Deep Concrete Inspection Using Unmanned Aerial Vehicle Towards CSSC Database

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Abstract— **Concrete spalling and crack inspection is a labor intensive and routine tasks, which is more challenge with bridges hard to access. Whereas the tremendous recent progresses in concrete inspection are based on even surface under ideal illumination, and no open database was released so far. In this paper, we propose an online inspection and image collection system using Unmanned Aerial Vehicle (UAV) (Fig.1) besides the web-exploration approach. We introduce a new Concrete Structure Spalling and Crack database (CSSC) using web-exploration over 38,483 images. Then, the UAV deploys the trained model for inspection, and collects images which contains region of interests (ROI) with possible flaws. Thus extra 7,648 images were collected through this approach to assist further training. We illustrate the complete procedures to do labeling, training, and post processing to find the corresponding ROI with VGG-16 [1]. We also provide a comparison on the database generated before and after field collection. Experiments on field data show that the proposed approach provides a robust visual inspection solution for concrete bridges and it is venerable for light illumination.**

I. Building CSSC Database And Field Tests

To our knowledge, there is no visual inspection dataset for CSSC. We build the CSSC database with web-exploration and UAV system field collection(in Fig.1).

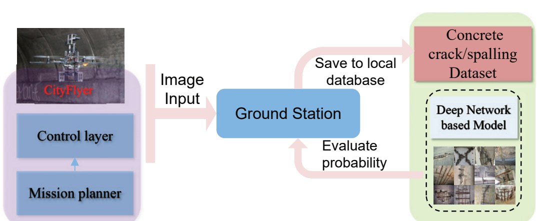

Fig. 1. UAV online image collection system architecture.

The initial database is collected through web-exploration.

For concrete spalling: We used Google, Yahoo, Bing, and Flickr to do searching with key words such as Concrete spalling, Concrete delamination, concrete bridge spalling, concrete column spalling, concrete spalling from fire. We found total of 22,268 images, and only 278 images are further picked up to be used for training.

For concrete crack: We searched key word of Concrete crack, crack repair, concrete scaling, concrete crazing, concrete crazing texture. We found a total of 16,215 images, and 954 images were used for training.

The data labeling and post processing are illustrated in Fig.2, and CSSC images are labeled with area where steel corrosion happens, crack images are labeled with the crack (procedure (1)). Then, we perform sub-cutting by random selection of ROI(procedure (2)). Finally, the post recognition is executed with random box approach to find the areas for marking (procedure (3)).

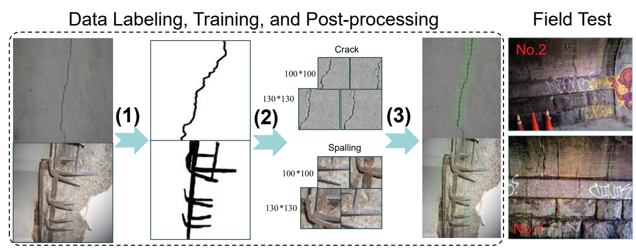

Fig. 2. Deep processing and filed Experiments.

We executed two field tests in Manhattan, New York. Results of using detection model are illustrated in right most of Fig.2 . For the CSSC database, we divided it into two subsets for training and testing. The testing shows an average 93.36% accuracy (in Table.I). The field detection accuracy are 72.45% and 67.65% before optimization, respectively. After trained with filed images, we got 11.14% and 13.73% improvement. (PID:Partial Incomplete Detection, APWB:AP With Image Blur, OE: Over Estimated)

TABLE I
QUANTIFIED RESULT OF DETECTION WITH CSSC DATASET

Dataset	Average Precision (AP)(%)	PID (%)	Total Image
CCNY-CSSC	93.36	6.64	370
Field Test No.	AP (%)	APWIB (%)	OE (%)
No. 1	72.45	76.73	97.18
No. 2	67.65	71.19	24.3
Model Optimized With Field Data			
Field Test No.	AP (%)	APWIB (%)	OE (%)
No. 1	83.69	87.97	93.34
No. 2	81.38	84.92	33.57

References

[1] Simonyan K, Zisserman A. Very deep convolutional networks for large-scale image recognition. arXiv preprint arXiv:1409.1556. 2014.

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