pooling layers and full connection layer. The activation function is Relu function. The convolution features are processed by full connection layer. The feature information of a single image is 4096 dimensions.

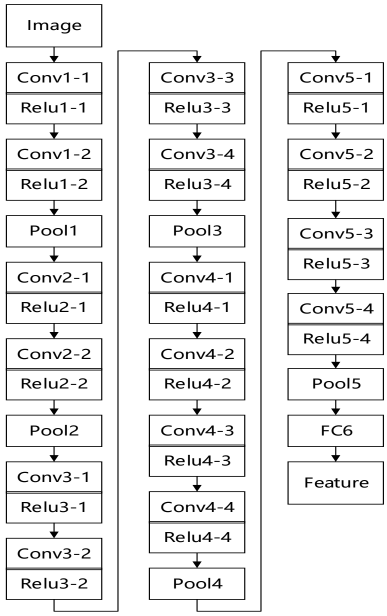



Fig. 3. Structure of Convolutional neural network

For the two-way feature fusion processing scheme, this paper tests the method of weighted fusion and the method of extended dimension. The weighted fusion is shown in formula (2) and the expanded dimension fusion is shown in formula (3).

$$Fea(4096) = a \times Fea1(4096) + b \times Fea2(4096), \quad a + b = 1 \tag{2}$$

$$Fea(4096, 2) = dstack(Fea1(4096), Fea2(4096)) \tag{3}$$

Weighted fusion needs to assign weights to the two-way features, and then fuse them. Based on this method, the dimension and scale of target feature will not change. The dimension expansion fusion does not change the value of each feature, it doubles the feature dimension as the final target feature.

The experimental results show that the effect of dimension expansion is better. This paper adopts the method of dimension expansion fusion. The two-way features are expanded as the final target feature.

### *3.3. Fusion feature regression calculation*

Build a full connection network for full connection of fusion features, and output an evaluation value for each test sample. In this paper, 0-1 interval is used to represent the damage degree of target from no damage to complete damage. The fusion feature data is transmitted forward and fed back through the iteration of full connection layer. The activation function is sigmoid function, as shown in formula (4). The loss function adopts the Euclidean distance function, as shown in formula (5). The whole process of fusion feature regression calculation is shown in Fig. 4.

$$f(x) = 1/(1 + e^{-x}) \tag{4}$$

$$d(a, b) = \sqrt{\sum_{k=1}^{n} (x_{1k} - x_{2k})^2} \tag{5}$$

In formula 5, a and b are n-dimensional vectors. $a(x_{11}, x_{12}, \dots, x_{1n})$,$b(x_{21}, x_{22}, \dots, x_{2n})$.

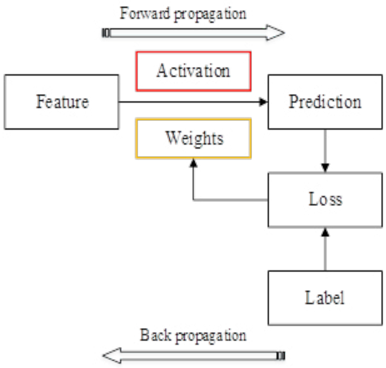



Fig. 4. Regression calculation process of fusion features

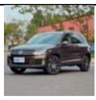
## 4. Experiment and analysis

### *4.1. Data overview*

As there is no public vehicle target damage assessment data set. In order to better carry out the research and verify the effectiveness of the method, this paper select the automobile as the typical target to verify the damage method. The experimental data in this paper are all from network images. The data is divided into training set and test set. In order to ensure the effectiveness of the experiment, the data of test set does not participate in the training.

(1) Training data. In this paper, according to the apparent damage degree of automobile, it is divided into five grades: no damage, slight damage, general damage, serious damage and complete damage. The details of some training samples and training sets are shown in Table 1.

Table 1.Training sample overview.

| Training sets |  |  |  |  |  |
|---|---|---|---|---|---|
| Damage description | No damage | Slight damage | General damage | Serious damage | Complete damage |
| Label | 0 | 0. 25 | 0. 5 | 0. 75 | 1 |
| Quantity /piece | 117 | 135 | 129 | 130 | 127 |

(2) Test data. In this paper, the test set randomly selects samples from the internet. The test samples did not participate in the model training and the damage level was determined according to the damage division of the training set before the test. The test samples are divided into five categories according to the damage level, and the amount of test samples in each part is equal, with a total of 90 pieces. The specifications and corresponding tag values of some test images are shown in Table 2.

Table 2.Test sample overview.

| Training sets |  |  |  |  |  |
|---|---|---|---|---|---|
| Damage description | No damage | Slight damage | General damage | Serious damage | Complete damage |
| Label | 0 | 0. 25 | 0. 5 | 0. 75 | 1 |
| Quantity /piece | 18 | 18 | 18 | 18 | 18 |

### *4.2. Experimental result*

In this experiment, there are 3 samples with cross domain damage assessment results. The rest samples are in the effective evaluation range. Some examples of experimental results are shown in Table. 3.

Table 3.Experimental results.

| Training sets |  |  |  |  |  |
|---|---|---|---|---|---|
| Label | 0 | 0. 25 | 0. 5 | 0. 75 | 1 |
| Predicted value | 0.05387053 | 0.1288309 | 0.57673687 | 0.7544152 | 0.96696043 |
| Distance | 0.05387053 | 0.1211691 | 0.07673687 | 0.0044152 | 0.03303957 |

### *4.3. Experimental analysis*

The damage degree of the target is difficult to be quantified and defined by the five tag values, so some of the tag values are only used as a reference for the damage degree. Through the calculation of the direct distance between the evaluation value and the tag value in the experiment, this paper think that as long as the distance between the evaluation value and the tag value does not cross the domain, it can be considered as correct and effective. In addition, through the specific evaluation value, we can also see that the evaluation of target damage degree in this paper is more detailed and quantitative than the tag value. The evaluation values is closer to the real damage degree of the target.

## 5. Conclusion

The effective evaluation of target damage degree is the key to combat situation evaluation and next operational deployment. The effective evaluation of target damage degree is also a useful information for rescue in natural disasters. Aiming at the problems in the current target damage assessment research, combined with the requirements of effective evaluation and accurate quantification of target damage degree, this paper proposes a method based on deep learning. Through the effective extraction and fusion of target features and regression calculation, the continuous damage evaluation value can be obtained for effective evaluation and quantification of target damage. In this paper, the automobile is taken as the target to carry out damage assessment experiment, and the experiment verifies the effectiveness and accuracy of the method for target damage assessment. The scope and definition of target damage assessment is relatively wide, and there is no corresponding evaluation rule reference, judgment, especially target functional damage. The technical method involved in this paper is only limited to the damage assessment of target shape.

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