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Development Of Synthetic Environments For Autonomous Bridge Visual Inspection

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Modern society is supported by the uninterrupted mobility of people and goods through transportation networks. Bridges and viaducts are the main components of the transportation networks. To maintain the operational safety and serviceability of those structures, their conditions are assessed visually by human inspectors, which is known to be time-consuming, labor-intensive, and even unsafe in some extreme conditions. To address the problem, automation of the process is desired to help prevent economic and social issues caused by sudden loss of functionality of those structures. Computer vision, artificial intelligence (AI), and robotics technologies have been applied successfully to automate visual inspection sub-problems, such as structural component recognition and damage recognition. However, scaling up those systems to the fully autonomous visual inspection, including data collection and all the necessary data post-processing, is not straightforward, because of the lack of platforms for developing, validating, and demonstrating such integrated systems in the consistent scenarios. This research aims at developing a collection of photo-realistic synthetic environments that can be used for investigating the autonomation of the entire bridge visual inspection process. The synthetic environments are generated randomly and programmatically, which can then be used for (1) generating relevant training datasets for visual recognition algorithms, (2) testing prototype systems for autonomous robotic navigations for inspection data collection, and (3) identifying the feasibility and effectiveness of other emerging advanced techniques in the bridge inspection scenarios. The synthetic environments are developed by incorporating design practices in relevant codes and guidelines. This research then generates datasets of rendered images and the associated ground truth annotations of structural components and damage. Finally, the datasets are used to significantly augment training datasets for deep semantic segmentation algorithms, demonstrating the potential of the developments for supporting the complex automation tasks in the actual bridge inspection scenarios. This research is expected to be a key step toward full automation of the complex visual inspection process.