



Earth and Space Science

Supporting Information for

An all-in-one rapid prediction of ground motion intensity measures hybrid network for multi-task in the north-south seismic belt of China

Qingxu Zhao¹, Mianshui Rong¹, Bin Zhang², Xiaojun Li¹

¹Key Laboratory of Urban Security and Disaster Engineering of China Ministry of Education, Beijing University of Technology, Beijing, China, 100124

²Institute of Earthquake Forecasting, China Earthquake Administration, Beijing, China, 100036

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Introduction

Supporting information provides additional information about the data and model to support the analyses in the main text, including detailed information about the selected seismic events, the magnitude distribution division of the dataset, examples of hyperparameter choices for the model structure, loss function curves for the model, the performance of CRAQuake when updating the inputs, a brief review of the data-driven algorithms in the field of earthquake engineering, and the impact on the sample sizes for training and validation.

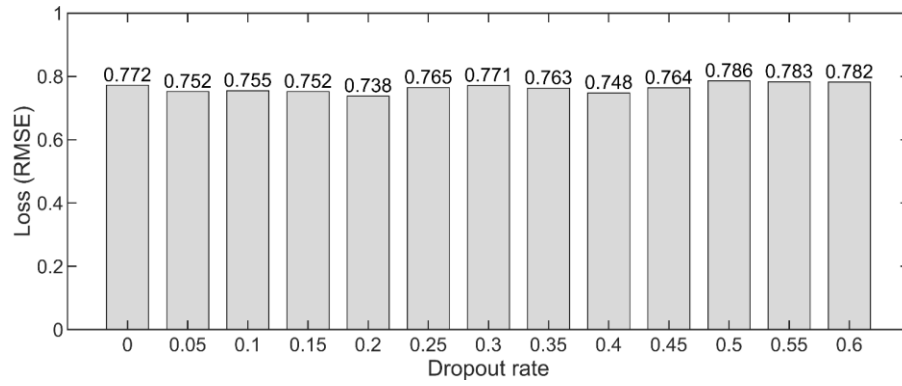


Figure S1. Loss values of CRAQuake at different dropout rates.

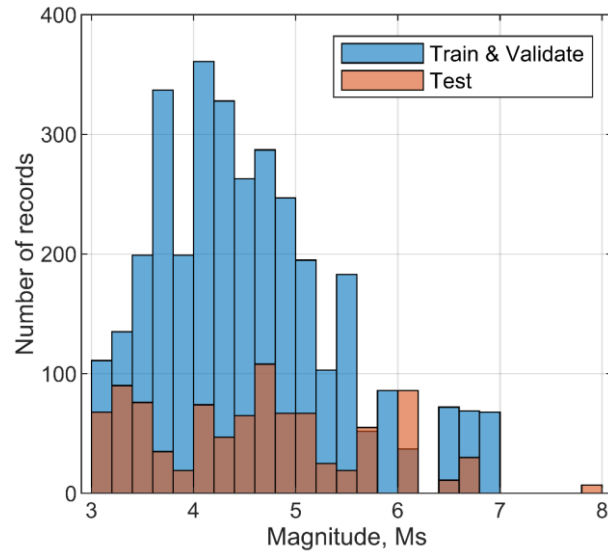


Figure S2. Histogram of magnitude distribution.

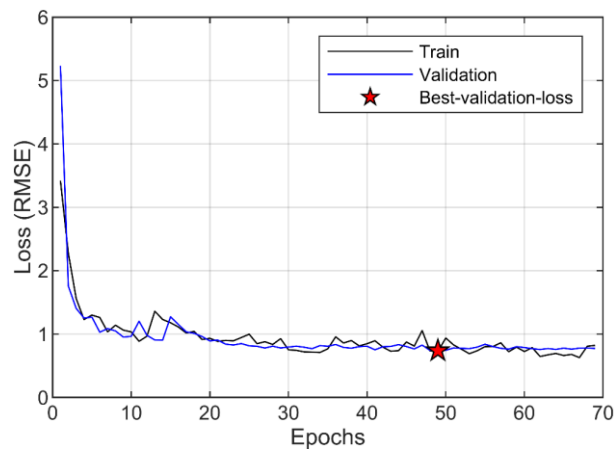


Figure S3. Training and validating loss curves of CRAQuake, the red star indicates the epoch with the minimum loss value on the validation set.

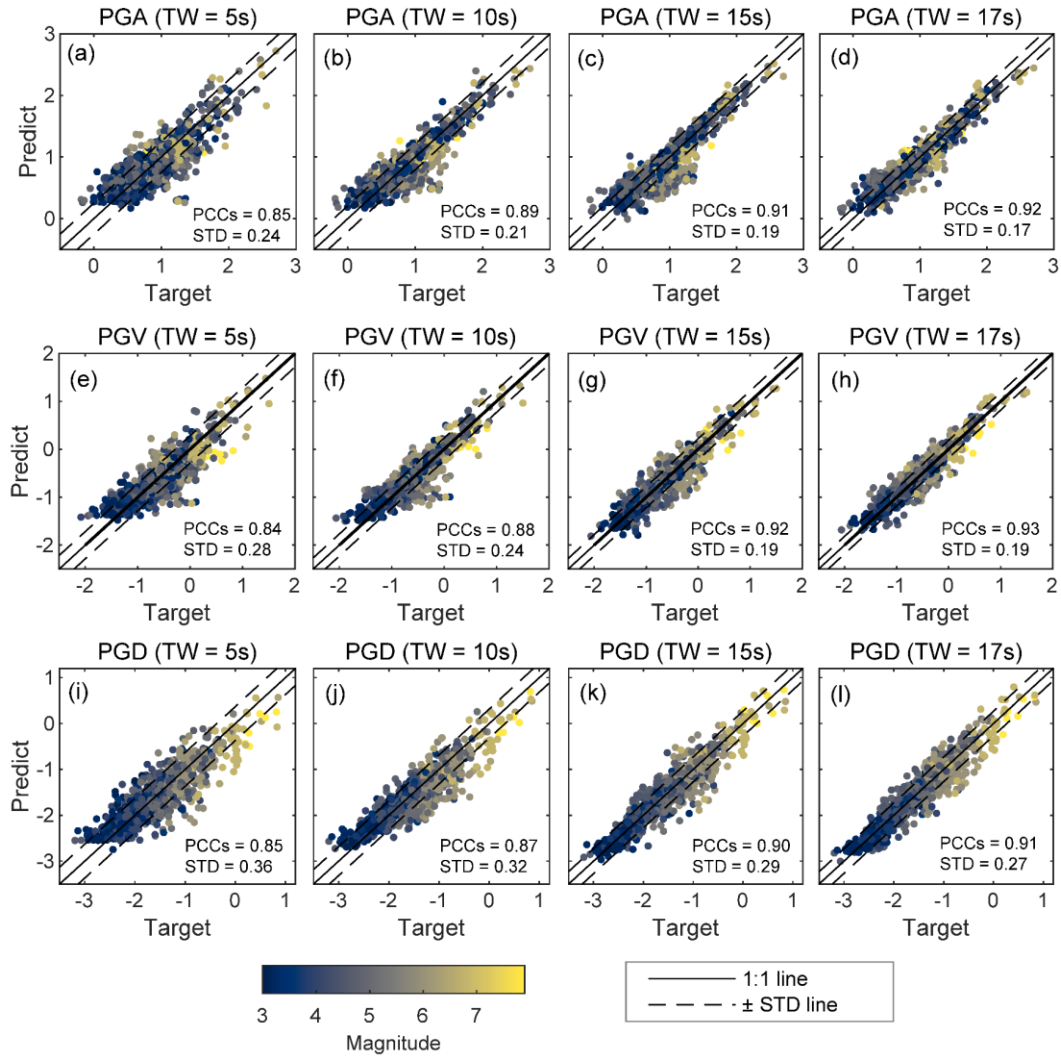


Figure S4. The linear relationship between IMs (PGA, PGV, PGD) Target values and predicted values when TW is 5s, 10s, 15s, and 17s.

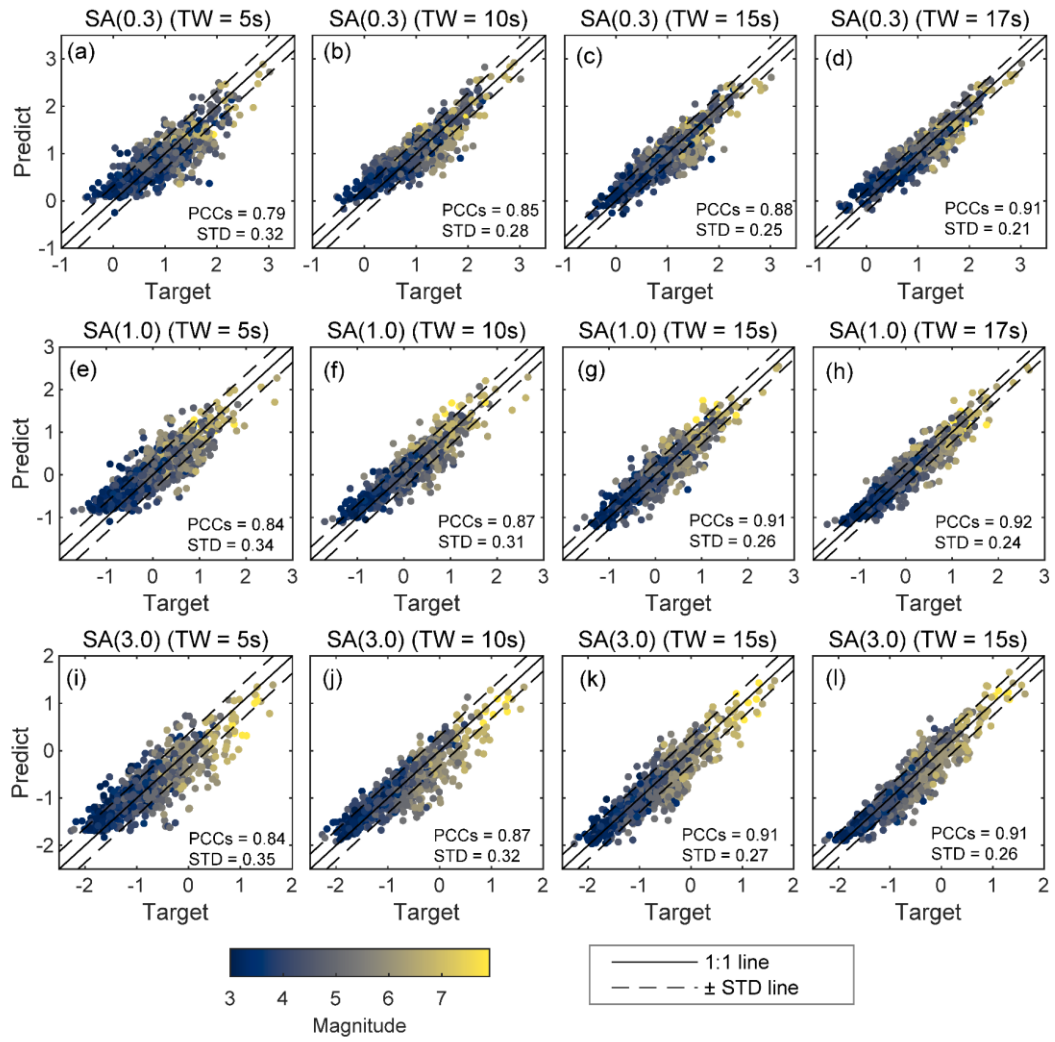


Figure S5. The linear relationship between IMs (SA at 0.3, 1, and 3 s periods.) Target and predicted values when TW is 5s, 10s, 15s, and 17s.

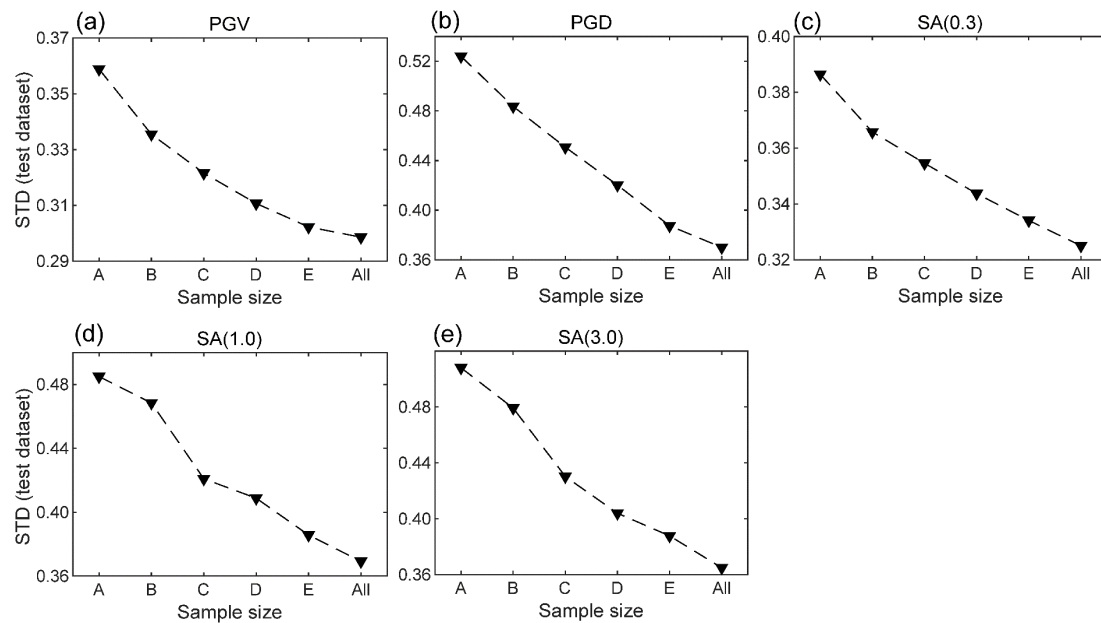


Figure S6. Impact of training and validation sample size.

Table S1. A brief review of some examples in the field of earthquake engineering using data-driven methods.

Approach	Applications in Earthquake Engineering	Input	Data sources	Reference
SVM	Prediction IMs (PGA)	P-wave features	Taiwan, China	(Hsu et al., 2013)
	Prediction IMs (Arias intensity, IA; cumulative absolute velocity, CAV; and significant duration, Ds)	Earthquake source, path, and location parameters	K-net in Japan	(Hu et al., 2022)
XGBoost	Prediction IMs (SA)	P-wave features	K-net in Japan	(Dai et al., 2024)
CNN	Magnitude estimation	Initial arrival wave	KiK-net in Japan	(Wang et al., 2022)
	Prediction IMs (CAV)	Initial arrival wave	KiK-net in Japan, Chile	(Y Wang et al., 2023)
	Site classification	Topographic slope and the mean horizontal-to-vertical spectral ratio (HVSr)	KiK-net and K-net in Japan, Italy	(Ji et al., 2023)
	Prediction IMs (PGA, PGV, SA)	Initial arrival wave	Italy	(Jozinović et al., 2020)
	Prediction IMs (PGA)	Initial arrival wave	KiK-net in Japan, Chile	(Liu et al., 2024)
RNN	Predict earthquake site response.	HVSr of single-station recordings	KiK-net and K-net in Japan, Italy	(Zhu et al., 2023)
	Prediction IMs (PGA)	P-wave features	K-net in Japan	(A Wang et al., 2023)
	Prediction IMs (Ds, CAV, IA, SA)	Earthquake source, path, and location parameters	NGA-West2	(Fayaz et al., 2021)
	Prediction IMs (Ds, CAV, IA, PGA, PGV, SA)	Earthquake source, path, and location parameters	NGA-West2 and KKiKSK	(Fayaz and Galasso, 2022)
	Prediction IMs (Ds, IA, PGA, PGV, SA)	Earthquake source, path, and location parameters	Chile	(Fayaz et al., 2023)

SAM	Magnitude estimation and Earthquake location	Raw waveforms and station coordinate	Japan and Italy	(Münchmeyer et al., 2021)
	Earthquake detection and phase picking	The full waveform of earthquake signals	STanford Earthquake, U.S.	(Mousavi et al., 2020)

Table S2. Architecture and Hyperparameters of CRAQuake.

Convolution block		RNN block		SAM block		FC block	
Title	Hyperparameters Setting	Title	Hyperparameters Setting	Title	Hyperparameters Setting	Title	Hyperparameters Setting
Conv layer	Filter size: 3, Number of Filters: 50, Stride: 2, Padding: Same	LSTM_1	Sigmoid Gate Activation Function, Tanh State Activation Function, Output mode: sequence, 100 units,	Multi-Head Self-attention	10 Heads, 50 Key Channels	FC_1	50 neurons
Max Pooling Layer	Pooling size: 3, Stride: 1, Padding: Same	GRU_1	Sigmoid Gate Activation Function, Tanh State Activation Function, Reset gate mode: after-multiplication, Output mode: sequence, 100 units	Layer norm		FC_2	20 neurons
		LSTM_2	Sigmoid Gate Activation Function, Tanh State Activation Function, Output mode: sequence, 50 units	Dropout	Rate of 0.2	FC_3	6 neurons
		GRU_2	Sigmoid Gate Activation Function, Tanh State Activation Function, Reset gate mode: after-multiplication, Output mode: last, 50 units				

Additional supporting Information (Files uploaded separately)

Captions for Table S3

Table S3. The event information dataset used in this study is accessible in Microsoft Word (Files uploaded separately).

Earthquake time	Event information dataset used in this study				
	Latitude (°N)	Longitude (°E)	Depth (km)	Magnitude (Ms)	Number of records
'09-Jan-2012 08:55:58'	32.22	104.769	22	4	1
'18-Jan-2012 09:28:26'	31.2	103.48	20	3.7	1
'08-Feb-2012 10:34:37'	30.959	103.48	19	4.1	1

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The above table shows a sample of the first few lines of Table S3.

Table S4. Division of the dataset.

	Times	Quantities
Training dataset	January 9, 2012 to January 4, 2017	2, 597
Validation dataset	January 5, 2017 to July 3, 2019	735
Test dataset	July 4, 2019 to November 19, 2022	949

Table S5. Event information on the three representative earthquake events was used in this study.

Title	Earthquake time	Latitude (°N)	Longitude (°E)	Depth (km)	Ms	Mw	Number of records
Wenchuan	2008 - 05 - 12	30.99	103.36	14	8.0	7.9	43
Lushan	2013 - 04 - 20	30.30	103.00	13	7.0	6.7	49

Ludian	2014 - 08 - 03	27.10	103.34	12	6.5	6.1	39
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Table S6. Sample size setting combinations.

Title	A	B	C	D	E	All
Training sample size	500	900	1300	1700	2100	All training Samples
Validation Sample size	200	300	400	500	600	All validation Samples