Volume 7, Issue 1, pp. 34-38, 2023.
International Journal of Scientific Engineering and Science
ISSN (Online): 2456-7361

Technology of Classification and Detection of Damage Conditions on the Road Surface

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***Abstract*—** *The development of today's technological world is occurring rapidly. allows for comparison with the preparation of a database that is fast, precise, and accurate. Some studies focus on the presence or absence of damage on the road surface, but basically, the data taken should provide informative information to obtain a mapping of the location (cluster), the type of damage, and the classification of road damage. Web-based mapping using Android applications from third parties allows the availability of data in real-time and photos of surface conditions. This study makes three contributions to address this problem. First, a road damage database was created for the first time. This dataset consisted of 9,053 images of road damage taken with a smartphone in the vehicle, and road images contained 15,435 examples of road damage. o produce this data set, the researchers conducted research in collaboration with 7 cities in Japan and obtained street images for more than 40 hours. These pictures were taken in different weather and lighting conditions. In each picture taken, a description of the bounding box representing the location and type of damage is given. In order to obtain the damage detection model from the dataset and evaluate the accuracy and runtime performance of both utilizing a server and smartphone, the second object detection approach uses a CNN. Thirdly, it can be demonstrated that the suggested object detection algorithms can accurately divide the different damage types into eight categories.*

***Keywords*—** *Database, Road Damage, Technology, Mapping, Android, Smartphone.*

I. Introduction

Damage detection and classification based on road imagery has emerged as an important goal, as road imagery provides basic information for some naturally image-based applications such as autonomous driving. This task is difficult in two respects. First, finding individual defects under different weather and lighting conditions requires robust defect detection and classification algorithms. Secondly, the algorithm must be able to distinguish different types of overlapping defects. This is a very common phenomenon observed in such defects.

A map is a visual representation of an entire region or part of a region, usually displayed on a flat surface, illustrating certain detailed features of a particular region to illustrate its geography [1]. Utilizing the Maps Application Programming Interface (API), spatial data of road damage places are transformed into road damage locations mapped in a web-based application (online mapping) to support government smart city programs. With the development of communication devices, particularly for navigational needs, the Google Maps API, Microsoft Bing Maps, and Yahoo Map API have evolved [2]. The API can be used for various purposes, one of which is road damage mapping. This facilitates the process of disseminating and analyzing information. The use of API also eliminates the use of additional software such as Global Information System (GIS) software, which requires a map server to render maps [3].

Infrastructure like roads, bridges, and tunnels was extensively built in Japan between 1954 and 1973, a time of rapid economic growth. But many of these structures date back more than 50 years [4].

The infrastructure building is aging, resulting in an increase in the number of structures examined. However, many places have ignored carrying out proper inspections due to a lack of resources or specialists because of the rising demand for inspections and the shortage of skilled field technicians or experts [5].

Road infrastructure is a problem that exists in Java and outside Java. Poor-quality roads cause damage, and potholes can disrupt traffic flow and hinder economic growth. Road infrastructure is an aspect that has a positive impact on economic output, namely the increase in regional income [6].

Countries all around the world are likely to encounter issues with the upkeep and management of infrastructure. It is obvious that effective and advanced infrastructure repair methods are required when considering these negative tendencies in infrastructure management and infrastructure maintenance methods. Based on some of these problems, the purpose of this study is to identify the need for follow-up research that can provide mapping database information on the location (cluster), the type of damage to the road surface, and photo documentation with the classification of the type of road damage quickly, precisely, and accurately.

As the use of map information grows, developers can create dynamic mappings that can be accessed at any time. This resulted in innovation through the combination of the web and maps. This development resulted in web-based mapping [2].

Similar to online mapping, web-based mapping uses the Maps API as the basic information panel it is displayed on spatial data in the form of locations represented as points or coordinates is stored in a database, contains descriptions or attributes, and is displayed in a map service using the Maps API [7]. Users can also modify, add, and delete location and attribute data, and the system can update the information dynamically.

Fig. 1. Web base mapping [8]

The majority of this work is limited to detecting road damage and mapping its location; identifying the type of damage is also critical for generating data based on the type of damage. Here is an outlined R-CNN (Convolutional Neural Network) mask that can be used to detect and classify the type of road damage simultaneously [9].

Mask R-CNN is a development of fast modeling to detect objects, locations, and fast segmentation on existing roads. This section summarizes the various components and their use in the path detected (see Fig. 2).

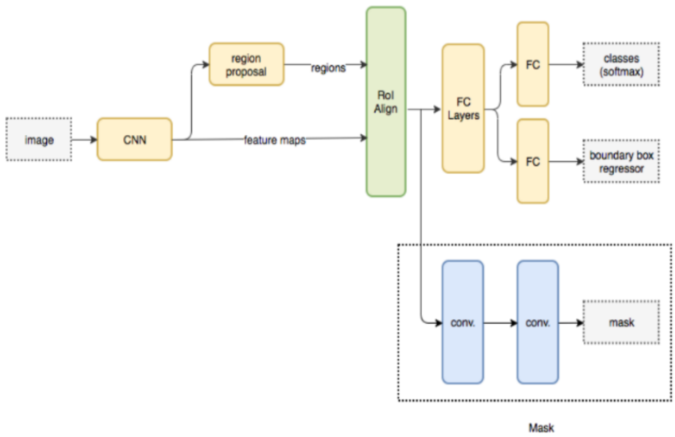


Fig. 2. Mask R-CNN Flow Chart [9]

II. Research Method

This study is a literature review, especially from journal articles on the results of research that has been done. So that the data displayed is secondary data. The study method is shown in the flow chart in Fig.3. The study step begins with a review of theoretical literature, previous research, and technical developments in web-based mapping. Level data is collected by using the Google Maps API to collect street location coordinates and longitude and latitude values. The road damage attribute is then assigned to the coordinate data. Prototyping methods are used at the stage of building a system, adding the required functionality, and building applications, such as mapping the location of road damage.

At the stage of analysis of the results, the system is built to display the results of mapping the location of road damage. For this study, we developed a system whose main function is to map the location of road damage using the Google Maps API (see Fig. 1).

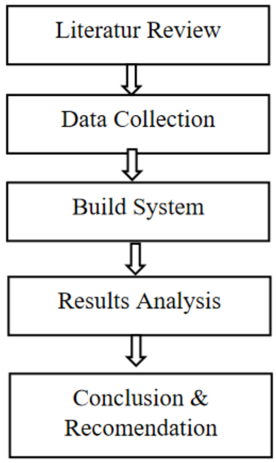


Fig. 3. Study Stages Flowchart

Damage data has three attributes: location description, longitude, and latitude. Data collection is done by looking directly at road conditions. However, the data entered remains dummy data to check if the system is working properly.

Road surface images or vehicle onboard cameras are used in road damage detection. Taking pictures from above for the model, its application in practice has limited conditions, considering the difficulty of shooting. On the other hand, it would be easy to adjust the model's visuals to the actual situation if they were made using photos taken by the camera installed in the vehicle. For example, those that use existing cameras installed in smartphones and common passenger cars can run models on smartphones, transfer images to external servers, and process them on servers. Anyone can easily detect road damage.


Fig. 4. Smartphone on dashboard [10]

Volume 7, Issue 1, pp. 34-38, 2023. *ISSN (Online): 2456-7361*

Utilizing a smartphone (LG Nexus 5X) on the dashboard of the vehicle and taking a 600 by 600 pixel image once every second (see Fig. 4), when a car is moving at an average speed of around 40 km/h (or about 10 m/s), the shooting interval of 1 second allows for the capture of an image without leakage or duplication. A smartphone application that can take pictures of the road and record location data once per second was developed for this purpose.

Each sort of damage in this study is represented by a class name, and the damage types are separated into eight groups. The first category for the damage is cracks. Then, the cracks are separated into crocodile cracks and linear cracks. Along with potholes and grooves, other road degradation might also include blurred road markings.

III. RESULTS AND DISCUSSIONS

Web-based mapping will map the location based on real-world coordinates on Earth. The GoogleMaps API makes use of latitude and longitude coordinates. The coordinates used are shown in Table 1 [8].

TABLE 1: Coordinate Data

No	Name	Latitude	Longitude
1	Ichira	42.3727°	140.9945°
2	Ichiba	35.6007°	140.1071°
3	Sumida	35.6956°	139.8004°
4	Adachi	35.7267°	139.7705°
5	Nagakute	35.1398°	137.0539°
6	Numazu	35.0517°	138.8671°
7	Muroran	42.3727°	140.9945°

Coordinate data is then stored in a MySQL database for further display in the form of POIs in web applications. Data from the database is called using the PHP programming language. Then the data is converted into JSON form to be displayed with the Google Maps API. The data exchange process is filtered to produce a mapping of the location of road damage that is entered into the system. Fig.5 - Fig. 7 are the results of mapping the location of damage in web-based mapping applications [8].

Fig. 5. Cluster 1 mapping result

Cluster processing with zoom size in the map toolbar When zoomed in (distance view), clusters are formed. A cluster is formed when two or more location points are close to each other. The central location point will be the center, or POI, of the cluster. If another location has a non-contiguous location, it will still be displayed, but it is the point of the other location, not the cluster.

After the cluster mark is done, the database retrieval stage is performed using a smartphone that has been placed on the vehicle dashboard.


Fig. 6. Cluster 2 mapping result


Fig. 7. Cluster 3 mapping result

A total of 9,053 photos of marked road damage make up the data set. There are 15,435 damage bounding boxes marked on these 9,053 photos, showing the number of samples per label collected in each area. Taking photos of streets in various parts of Japan cannot completely eliminate data bias. The D40, for example, poses a greater risk; as a result, road management repaired these breakdowns as soon as they occurred, which is why there weren't many examples of the D40 in practice. The blurring of the white line is frequently not seen as damage; but, in this investigation, it was also regarded as harm. In total, there are 15,435 damage bounding boxes and 9,053 damage photos in the new dataset. The image has a 600 × 600 pixel resolution. Because of the variety of the region and its weather, the dataset closely resembles the real world. The damage detection model is evaluated using this dataset. Fig. 8 shows the notation process, and Fig. 9 shows pictures taken using a smartphone camera [10]. Table 2 shows the types of road damage in the dataset and their definitions according to the JRA road maintenance and repair Handbook (2013) in Japan [11].

International Journal of Scientific Engineering and Science
Volume 7, Issue 1, pp. 34-38, 2023. ISSN (Online): 2456-7361

Fig. 8. Notation process [10]

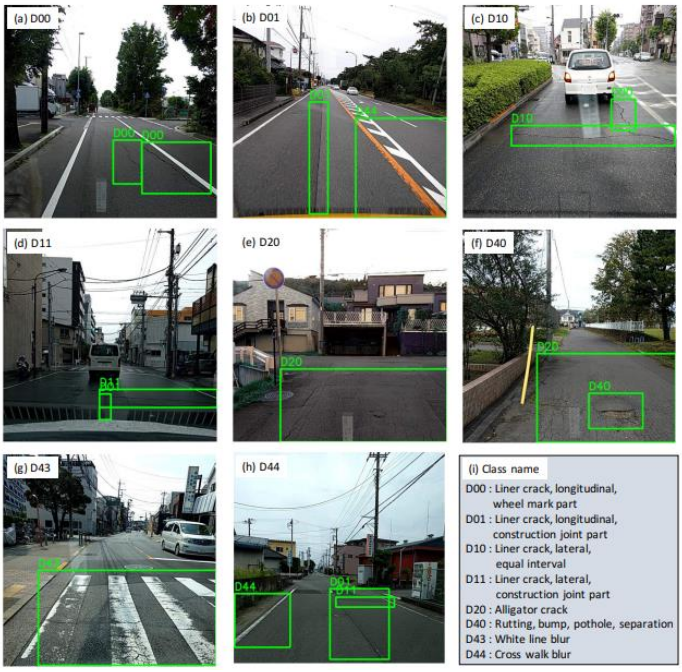
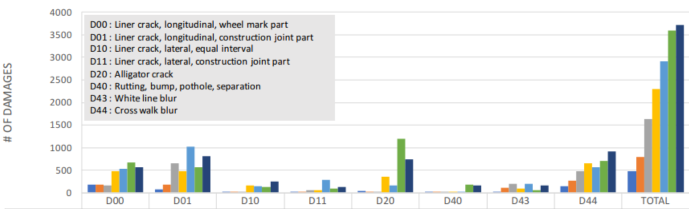


Fig. 9. Pictures taken using a smartphone camera [10]

TABLE 2: Types of road damage in the dataset and their definitions

Damage Type			Detail	Class Name
Crack	Linear Crack	Longitudinal	Wheel mark part	D00
			Construction joint part	D01
		Lateral	Equal interval	D10
			Construction joint part	D11
	Alligator Crack		Partial pavement, overall pavement	D20
Other Corruption			Rutting, bump, pothole, separation	D40
			White line blur	D43
			Cross walk blur	D44



	D00	D01	D10	D11	D20	D40	D43	D44	TOTAL
Ichihara city	175	71	18	9	43	8	20	138	482
Chiba city	183	187	13	12	27	3	104	267	796
Sumida ward	168	660	20	61	21	19	201	482	1632
Nagakute city	482	477	169	58	351	14	90	659	2300
Adachi ward	529	1013	153	279	172	11	191	567	2915
Muroran city	671	574	124	88	1192	189	50	712	3600
Numazu city	560	807	245	129	735	165	161	908	3710
TOTAL	2768	3789	742	636	2541	409	817	3733	15435

Fig. 10. Total cases of damage in each class in each municipality [10]

Fig. 10. is the each local government has a different distribution of damage types. For instance, Muroran city has more D20 damages than other towns combined (1,192 damages). Because Muroran City is situated in a snowy area, alligator cracks are frequently brought on by snow thawing [10].

The quantity of each sort of damage cases in each municipality It is clear that each local government has a varied distribution of damage types. For instance, Muroran city has more D20 damage (1,192 damage) than other cities do. Because Muroran is located in a snowy region, crocodile cracks frequently form during snowmelt [10].

IV. Conclusion

The system can develop a model that can give priority to road repairs based on marker clusters for all areas with significant damage. Information is obtained from the marker cluster. The system is expected to inform the analysis process before a decision is made to determine the location of road repairs.

The results of this road damage image can be visually detected and classified into 8 classes that become a database to provide road damage data.

In places with a shortage of specialists and funds, a straightforward road assessment technique utilizing only a smartphone will be helpful. To support research in this area, datasets, models, source code, and smartphone applications have been made publicly available so as to provide precise, fast, and accurate information

Acknowledgements

Thanks to the help of all parties during the preparation of this paper, the writing of this paper can be completed easily. Thank you to everyone who helped with the writing of this paper, especially the supervising lecturers, who were quite active in offering guidance and suggestions.

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