PACIFIC EARTHQUAKE ENGINEERING RESEARCH CENTER 2019 ANNUAL MEETING JANUARY 17-18, 2019 LOS ANGELES, CA

SEISMIC 25 YEARS AFTER NORTHRIDGE: RESILIENCE

Plenary 4a: Φ-Net 2018 Challenge & Blind Prediction Winners

Khalid M. Mosalam PEER Director, Taisei Prof. of Civil Eng., UC-Berkeley

PEER Annual Meeting – Los Angeles, CA

January 17-18, 2019

Outline

- Introduction
- Blind Prediction of a Large-Scale Shaking Table Test on a Shallow Foundation in Liquefied Soils
- Winner of Blind Prediction & presentation
- PEER 2018 Φ-Net Challenge
- **Engineering winner of Φ-Net 2018 Challenge & presentation**
- **Computer Science winner of Φ-Net 2018 Challenge & presentation**



Why Blind Predictions/Challenges?

- Highlight the gap between analysis & experiments
- What are the sources of these differences?
- A step towards IV&V [Independent Verification & Validation]
- What does this mean to:
 - Safety of our structures
 - Expected performance levels (Immediate Occupancy vs. Operational)
 - Hybrid simulation, that relies on accurate modeling of part of the system
- How to systematically improve the analytical predictions?
- Many possibilities for blind predictions (challenges) of existing & new components, systems & systems of systems.



Future 2019-2028 PEER Blind **Prediction Contests & Challenges**

PEER core institutions include major labs with unique features offering opportunities for future **blind prediction contests**:

- The largest 1 DOF shaking table (UCSD) \checkmark
- The largest 6 DOF shaking table (UC Berkeley)
- The largest geotechnical centrifuge (UC Davis) ✓
- The largest field testing facility (UCLA) \checkmark
- The largest tsunami wave tank (OSU) \checkmark
- The largest shaking table array (UNR)
- PEER will be engaged in a multidisciplinary ٠ research in TBSI (Tsinghua-Berkeley Shenzhen Institute) to develop the digital twin of urban system to create city's resiliency against hazardous conditions.
- A 4 km² testbed in Shenzhen will be outfitted. with sensors to validate algorithms & tools offering a playground for future **AI challenges**.



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Highway

Class B Blind Prediction of a Large-Scale Shaking Table Test on a Shallow Foundation in Liquefied Soils

Ramin Motamed, PhD, PE Department of Civil & Environmental Engineering University of Nevada, Reno

Acknowledgements

- Pacific Earthquake Engineering Research Center (PEER)
- Milad Jahed Orang (PhD Student, UNR)
- Prof. Ahmed Elgamal (UCSD)
- Staff & a group of graduate students at UCSD (Athul Parayancode, Muhammad Zayed)







Background and Motivation

- 2011 M9.0 Tohoku Earthquake
- Widespread Liquefaction
 - 27,000 buildings damaged
 - Similar to Christchurch, NZ
- <u>Building foundation</u> performance varied
 - Deep foundations \rightarrow good performance
 - Shallow foundations → extensive damage
 - 0 cm < 30 cm < 70 cm
 - Factor of 2.3



Building (Pile Supported) -No Settlement

Building (Mat Foundation) -70cm Settlement

Free field -30cm Settlement

Photo: Ashford et al., 2011



Shaking Table Test – June 19-21 2018





Blind Prediction Timeline

Date	Actions
09/19/2018	Pre-announcement published
10/24/18	Website went live, news published
11/9/2018	Deadline for questions
12/16/2018	Deadline for submitting prediction results
12/21/2018	Winner notified





PEER is pleased to announce the 2018 Blind

Blind Prediction Summary

Team	Program	Modeling
1	FLIP	2D
2	LS-Dyna	3D
3	ANSYS	2D
4	OpenSees	2D
5	FLAC	2D
6	OpenSees	3D
7	Plaxis	2D



Blind Prediction Results!

Third Place:

Arup

Nick O'Riordan, Anton Pillai, Samila Bandara & Ulas Cilingir



Blind Prediction Results!

Second Place:

University of Washington

Long Chen & Pedro Arduino



Blind Prediction Results!

• Winner:

Tokyo Electric Power Services Co., Ltd. Yuta Nakagama Yuichi Otsuka & Yukio Tamari



Team TEPSCO

- Yuta Nakagama, Civil Engineer (20's)
- Yuichi Otsuka, Civil Engineer (20's)
- Yukio Tamari, Ph.D., P.E. Civil Engineer, Manager (50's) Principal Investigator



Yuta



Yuichi



Engineering for the NEXT

TEPSCC

Yukio

- All are from Research and business incubation office in TEPSCO (<u>T</u>okyo <u>E</u>lectric <u>P</u>ower <u>S</u>ervices <u>Co</u>., Ltd.), Japan.
- TEPSCO was established in 1960 as an affiliated company of TEPCO to provide consulting services for electric power industry.



The beginning of the start of our participation



- Due to unexpected set of coincidences
- Announcement about GEESD V 2018 in "PBD-III Vancouver 2017", BC, Canada
- First encounter with the organizer (Dr. Ramin) in GEESDV 2018, Austin, TX.
- Got invitation of the Blind prediction contest in Oct 2018 and accepted.



What I want to share with all of you

Engineering for the NEXT

- Deep gratitude to all.
- Key: Soil behavior at large strain.
- Please look at our poster on the numerical analysis using "FLIP TULIP" during the poster session.
- Matter for congratulation will be handed down to audience.
- The winner next time is "you".



PEER Hub Image-Net (Φ-Net) 2018 Challenge

Yuqing Gao PhD Candidate, UC-Berkeley & Khalid M. Mosalam PEER Director, Taisei Prof. of Civil Eng., UC-Berkeley

Background

Deep Learning in vision-based Structural Health Monitoring

- No uniform & systematic detection framework
- Lack of large number, well-organized & labeled data
- Great impact of ImageNet
 - + Build discipline-specified ImageNet
- PEER response
 - + Build a open-source large-scale dataset & propose framework/pipeline for automated detection (**P**EER **H**ub **I**mageNet, **Φ-Net**)
 - Hold an inter-discipline competition and aim for baseline performance +
 - + Promote AI & machine learning in the earthquake engineering community



"The IM GENET of x"















SpaceNet

ShapeNet

Medical ImageNet

ActivityNet



Gao, Y. & Mosalam, K.M. (2018). Deep transfer learning for image-based structural damage recognition. Computer-Aided Civil & Infrastructure Engineering, 33(9), 748-768.

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Φ-Net & Tasks



Organizers

Technical Committee



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https://apps.peer.berkeley.edu/ phichallenge/acknowledgements	L	1	21

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Φ-Net 2018 Challenge

- From August 23rd to November 25th, 2018
- Teams completed 8 multi-classification tasks



- ~30,000 labeled images for training; <u>https://apps.peer.berkeley.edu/spo/</u>
- Total of 68 team applications worldwide, ~50% participation



Team Submission Statistics

Basic Tasks

- 1. Scene level identification (Cardinality = 3): 32% to 95%
- 2. Damage state check (Cardinality = 2): 47% to 91%





Optional Tasks

- 3. Spalling condition check (Cardinality = 2): 72% to 83%
- 4. Material type identification (Cardinality = 2): <u>95%</u> to <u>100%</u>
- 5. Collapse check (Cardinality = 3): 46% to 71%
- 6. Component type identification (Cardinality = 4): 64% to 76%
- 7. Damage level (Cardinality = 3): 55% to 80%
- 8. Damage type (Cardinality = 4): **37%** to **77%**





Φ-Net 2018 Challenge





Winner in Overall Performance

Engineering Category

Stanford EIG

Seongwoon Jeong & Max Ferguson

Stanford University



PEER Hub ImageNet (PHI) Challenge Stanford EIG





Seongwoon Jeong

Max Ferguson

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Acknowledgement:

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Methodology



Results

Data sets	No. of images	ConvNet	Augment	Ensemble	[T1]
[T1] Scene classification	17,424	SENet154	0	0	[T2]
[T2] Damage check	5,913	SENet154	0	х	[T3]
[T3] Spalling condition	3,294	DenseNet161	0	0	[T4]
[T4] Material type	4,337	SENet154	0	х	(T5]
[T5] Collapse check	515	ResNext101	0	х	[T6]
[T6] Component type	2,630	ResNet152	0	0	[T7]
[T7] Damage level	2,632	ResNet152	0	х	[T8]
[T8] Damage type	2,632	ResNet152	0	0	[]



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Winner in Overall Performance

Computer Science Category

Kar98K

Jianfei Yang (Nanyang Technological University)

Zhaoyang Zeng (Microsoft Research Asia)

Kai Wang (Shenzhen Institutes of Advanced Technology)

Han Zou (University of California, Berkeley)



Team – Kar98K



Jianfei Yang Nanyang Technological University



Zhaoyang Zeng Microsoft Research Asia



Kai Wang Shenzhen Institute of Advanced Technology



Han Zou University of California, Berkeley



Problem Statement





Solutions



Challenges

- Difficult image recognition scenario
- Cumbersome to train models for all tasks
- Lack of data for some categories

Multi-task Transfer Learning Framework

- ✓ State-of-the-art deep feature extractors
- ✓ Simultaneous multi-label learning for all tasks
- ✓ Various data augmentation skills



Experiments and Results

Final Solution:

Task 1 (main task): [Deeper models + Basic augmentation + Multiple Resolutions] * Model Ensemble

Task 2-8 (subtasks): [Basic models + Multi-task transfer learning] * Model Ensemble

Table 1: Task 1 results in the private and public test.

 Table 2: Private result of task 2-8

 Task 2 Task 3 Task 4 Task 5 Task 6

	Private	Public		Task 2	Task 3	Task 4	Task 5	Task 6	Task 7	Task 8
ResNet-50	92.975	91.643	ResNet-50	81.216	79.854	98.895	60.000	72.644	-	-
DPN-98	93 709	92 424	DPN-98	81.891	80.097	98.526	67.692	74.468	67.173	64.437
Augmented DPN-98	03 803	02.075	Multi-task ResNet 50	89.459	82.281	99.263	52.307	74.772	78.419	73.556
Encomble 1	05.095	03 803	Ensemble	89.324	82.766	99.263	63.076	76.291	79.939	76.291
Elisellible 1	95.007	95.095	Best private model	90.270	83 495	99 263	75 384	76 291	81 155	76 595
Ensemble 2	95.224	93.526		70.270	05.475	77.205	75.504	70.271	01.155	10.575

Results and conclusions:

- > The main detection task is a general image recognition problem, which requires more powerful models.
- Other subtasks are more difficult to improve. The simple and advanced models provide similar results, but our transfer learning framework improves the accuracies of the baseline models by 3-8%.
- > We take the 1^{st} place in the overall evaluation and 4 independent tasks (1, 3, 6, 7).



Have enjoyable Poster Session & Reception!



Seismic Resilience 25 Years after Northridge: Accomplishments and Challenges

"Seismic Resilience 25 Years after Northridge: Accomplishments and Challenges" will feature the role of multi-disciplinary performance-based engineering with seismic and related natural hazards to achieve community resiliency. The meeting will open on Thursday, January 17 with plenary sessions highlighting the role of PEER research in the fields of performance-based engineering and resilience, and to identify areas where research and development of technology and tools are needed for effective decision-making. On Friday, January 18 concurrent breakout sessions will be formatted for more detailed discussion and engagement of PEER-funded researchers and projects, with the goal of creating a synergy of resources and information.

Location

Mong Center UCLA Campus 404 Westwood Boulevard Los Angeles, California

Friday

- 3

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Who Should Attend

Decision-making stakeholders, practicing professionals, researchers, faculty, students, and others interested in the practice of performance-based engineering for natural hazards are encouraged to attend. Program details can be found at:

peer.berkeley.edu/peer-2019-annual-meeting-program

Registration

Advanced registration is required for attendance at the 2019 PEER Annual Meeting. Registration details can be found at:

peer.berkeley.edu/peer-2019-annual-meeting registrat

Early Bird Registration ends December 7, 2018

Poster Session & Reception

Emerging researchers and students are encouraged to apply to participate in the poster session. All accepted posters will be displayed during a reception on the evening of Thursday, January 17, 2019. Submit your poster at:

	January 17, 2019	January 17, 2019 Janua					
8:00 - 8:30 AM	REGISTRATION / BREAKFAST	REGISTRATION / BREAKFAST					
8:30 - 10:00 AM	PLENARY -1 PEER Overview Northridge Overview	PLENARY- 5 Welcome Advances in Infrastructure Monitoring and Reconnaissance					
10:00 - 10:30 AM	BREAK	BREAK					
10:30 - 12:00 PM	PLENARY - 2 Advances and Challenges since Northridge	CONCURRENT - 1 Impact of Ground Motions on Bridge Performance and Design	CONCURRENT- 2 Geo Hazards I	CONCURRENT Computation Simulation o Geotechnical a Structural Syste			
12:00 - 1:30 PM	LUNCH & Special Presentation	LUNCH					
1:30 - 3:00 PM	PLENARY - 3 Regional PBEE - Lifeline Systems	CONCURRENT - 4 New Trends In Seismic Design of Bridges	CONCURRENT- 5 Geo Hazards II	CONCURRENT PBEE to Prom Discounts fo Single-Famil Dwellings			
3:00 - 3:30 PM	BREAK		BREAK				
3:30 - 4:30 PM	PLENARY - 4 Computational Tools for Simulating Natural Hazard Effects and Community Resilience	PLENARY - 6 Resilient Los Angeles					
4:30 - 5:00 PM	PLENARY – 4a 2018 PEER Blind Prediction Contest & PHI Challenge Winners	PLENARY - 7 Concurrent Summaries & Closure					
5:00 - 5:30 PM	BREAK						
5:30 - 7:30 pm	POSTER SESSION & RECEPTION (Open to the Public)	1					

Thursday

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