AUSTRALIAN NETWORK OF STRUCTURAL HEALTH MONITORING

Newsletter

Issue 12, June 2017

Contents

President Message

Tommy Chan

Professor in Civil Engineering, Queensland University of Technology

In early May I went to Singapore to give a keynote speech at the 5th Annual International Conference on Architecture and Civil Engineering (ACE 2017). Please see the photo attached. The conference is quite a successful one with delegates from 70 universities and 30 countries. I used the opportunity to introduce ANSHM, promoting SHM technologies as well as publicizing SHMII-8 later the year. My presentation was well received and I tried to explain to the audience how important it is to have SHM in this 3rd Millennium. Although SHM has been introduced for few decades, yet as usual I notice that there are many in the fields of architecture or even civil engineering that they know very little about SHM. The conference not only provided a platform to have dialogues between architects and engineers and also they agree that SHM is crucial for the current and next generation structures, no matter civil engineering structures or building structures.

Another exciting news in May is that we have the SHMII-8 contract finally signed. This could facilitate much the organising of the conference and please take note the SHMII updates in this President Message. Besides we also held our 2nd Executive Committee meeting for this year about a week ago. We realised that the inclusion of the SHM section in the latest AS5100 and also having

SHMII being held in Australia will give a very positive impact on SHM in Australia. Therefore although we need to focus more on the organising of SHMII for the year, we still need to allocate some manpower on preparing our next step heading towards the objectives of ANSHM to promote and advance the field of SHM in Australia, establish a research centre/hub, prepare SHM guidelines and eventually a standalone SHM standards. I will also share an important taskforce established in the recent EC meeting in relation to this in this President Message. Below are the updates of the month.

SHMII-8 (https://shmii2017.org/)

As mentioned above that we have the SHMII contract signed between myself and Saeed with ISHMII President. Although it is later than we originally planned, yet we are still glad about that as we could confirm the registration fee, sponsorship arrangement, etc.

Registration Fee

- Some of you may have already been aware that we have uploaded the registration fee information on the conference site, which could be summarised as below:

	Early Bird Registration*	**Standard Registration**
Non-ISHMII Member Registration	A$1250	A$1350
ISHMII Member Registration	A$1000	A$1150
Student Registration	A$500	A$600

*Early bird registration rate expires on Monday 28 August 2017

- Each non-member individual or student registrant at the Conference will receive a one-year free membership in ISHMII including all advantages of a regular ISHMII member such as free on-line access to the Journal of Civil Structural Engineering. These new members get the membership for one year beginning with the day of payment at the conference/workshop.

- It can be seen that the student registration is set a very low value, comparing to other international conferences. The reason for that is to encourage HDR students in Australia to attend the conference to get exposed to various areas in SHM which will be very helpful to their future careers related to SHM. Please encourage your HDR students to attend the conference.

Paper Submissions including MS/SS

- More than 300 abstracts were submitted, of which around 240 are for general sessions and 71 for 3 mini symposia and 3 special sessions. The event manager will check on room availability and costings to accept extra submissions as posters.
- As we received numerous requests for extension of the full paper submissions, we have decided to postpone the deadline of submissions to 11th of June.
- Please note that there is a review process after receiving the paper and we plan to notify and confirm the number of papers to be presented in the conference by the end of July. It is important for us to plan the programme for the conference based on the number of accepted paper. Please submit your paper by the extended deadline.
- Saeed as the leader of the editorial sub-committee has sent an Advocate invitation to invite the potential reviewers for the conference. It is gratefully appreciated if you sign up for an account as "Review and Program Committees" (Advocate) into OpenConf https://www.openconf.org/shmii8/ to be able to access to author information on the submission summary page so you have the author's email address.
- Since we have that many papers to be reviewed, please conduct the review promptly when you are invited to review the papers. We will try our best to limit the number of papers to be reviewed by each reviewer.
- Please note that there is a rule in ISHMII that for SHMII conference regarding authors with multiple papers. In general, the policy is that, if there are two authors registered for the conference, then they could have two papers to be included in the conference proceeding and be presented, three authors registered, three papers, and so on so forth.
- The details of SS and MS has been uploaded on the conference website.

International Scientific Committee

- The list of ISC has been uploaded to the conference website. Please note that we are still awaiting the confirmation of some invited potential ISC members and also keep inviting some recently identified.

Sponsorships

- ISHMII will help to attract more exhibitors/sponsors from overseas.
- Normally, ISHMII requires 20% of the SHMII sponsors to be contributed to them. We are so glad that now they agree this does not apply to the local sponsors and we only need to contribute 20% of the sponsorship from the international sponsors.
- So far, besides the QUT sponsor of $5,000, we have confirmed the following sponsorships:
    - Silver Sponsorship
        - Geomotion / Worldsensing (joint sponsorship) (www.geomotion.com.au)
    - Exhibitor sponsorships
        - Bestech (www.bestech.com.au)
        - SAV Tek (www.savtek.com.au)
        - Strucomp (www.strucomp.com)

- Besides, there are 1 more gold, 1 more silver, 1 more bronze, and many more exhibitors sponsorships are being granted or have expressed their interests. It seems that many are very keen to support our activities as well as to make use of this opportunity to exhibit their organisations/companies.
- Although the sponsorship situation looks really great, please continue to follow up those you have asked earlier or approach any of your connections about this sponsorship/exhibitor opportunity. Please use the latest version of the sponsorship document (https://shmii2017.org/wp-content/uploads/2017/05/SHMII-Sponsorship-Prospectus.pdf)

Keynote Speakers

- The two lists of Keynote Speakers to be invited have been confirmed by ISHMII, and as recommended, there is possibility that we invite representatives from Africa-Arabic countries as well as Latin America if some speakers from list A (to be invited) are not available.
- We will send the invitation letters very soon and upload the details of those who have confirmed.

Special Forums

- There will be few forum discussions arranged in SHMII-8 and one of which will be ANSHM Industry Forum.
- New ASCE president of the Australia Chapter is interested to have a presentation/special session/special forum in SHMII

9th ANSHM Workshop (ANSHM mini-symposium in SHMII-8)

For the 9th ANSHM Workshop (ANSHM mini-symposium in SHMII-8), the deadline of 10 June 2017 for paper submission is fast approaching and another reminder for paper submission has been sent to all ANSHM members. Due to request from some members, we are now accepting paper submissions from all ANSHM members including those that have not submitted abstract to us. Once again, please kindly note that this mini-symposium will be used as our 9th ANSHM annual workshop so please try your best to contribute to this session. If you have any problem with submitting the paper and need a short extension, please do let us know by return email to Andy (a68.nguyen@qut.edu.au) or myself. So far we are expecting to have around 20 papers (13 abstracts and other written EOIs) for this mini-symposium.

As mentioned earlier, the ANSHM Advisory Board Meeting (ABM) is to be held on 5 Dec 2017, before the SHMII-8 Welcoming Reception and the ANSHM Annual General Meeting (AGM) (to be held on 5 Dec 2017 or during SHMII-8 (7 – 9 Dec 2017). Please kindly put these dates on your calendar. Alex will closely work with the Editorial Subcommittee of SHMII-8 to ensure the number of attendants to these two meetings. I will also send you a questionnaire to estimate the number of attendants.

Research Collaboration

As mentioned earlier, we have some benchmark/testbed structures which generate data for SHM studies. We could make use of those data to test our developed SHM technologies which may include dynamic characteristics identification, system identification, damage detection, structural capacity evaluation, moving force identification, weigh-in-motion studies, etc. In our last LOC, we decided to form a task force coordinated by Xinqun to work on it. We will explore

- What data are available, e.g. a Cable stayed bridge (UWS) QUT P-Block building, QUT Bridge Model, Curtin U Living Laboratory, or even SHM data from Data61.
- What methods to be tested
- How to call for participation
- How to report the findings

We will first investigate how this could be done amongst ANSHM members and then we may have a special session in SHMII-8 to call for international participation. In the EC meeting, we consider that this is an important taskforce heading towards our objectives.

ANSHM 3rd Special Issue in JCSHM

The response to the call for papers for this special issue is not as good as expected. It has been raised some universities now require their academics to submit paper only to Q1 journals. I consider it is not

a healthy policy as it will hamper the growth of new journals. QUT also has a similar policy but we consider that some non Q1 journals are good place for publication so for each discipline, besides Q1 journals, we also have a list of preferred journal for this discipline and we are also encouraged to publish papers in those journals on the list and JCSHM is on the list. Actually CJSHM is a very good journal in the area of SHM for civil structures. We anticipate that this journal could be indexed by SCI later this year.

There are few papers expected to be submitted very soon but the number will still be much less than what is expected for a special issue. We are still receiving papers for this special issue. Please prepare your paper following "Introductions for Authors" (http://www.springer.com/engineering/civil+engineering/journal/13349) and submit online to this issue 'SI: Structural Identification and Evaluation for SHM Applications' through the official journal submission system. It is important to select the correct 'SI', otherwise your paper will be dealt with the Chief Editor and considered as a general submission.

ANSHM Social Media

In the last EC meeting, we consider to set up our social media to have a better way to notify our members about our activities. Lei will put up the SHMII8-related information, e.g., mini symposia, special sessions, keynote speakers, etc. to our Facebook and LinkedIn pages.

ANSHM Special Session in 7WCSCM

You may have known that Prof Hong Hao, Dr Kaiming Bi and Dr Jun Li will organise an ANSHM special session at the 7th World Conference on Structural Control and Monitoring, (7WCSCM), Qingdao, China, 22-25 July in 2018. We have sent the call for abstracts and so far 13 abstracts have been received.

Conferences/Special Sessions/Mini-symposia of our interests

- 9th International Conference on Bridge Maintenance, Safety and Management (http://iabmas2018.org), will be held in Melbourne, 9-13 July 2018. IABMAS conferences attract about 400-500 bridge engineers and academics. There will be a special session SS11 - Structural Health Monitoring for Infrastructure Asset Management, organised by Jun Li, Xiao-Wei Ye, Ting-Hua Yi, Huapeng Chen. Abstract submission deadline: 2 Jun 2017.
- There is a special session focusing on SHM in the coming 6th ISRERM at National University of Singapore (http://cee.nus.edu.sg/ISRERM/index.html), on 31 May – 1 June 2018. It is organized by Prof. H.F. Lam and Prof. S.K. Au.
  Abstract submission deadline: 30 August 2017.

Newsletter

Regarding this issue of the Newsletter, we have two very interesting articles, one from Curtin University and the other from Griffith University. Using ultrasonic sensors for SHM has been a challenge. The article by Subhra Majhi and Abhijit Mukherjee at Curtin University describes how travelling wave based techniques could be effective in identifying local damages in steel and concrete structures. A brief description of the Ultrasonics based structures monitoring laboratory at Curtin University is also given at the end of the article.

Nayyeri et al. of Griffith University report another important study on crack detection. In a two-step approach, a structure saliency map could be produced and the map could be further converted into a binary crack map which is very useful to detect cracks. Please enjoy.

With kind regards,

Tommy Chan

President, ANSHM

www.ANSHM.org.au

AUSTRALIAN NETWORK OF STRUCTURAL HEALTH MONITORING
Newsletter

Passive and Active Wave based Schemes for Structural Health Monitoring

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Abstract

Periodic and reliable assessment of civil infrastructure is imperative for their sustainability. Traditionally, these assessments are based on visual inspection, which makes them tedious and subjective. Travelling wave based techniques have proved to be proficient in identifying local damages in steel and concrete. A hybrid method combining the active and passive techniques is found to be efficient in monitoring of infrastructure throughout various stages of its deterioration.

Introduction

OECD countries are facing the challenge of maintaining ageing infrastructure with ever shrinking budgets (Schieb, 2007). According to the National State of the Asset (2015) report, estimated gross replacement value of local government infrastructure for all Australian councils is $438 billion of which 11% or $47 billion of assets are in poor or very poor condition. Conditional evaluation of structures is still primarily undertaken through visual inspection which makes this approach very subjective. Travelling wave based technologies can be perceived as a scientific alternative to the existing scheme of health evaluation of civil engineering structures. Wave based technologies rely on the analysis of pulses emanating from a site of damage in a structure to detect it. They are broadly classified as passive and active wave based monitoring systems depending on their attribute mode for the detection of damage. Passive wave based systems rely on observing the arrival times of the pulses from different points in a structure, to identify the location of damage. This technique is effective only during the incipient stages of damage. The damage detection paradigm in active wave monitoring schemes is based on the interaction of travelling ultrasonic waves with the any existing damage in the member. These waves are analysed and the location of damage is then identified. Thus, a combination of passive and active wave based monitoring paradigm is a viable and scientific method for health inspection of civil engineering infrastructure.

Passive wave based structural health monitoring

he acoustic emission (AE) system is a passive wave based monitoring systems(Di Benedetti et al., 2012). This systems is apt for detection and location of damage viz., a crack in a structural member during their incipient stage (Figure1). The acoustic activity from developing cracks are picked up and located by acoustic transducers. Thus, micro-cracks which grow over time to form cracks before their emergence can be picked up as acoustic events using this system.

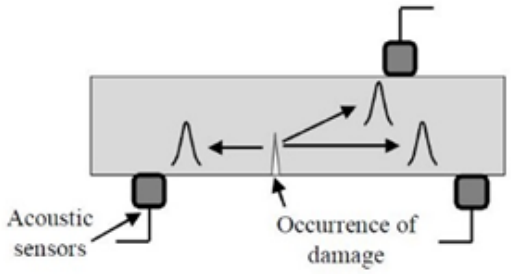

Figure 1: Passive wave based health monitoring scheme

The passive nature of this scheme restricts its effectiveness to the point of incitation of damage in a structure. The acoustic activity (events) of a model concrete beam reinforced with carbon fibre reinforcement subjected to 3-point bending is shown in Figure 2. The competence of this technique is evident from the band of acoustic events at the central part of the beam which leads to formation of a flexure crack resulting in failure of the beam.

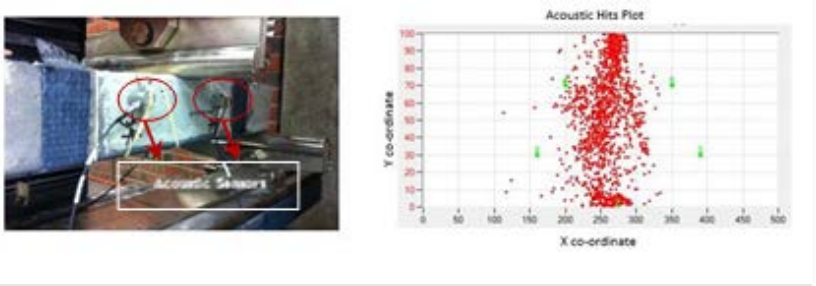

Figure 2: Acoustic monitoring of model beam

Active wave based structural health monitoring schemes

Piezo (PZT) transducers based ultrasonic health monitoring schemes have been used for health monitoring of infrastructure (Sharma & Mukherjee, 2010). The ultrasonic travelling waves generated by the transducers travel through the structure, interacting with damages in them and by analysis of this wave, as shown in Figure 3, the location and extent of damage in a structure can be established. The energy output associated with the piezo based systems is of the order of µ-Joules which is scant and needs to be elevated to monitor the condition of large civil engineering structures efficiently. Moreover, as this techniques is based on contact of the transducer with the structure, there may be an issue with the reliability in the measurements over the time. A comparison of ultrasonic time signals generated and received by1MHz frequency transducers on a pristine mild steel bar and a bar with 25% reduction in diameter in form of a central groove is shown in Figure 4. The former of the two peaks in Figure 4(a) are from the reception of the incident ultrasonic signal and the later due to the reception of the reflection of the incident ultrasonic signal. The presence of an addition peaks and a change in the characteristic of the two peaks indicate the location of groove in the bar.

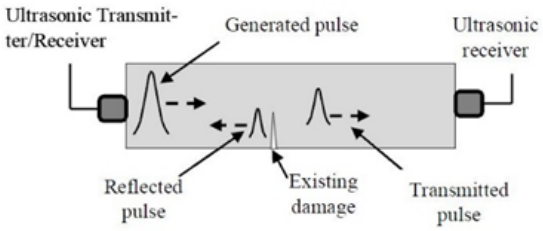

Figure 3: Piezo based active health monitoring scheme

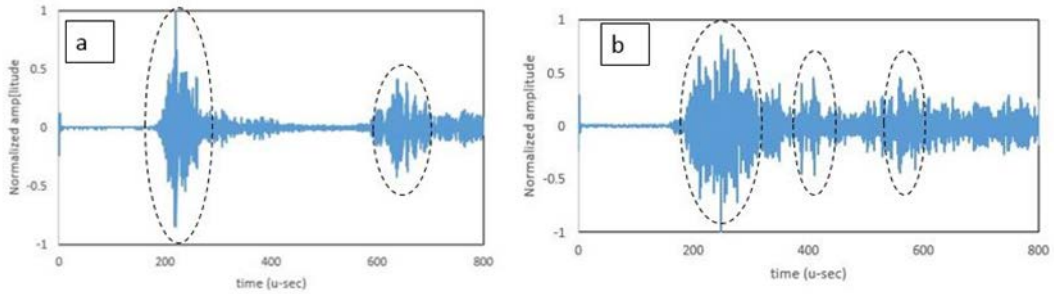

Figure 4: Signal comparison between (a) pristine and (b) grooved bar: PZT ultrasonic system

Laser Ultrasonics, is a non-contact monitoring technique which involves generation of ultrasonic waves by using a high energy Pulsed Laser (~1 Joule) and detection of these waves by Interferometry based Laser Vibrometer, as shown in Figure 5. Remote inspection of large civil engineering structures which are constructed of heterogeneous and attenuate materials like concrete using ultrasonics can be a challenge. Laser Ultrasonics offers a non-contact, higher energy output solution to overcome this challenge. Also, a Pulsed Laser generates a broadband spectrum of frequency which eliminates the necessity of using transducers of different frequency to excite distinct modes in structural element. As the detection of the signal is done in non-contact mode using a Laser Vibrometer, there is an improvement in the reliability of the measured signals. Thus, a number of damage condition can be detected using laser based ultrasonics. A comparative study of time signals between the pristine and the grooved mild steel bar as discussed in the earlier section is shown in Figure 6. A clear distinction in the signal pattern between these two cases is observed. An additional peak between the two main peaks at around 400 µsec indicates the presence of the groove.

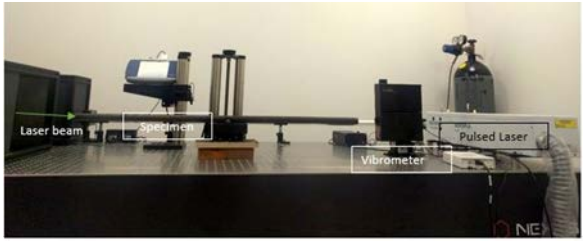

Figure 5: Laser based active health monitoring scheme

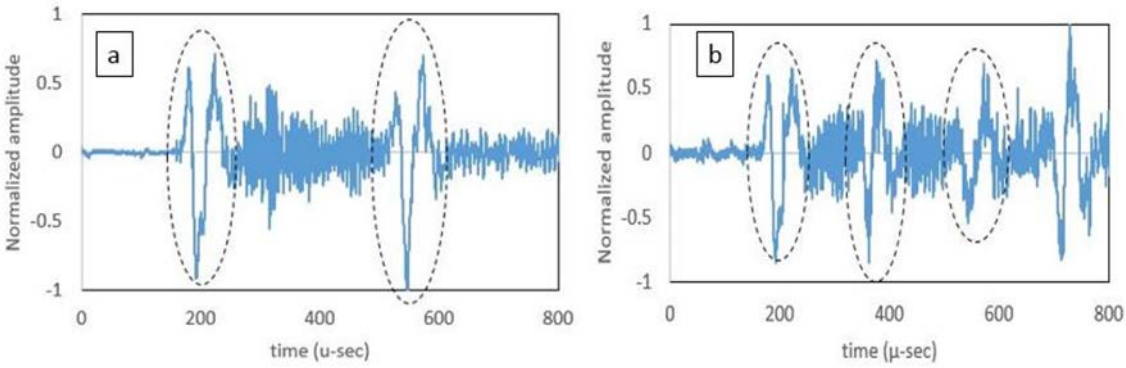

Figure 6: Signal comparison between (a) pristine and (b) grooved bar: Laser ultrasonic system

Conclusion

Travelling wave based technologies have demonstrated the potential for condition monitoring of civil infrastructure. The passive wave based health monitoring systems are effective in the initial stages when a damage to a structural member initiates. The active ultrasonic wave based systems are accomplished at detection of damage to structural members after the incitation of damage in a structural element. Thus, a combination of passive and active wave based paradigm is essential for the health monitoring of Australia's ageing infrastructure.

Ultrasonics based structures monitoring laboratory at Curtin University

The ultrasonics based structures monitoring laboratory at Curtin University has advanced active and passive wave based ultrasonic monitoring instrumentation. Important instrumentation in the laboratory includes, an 8-channel Mistras Acoustic Emission system for passive wave based system, a Pulser-Receiver system of make JSR ultrasonics with piezo based transducers spaning 50 kHz to 10 MHz for active wave based sensing. A state of the art Pulsed Laser (energy output ~1J) and a Laser Vibrometer are the latest in non-contact active wave monitoring system with the lab. Currently leading research in the field of wave based monitoring of structures in this laboratory is being undertaken by Subhra Majhi, Jay Kumar Shah (PhD students) and several other students under the leadership of Professor Abhijit Mukherjee with active collaboration from several Australian and international universities. The ultrasonics laboratory is presently funded jointly by Curtin University and the Australian Research Council through Linkage project, LP 150100475.

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AUSTRALIAN NETWORK OF STRUCTURAL HEALTH MONITORING

Newsletter

Crack Detection via Salient Structure Extraction from Textured Background

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Introduction

Cracks are significant linear structures over textured surfaces of infrastructures made of brick, concrete, or asphalt. Reliable crack detection is essential for the safety inspection of roads and bridges. Although understanding and differentiating cracks from the background is an effortless process for human, it is much more challenging for the computer. In our research, we propose a novel method for crack detection via salient structure extraction from textured background. This method contains two key steps. In the first step, we extract strong edges and distinguish them from strong textures in a local neighbourhood via a relative total variation approach. In the second step, the spatial distribution of texture features are calculated so as to detect cracks as salient structures that are not widely spread across the whole image. The outputs from these two steps are fused to calculate the final structure saliency map which is then binarised to generate the crack masks.

Crack Detection Method

Step 1 - Local Structure Extraction

The goal of this step is to extract strong structures or edges and distinguish them from background textures. A total variation method can be used for this purpose, which preserves strong edges and suppresses background noises. In our work, we propose to use variation and relative total variation (RTV) to calculate the structure feature map for cracks. Given a crack image I of N pixels, for each pixel I(i), a local neighbourhood patch N_i can be extracted for local texture analysis. The output of this step is a structure map that shows the extracted cracks and suppressed background texture.

Step 2 - Global Texture Distribution

In this step, we aim to calculate the spatial distribution of textures across the image. The motivation is that background textures, i.e., those formed by road materials, will be widely distributed over the whole image, but the cracks only appear in some parts of the image. In order to calculate the distribution of textures, we first quantize the texture patterns using Bag-of-Words model. Given vectorised local patches n_i $(i = 1, \cdots, P)$ at pixel i, where P is the total number of pixels, we use the

K-means clustering algorithm to cluster the vectorised image patches into K clusters. After that, we calculate the horizontal and vertical spatial variances of pixels for each texture distribution map.

Step 3 - Fusion Step

As the final step, we convert the saliency map into a binary crack map. Considering that the saliency map contains both foreground salient cracks and some noisy background pixels, we use a threshold selection method to calculate an optimal threshold for the binarisation. The goal is to minimize the within-class variance and maximize the between-class variance.

Experimental Results

The dataset contains 115 images in different resolutions and aspect ratios, and contains roads made of concrete or asphalt. We manually labelled the location of cracks for the quantitative evaluation purpose. Some sample images and their ground truth can be found in the first and second rows of Figure 1.

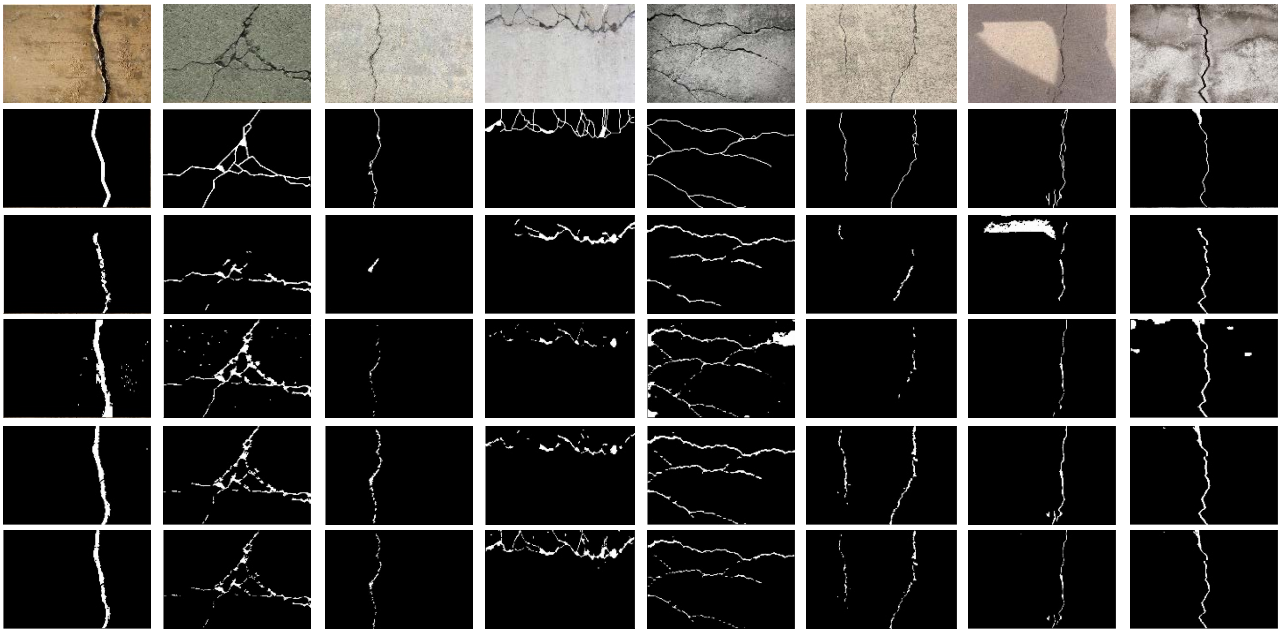

Fig. 1. Crack detection results. From up to down: original image, ground truth, results from saliency detection method, results from local structure extraction, results from global texture distribution, proposed method.

Table 1 shows that the proposed method has demonstrated superior performance than the alternative methods in all three evaluation criteria. The global texture distribution method generated the second best performance. This implies that the spatial distribution of textures is a very important feature to

distinguish cracks from road textures. Textures generated by the road materials tend to appear across the whole image, therefore, cracks can be effectively detected by removing those widely distributed textures. Combining both local and global features, the cracks can be more accurately detected.

Table 1. Qualitative results of methods under comparison.

	Precision	Recall	F-measure
Saliency detection	0.814	0.663	0.697
Local structure	0.823	0.536	0.596
Global texture	0.855	0.751	0.790
Proposed method	0.859	0.817	0.815

Conference News

- ***4th International Conference on Smart Monitoring, Assessment and Rehabilitation of Civil Structures (SMAR 2017),*** 13-15 Sep 2017, Zurich, Switzerland. (http://www.smar2017.org/)
- ***8th Structural Health Monitoring of Intelligent Infrastructure Conference (SHMII-8),*** 5-8 Dec 2017, Brisbane, Australia***. Organized by ANSHM and QUT.*** (http://shmii2017.org/)
- ANSHM mini-symposium in the ***8th Structural Health Monitoring of Intelligent Infrastructure Conference (SHMII-8)***, 5-8 Dec 2016, Brisbane, Australia. Organized by Prof. Tommy Chan and Dr. Andy Nguyen
- Mini-symposium ***"Recent Research Advances on Structural Control and Health Monitoring in Australia"*** in the ***7th World Conference on Structural Control and Monitoring (7WCSCM)***, in Qingdao, China, 22-25 July 2018. Organized by Prof. Hong Hao, Dr. Kaiming Bi, and Dr. Jun Li
- ***"SS11 - Structural Health Monitoring for Infrastructure Asset Management"*** in the **9th International Conference on Bridge Maintenance, Safety and Management**, Melbourne, 9-13 July 2018. (http://iabmas2018.org)

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- ANSHM Facebook group: www.facebook.com/groups/ANSHM
- ANSHM LinkedIn group:

www.linkedin.com/groups/ANSHM-Australian-Network-Structural-Health-4965305

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