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To learn more about how to request items watch this short online video. We will contact you if necessary. Please also be aware that you may see certain words or descriptions in this catalogue which reflect the author’s attitude or that of the period in which the item was created and may now be considered offensive. Download fulltext PDF Currently, this condition a ssessment is mainly performed through visual inspection, which has been id entified with several limitations e.g. the time consuming a ssessment process and heavy relia nce o n inspecto rs’ pe rsonal experience. In o rder to overcome these li mitations and enhance the curre nt inspection pr actice, this paper presents a novel method for automated bridge condition assessment using a hy brid sensing system. Under the method, existing conditions of b ridge c omponents are first captured with a st ream of po int clouds and color images. T hen, the bridge components and the defects inflicted on th e components are detected utilizing their visual patterns. The detection results are mapped to the point cloud. This way, the 3D information of the components and defects can be retrieved. The bridge conditio n assessment can be made effecti vely through the 3D visualization of this information before car rying out any onsite detailed evaluations. KEYWORDS Hybrid Sensing, Condition Assessment, Point Clo uds, Digital Images, and Bridge Inspection INTRODUCTION It is al ways necessar y to inspe ct the physical and functional co nditions of bridges to ensure the y still meet the service requirements. T he inspection is typically performed ever y two years or even fewer, considering over 40% of the bridges in Canada have been more than 50 years old Bisby and Briglio, 2004. During the inspection, bridge conditions are m ainly assessed by inspecto rs th rough their visual observations of the defects in flicted on the bridge components, such as columns, girders, and deck s.

The visual observations have been identified with se veral limitations. For example, the manual observation process is timeconsuming, and the observation results are heavily dependent on the insp ectors’ personal experience and knowledge FEWA, 1991; FE WA, 1992. In order to o vercome the limitations o f manual inspection, s everal attempts have be en proposed to automate the current bridge inspection p rocess. A lot of manual editing and correction work is still required, which makes the overall information retrieval proc ess labo r intensive and timeconsuming Zhu, 201 2. Then, the bridge co mponents and the defects inflicted on the components are detected from the images based on their visual patterns. The detection results are further mapped to the point clouds to retrieve the 3D infor mation of the components and their defects. This way, t he bridge condition assessment can be made effectively t hrough the visualization of t he bridge co mponents and t heir inflicted defects in 3D. Bridge inspectors could rel y o n the visualization results to have a better understanding ab out brid ge existing conditions, before any detailed onsite e valuations ar e carried out. So far, a pilot study has been performed to test the proposed method in t he structural lab at Concor dia University. The test results from the study have shown the eff ectiveness and promise of the method for automated bridge conditions assessment. BACKGROUND Current Practice of Bridge Conditions Assessment It is important to maintain t he physical and functional req uirements of bridges when t hey are in service. This goal can be achieved by carefully planni ng and implementing regular bridge repair, maintenance, and re habilitation activities. T he rating is given based on the e xtent and severity of the defects inflicted on the bridge components, which are typically observed b y inspectors. The manual visual observations have a n umber of limitations that ha ve been identified.

Fo r example, the observation results are subjective and not al ways reliable Phares et al. 2004. Also, the safety risks are associated with inspectors since they o ften work at high heights or in heavy traffic zones NJDOT, 2009. The r equirement of e xperienced inspectors poses a challenge for the construction industry, which is now facing the pressing shortage of experienced and highly trained inspection personnel TPFP, 2009. Recent Research Efforts towards Automated Bridge Conditions Assessment In order to overcome the limitations o f manual observations, m any attempts have bee n made to automate the current bridge conditions asse ssment process. For example, digital image processing techniques, such as edge detection, morphological opera tions, etc., have been used to automatically locate the defects on bridge components Abudayyeh et al. 2 004. McRobbie et al. 2007 noted that the offsite conditions assessment conducted with digital images could reach a high level o f accuracy which wa s even comparable to the onsite one. However, the image processing results are typically two dimensional 2D. In ord er to extend the image proce ssing results, the retrieval of 3D bridge information has been investigated. McRobbie et al. 2010 mentioned that t he inspection results based on the 3D br idge information could completel y simulate onsite manual observations, and therefore address the limitations of manual observations. So far, the methods for the retrieval o f 3D bridge information are bro adly classified into two gro ups. The methods in the first group were built upon the 3D point clouds cap tured directly b y terrestrial laser scanners. The laser scanners could collect millions of 3D points with one scan in minutes, but they are typically heavy and not portable Foltz, 2000. In addition, the 3D points collected by the laser scanner only record the spatial information o f the bridges.

As a contrast, the method s in the second group relied on the digital images or videos ta ken b y digital cameras or camcorders. The digital cameras or camcorders are easy to use and portable, but the 3D in formation has to be e stimated indirectl y from multiple images or video frames shot Bo th groups of methods have pros and cons in sensing accuracy, resolution, cost, etc. Zhu and Brilaki s, 2010. For this reason, re searchers have been investigating t he possibility to integrate the point clouds and d igital images to enhance the current i nformation retrieval process ElO mari and Moselhi, 2008; Zhu, 2012. PROPOSED METHODOLOGY This paper follows the idea of integrating point clouds and digital co lor images, and propo ses a novel hybrid sensing method for automated bridge conditions assessment. Under the method, existing conditions of bridge components are first captured by the Kinect with a stream of point clouds and color images. Then, the bridge com ponents and the defects on th e bridge components are detected with digital image processing te chniques considering t heir unique vis ual patterns. The detection results are further mapped to the point clouds. This way, the 3D bridge co nditions can be retrieved and the a ssessment can be made effectively with the 3 D visualization of the bridge components and their defects. Figure 1 illustrate s the overall framework of the proposed method. Figure 1 The Proposed Method Bridge Components Recognition The detection of bridge components is the first main step in the proposed method. The detection mainly relie s on t he visual patterns of the components in color images. Most bridge components, such as columns, b eams, and decks, have si mple top ological and ge ometrical configurations. Therefore, the focus is placed on the detection of these configurations fro m the images. Then, t he material texture featur es are extracted with di gital filterin g.

Based on the locations and sizes of the contour and material texture features, the This way, the bridge components can be automatically detected in the i mages. Different types of bridge components can be detected by retrieving their geometrical and topological configurations with appropriate and slight c ustomization. For example, bridge columns rectangular or circular in a co lor image are do minated by long nearvertical lines cont our features and concrete surfaces material texture features. Therefore, the columns can be located by se arching such cues in the image. More details can be found in the writers pervious work Zhu and Brilakis, 2010 . Defects Detection After the detection of bridge components, the second m ain s tep in the proposed method is to detect the defects present on the bridge co mponents. Typically, there could be different types o f the defects on the components, such as cracks, spalling, etc. The particular algorithms used for the detection of these defects are chosen on a caseb ycase basis dependin g on the nature of each defect. For example, the cracks in images are composed of a small number of pi xels organized linearly. Therefore, in order to detect the m, the images are first split into three co lor planes Red, Green, and B lue. Then, the appropriate co lor plane is selected to apply the edge de tection algorithms. The edge detectio n results are morphologically dilated to ensure the connectivity of the cracks and erod ed to retrieve the crack skeletons. This way, the cracks can be detected and the crack severity can be measured based on the quantitative information provided by the crack skeletons and their branch points Adhikari et al. 2012. 3D Mapping The imagebased detection re sults for bridge components a nd their defects are li mited to 2D. In order to extend the recogniti on results to 3D, they need to be mapped to the point clouds.

Here, the mapping is perfor med us ing the oneo none relationship b etween the 3D points and 2D image pixels, which is auto matically maintained by the Kinect. First, each pixel is checked whether it lies in the ar eas of the bridge components or the de fects in the image. If so, the 2D coordinate of the pixel is retrieved. Based on the 2D coordinate of the pixel plus its dep th value, the 3D point corresponding to the pixel can be located and marked in the p oint cloud. T his way, the 2D recognition results for the bridge co mponents and the defects can be extended to 3D. IMPLEMENTA TION AND RESUL TS Implementation The pr oposed framewor k has been divided into different modules and im plemented separately. The module for the defection of defects was developed using MATLAB R2012a. Images and point clouds were trans mitted between the modules, so that they c an work together. Figure 2 shows the modules i n the proposed framework a nd Figure 3 illustrates that the 3D point clouds and digital images that were captured simultaneousl y by the Kinect working with a mobile workstatio n. Results The proposed framework was tested for sensing and modeling t he conditions o f concrete co lumns in the Structural Engineering Labo ratory at Concordia University. Figure 3 shows an example of a concrete column in the lab. The resolution o f the images is fixed at 64 0 x 480 p ixels. The imagebased d etection result for the co ncrete column has been illustrated in Figure 4, where the detection result is marked red. The detection result was then mapped to the corresponding 3D po int clo ud Figure 5, and from that, the concrete column was identified Figure 6. The imagebased detection result for the crack has be en illustrated in Figure 8, where the de tected crack is marked red. The detection result was t hen mapped to the corresponding 3D point cloud Figure 9 , and from that, the crack was identi fied Figure 10.

When the components a nd defects are id entified in the po int clouds, their 3D geometrical information can be retrieved. T his information rep resents the e xisting conditions of the components, which could facilitate i nspectors to perform quantitative condition assessments. A ccording to th e preliminary Currently, the inspection is performed manually, which has been identified with many limitations, such as the time consuming process and subjective inspection results. In order to overco me these limitations, several attempts have been proposed to automate the current bridge inspection process. One of suc h attempts is to automatically retrieve the information of b ridge components and their defects using remote sensing techniques. This pap er follo wed this idea and presented a novel method for the retrieval of bridge component s and their defects w ith a hy brid s ensing system, Kinect. Under the method, the Kinect was used to capture the exi sting conditions of bridge co mponents as a stream of point clouds and co lor images. Then, the br idge components and the defects inflicted on the components are detected from the color i mages. The im agebased de tection results are mapped to the corresponding point clouds. This w ay, the 3D in formation of the bridge components and their defects can b e retrieved, and the bridge condition assessment can be made quantitatively. So far, the method has been te sted in the Structures Lab at Concord ia University to retrieve the 3D information of concrete columns and cracks. The preliminary results showed the effectiveness of the method. ACKNOWLEDGEMENT The support of Concordia University, Montreal, Canada, and the Natural Sciences and Engineering Research Co uncil of Canada NSERC is gratefully acknowledged. The contribution of all experts participated in this research is also war mly acknowledged. Federal Highway Administration FHWA, 199 1, Bridge Inspections Training Manual, J uly.

Firstly, to present a survey of the actual and most advanced methods for manmade structures monitoring, more specifically dams and bridges. Theoretical and technical aspects of these methodologies are presented and discussed focusing on innovative inspection methods and on the opportunities that could deliver. Secondly, to identify the opportunities that could potentially improve the inspections and maintenance processes, being the satellitebased monitoring, using radar imagery, recognized as viable source of independent information products that may be used to remotely monitor the health of these specific manmade structures. By applying Multitemporal InSAR processing techniques to a series of radar images over the same region, it is possible to detect vertical movements of structure systems on the ground in the millimeter range, and therefore, identify abnormal or excessive movement indicating potential problems requiring detailed ground investigation. In this paper it is clearly demonstrated that with the new highresolution synthetic aperture radar satellites scenes, InSAR technology may be particular useful as hot spot indicator of relative deformations structures over large areas, making possible to develop interferometric based methodologies for structural health monitoring. From a technological standpoint, this approach represents a substantial evolution over the current stateoftheart. View Show abstract Automated condition assessment of concrete bridges with digital imaging Article Jun 2014 SMART STRUCT SYST R.s. Adhikari Ashutosh Bagchi Osama Moselhi The reliabilityof a Bridge management System depends on the quality of visual inspection and the reliable estimation of bridge condition rating. However, the current practices of visual inspection have been identified with several limitations, such as they are timeconsuming, provide incomplete information, and their reliance on inspectors experience.

To overcome such limitations, this paper presents an approach of automating the prediction of condition rating for bridges based on digital image analysis. The proposed methodology encompasses image acquisition, development of 3D visualization model, image processing, and condition rating model. Under this method, scaling defectin concrete bridge components is considered as a candidate defect and the guidelines in the Ontario Structure Inspection Manual OSIM have been adopted for developing and testing theproposed method.The automated algorithms for scaling depth prediction and mapping of condition ratings are based on training of back propagation neural networks. The result of developed modelsshowed better prediction capability of condition rating over the existingmethods such as, Naive Bayes Classifiers and Bagged Decision Tree. View Show abstract US Federal Highway Administration, FHWA HI94034 Jan 1992 Bridge Maintenance Training Manual, 1992, US Federal Highway Administration, FHWA HI94034. Prepared by Wilbur Smith Associates. Federal Highway Administration FHWA Jul 1991 Federal Highway Administration FHWA, 1991, Bridge Inspections Training Manual, July. Visualisation and display of automated bridge inspection results Jan 2009 S Mcrobbie R Woodward McRobbie S., Woodward R., and Wright A., 2010, Visualisation and display of automated bridge inspection results, Transport Research Laboratory, UK It relies on tangible data collected from construction job sites, which is then used to compare actual work performed to that planned. One method used to collect actual work data is 3D laser scanning, where the construction site is scanned at different times to generate data, which can then be used to estimate the quantities of work performed within the time interval considered between two successive scans. Photogrammetry is another method for data collection where the geometrical properties of an object on site are generated from its photo image.

This paper presents a method, which integrates D scanning and photogrammetry in an effort to enhance the speed and accuracy of data collection from construction sites to support progress measurement and project control. The application of the proposed method is demonstrated using a building presently under construction. View Show abstract An imaging data model for concrete bridge inspection Article Aug 2004 ADV ENG SOFTW Osama Abudayyeh Mohammed Al Bataineh Ikhlas AbdelQader Bridge management systems were developed to address the data organization and decision making aspects of bridge inspection and maintenance. However, these systems still neglect the automation aspects of bridge monitoring and inspection. Automation may result in monetary savings and can optimize the inspection process. This paper discusses the data model that was developed to support automated imaging inspection of concrete bridges. The paper discusses the framework for an automated bridge inspection methodology and provides a detailed discussion of the data modeling efforts involved in the development of the imaging information model. View

Show abstract 3D laser scanner provides benefits for PennDOT bridge and rockface surveys Article Jan 2000 B. Foltz View Imagebased 3D Modelling A Review Article Fulltext available Sep 2006 Photogramm Rec Fabio Remondino Sabry ElHakim In this paper the main problems and the available solutions are addressed for the generation of 3D models from terrestrial images. Close range photogrammetry has dealt for many years with manual or automatic image measurements for precise 3D modelling. Nowadays 3D scanners are also becoming a standard source for input data in many application areas, but imagebased modelling still remains the most complete, economical, portable, flexible and widely used approach.

View Show abstract Detection of largescale concrete columns for automated bridge inspection Article Dec 2010 AUTOMAT CONSTR Z Zhu Stephanie German Paal Ioannis Brilakis There are over 600,000 bridges in the US, and not all of them can be inspected and maintained within the specified time frame. This is because manually inspecting bridges is a timeconsuming and costly task, and some state Departments of Transportation DOT cannot afford the essential costs and manpower. In this paper, a novel method that can detect largescale bridge concrete columns is proposed for the purpose of eventually creating an automated bridge condition assessment system. The method employs image stitching techniques feature detection and matching, image affine transformation and blending to combine images containing different segments of one column into a single image. Following that, bridge columns are detected by locating their boundaries and classifying the material within each boundary in the stitched image. Preliminary test results of 114 concrete bridge columns stitched from 373 closeup, partial images of the columns indicate that the method can correctly detect 89.7% of these elements, and thus, the viability of the application of this research. Bridging the speed and dissipationgap imposed by electronics, hybrid processor has widespread use in communications, sensing and general computing.They usually also include pre and postprocessing steps, which can be moved into the Cloud in order to keep costs low. The goal is to lower the gap for nonprofessionals in order to exploit external facilities through an automated deployment and scaling both vertically HPC and horizontally Cloud. This paper demonstrates how representative eScience applications can easily be transferred from HPC to Cloud using the modelbased crosscloud deployment platform PaaSage.

However, the current practices of visual inspection have been identified with several limitations, such as they are timeconsuming, provide incomplete information, and their reliance on inspectors experience. The proposed methodology encompasses image acquisition, development of 3D visualization model, image processing, and condition rating model. Under this method, scaling defectin concrete bridge components is considered as a candidate defect and the guidelines in the Ontario Structure Inspection Manual OSIM have been adopted for developing and testing theproposed method.The automated algorithms for scaling depth prediction and mapping of condition ratings are based on training of back propagation neural networks. The result of developed modelsshowed better prediction capability of condition rating over the existingmethods such as, Naive Bayes Classifiers and Bagged Decision Tree. The objective of this research is to develop an integrated model based on digital image processing in developing the numerical representation of defects. The crack quantification model evaluates crack lengths based on the perimeter of the skeleton of a crack which considers the tortuosity of the crack. The change detection model is based on the Fourier Transform of digital images eliminating the need for image registration as required in the traditional. Also, the integrated model as proposed here for crack length and change detection is supported by neural networks to predict crack depth and 3D visualization of crack patterns considering crack density as a key attribute. Read more Conference Paper Fulltext available A Study of ImageBased Element Condition Index for Bridge Inspection August 2013 R.s. Adhikari Osama Moselhi Ashutosh Bagchi View fulltext Discover more Download citation What type of file do you want. RIS BibTeX Plain Text What do you want to download. Citation only Citation and abstract Download ResearchGate iOS App Get it from the App Store now.

Install Keep up with your stats and more Access scientific knowledge from anywhere or Discover by subject area Recruit researchers Join for free Login Email Tip Most researchers use their institutional email address as their ResearchGate login Password Forgot password. Keep me logged in Log in or Continue with LinkedIn Continue with Google Welcome back. Keep me logged in Log in or Continue with LinkedIn Continue with Google No account. All rights reserved. Terms Privacy Copyright Imprint. A conventional bridge inspection has a lot of problems because inspection is conducted manually by human. As an alternative, we are to develop a robot system having machine vision and this robot system is mounted on an end linkage of specially designed car having seven DOF Degrees Of Freedom to inspect cracks beneath bridge. This system is able to check a status of the bridge and record its changes every other year. As a result, the developed robot system offers us the inspection result of quality and reliability about the bridge inspection status. Also, we have tested the effectiveness of the suggested system through outdoor experiments.All Rights Reserved. Our vast network of industry associations, alumni and corporates connect enable students to learn best practices and cutting edge technologies. Our vast network of industry associations, alumni and corporates connect enable students to learn best practices and cutting edge technologies. An MBA in Marketing opens up the world to its aspirants. Turn into finance masterminds. Learn FMM at DKS to make it a rewarding career. At DKS, we prepare tomorrow’s leaders who contribute to operational efficiency. My experience as a student has been amazing and very memorable. It helped me enhance my creativity by providing a homely environment with a wellequipped lab. Right from my director to my teachers all helped me and supported me and I am thankful to everyone.