

Supplementary Material

Detectability enhancement of small defects in materials with high structural noise: A deep learning approach for baseline signal reconstruction

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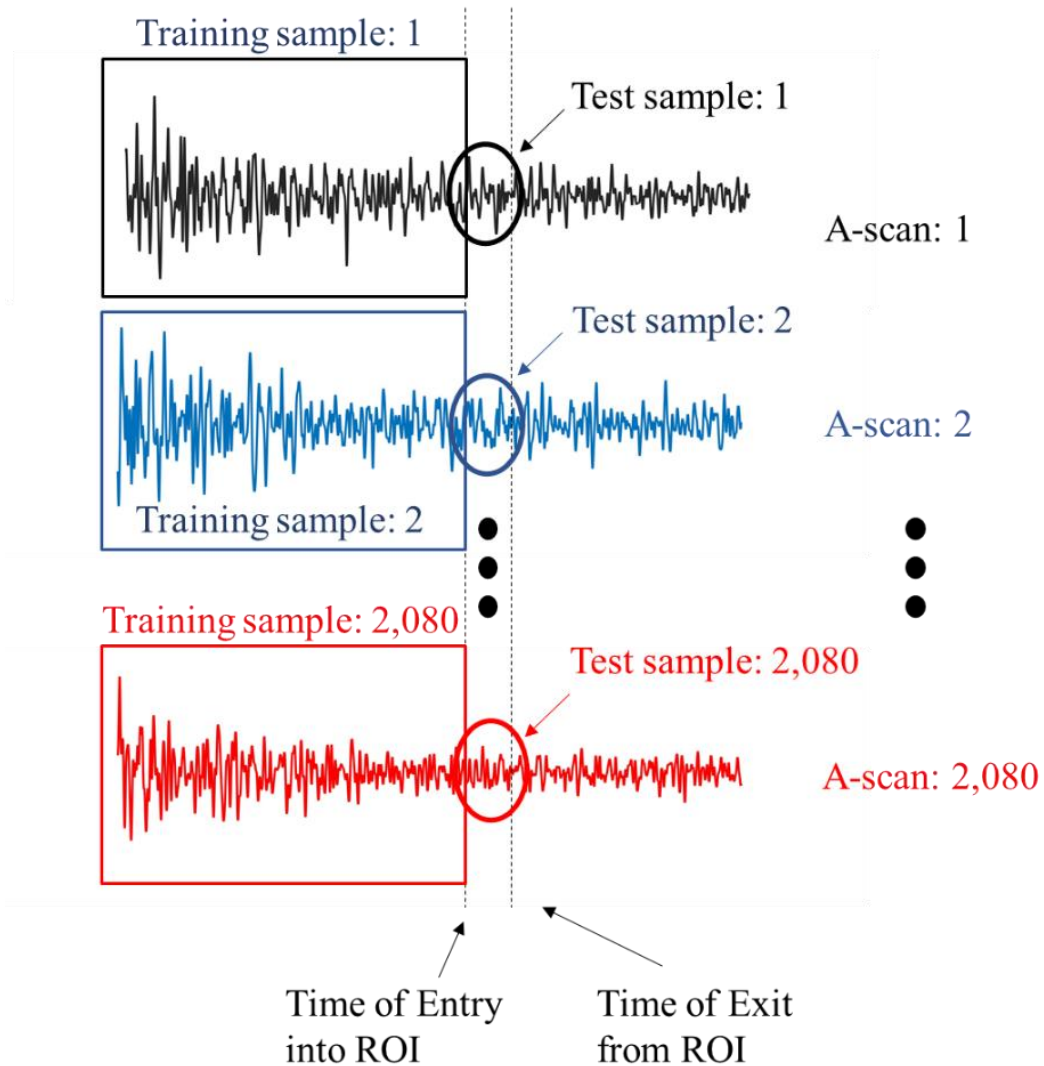


Fig. S1 Process of dataset preparation. This figure is a simplified version of Fig. 5. In practice, the entry times of different A-scan channels into the ROI vary slightly from one another.

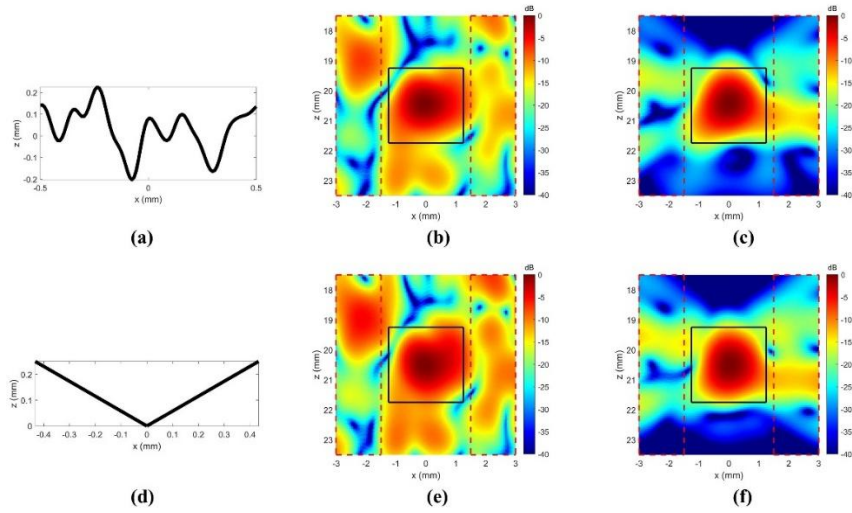


Fig. S2 (a) shows the shape of a rough crack with a size of 1 mm, while (b) and (c) present the corresponding TFM and BS-TFM results. (d) shows a branched crack with each branch measuring 0.5 mm in length and forming a 120° angle, and (e) and (f) are the corresponding TFM and BS-TFM results. All results are obtained using the simulated grain structure #S1.

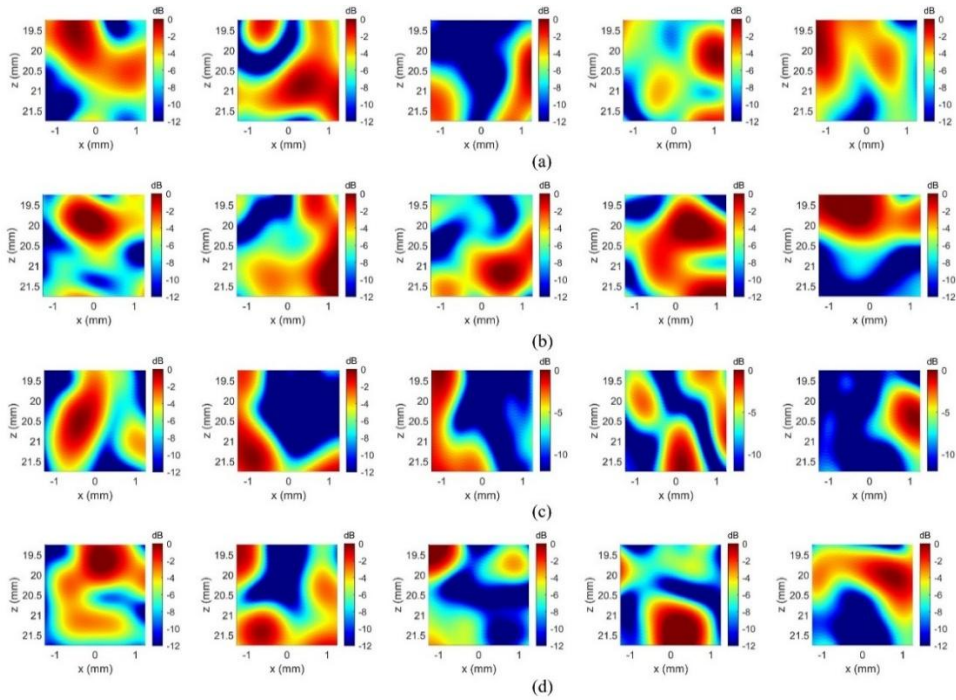


Fig. S3 The true grain images [(a) and (c)] and the predicted results [(b) and (d)] for samples #S11—#S20. Subfigures (a)-(b) present the results for simulated grain structures #S11—#S15 (from left to right), while (c)-(d) show the results for #S16—#S20 (from left to right).

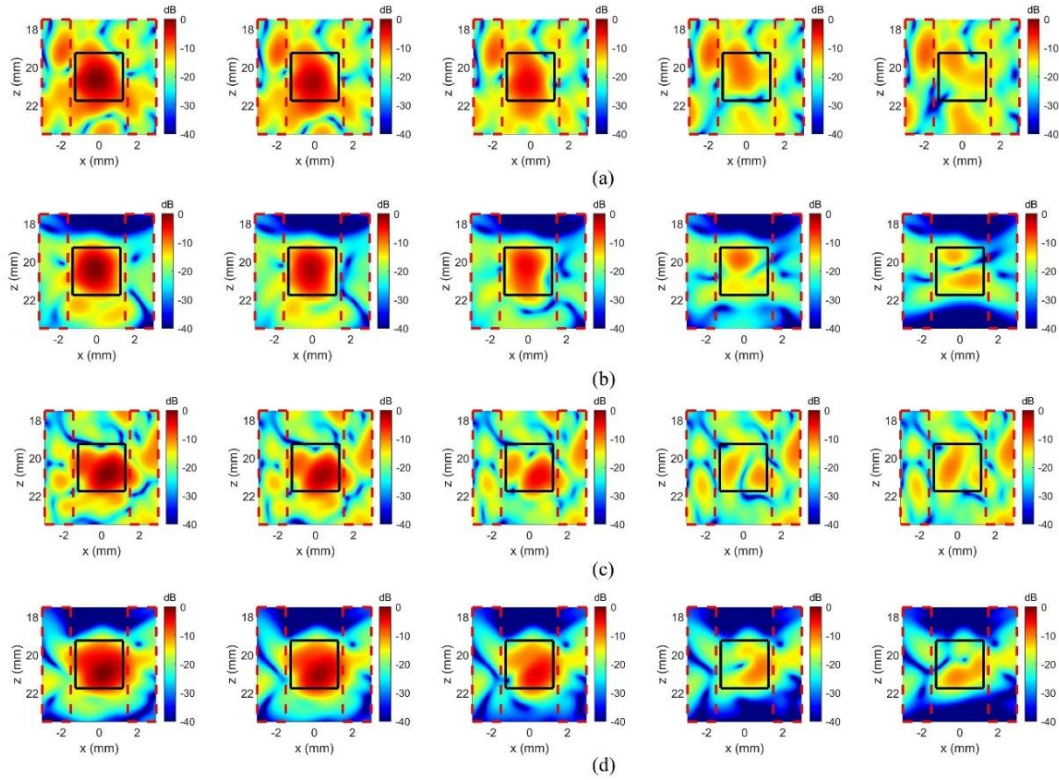
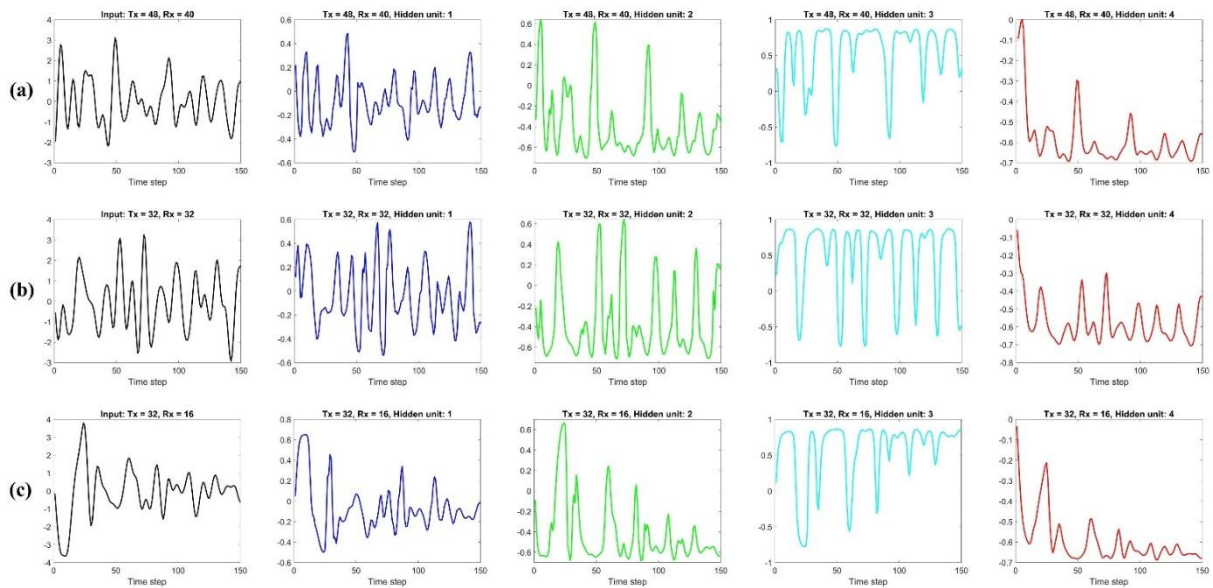


Fig. S4 Comparison of TFM (a, c) and BS-TFM (b, d) results of cracks having various sizes for grain structures #S11 (a, b) and #S16 (c, d). The first to fourth columns show the results of 1 mm, 0.75 mm, 0.5 mm, 0.25 mm cracks, respectively,



and the last column corresponds to the results of defect-free grain structures.

Fig. S5 Input time traces (first column) and the corresponding hidden layer activations of the first four hidden units of the LSTM model (second to fifth columns) for three representative A-scan channels: (a) Tx = 48, Rx = 40, (b) Tx = 32, Rx = 32, and (c) Tx = 32, Rx = 16. Here, Tx and Rx denote the indices of the transmitter and receiver

elements, respectively.

Table S1 Results of paired t-tests comparing SNR values obtained from TFM and BS-TFM for grain structures #S1—#S10 (1 mm, 0.75 mm, 0.5 mm, 0.25 mm cracks, and the non-defect case).

Crack	Mean difference (dB)	t-statistic	p-value	95% confidence interval (dB)
1 mm	4.00	11.74	9.27×10^{-7}	[3.23, 4.77]
0.75 mm	4.59	10.05	3.44×10^{-6}	[3.55, 5.62]
0.5 mm	5.37	8.06	2.09×10^{-5}	[3.86, 6.88]
0.25 mm	5.06	6.28	1.44×10^{-4}	[3.24, 6.88]
No defect	3.34	7.31	4.54×10^{-5}	[2.30, 4.37]

Table S2 SNR results (in dB) for branched cracks and rough cracks in various grain structures, computed from TFM and BS-TFM images.

Sample	TFM		BS-TFM	
	Rough crack	Branched crack	Rough crack	Branched crack
#S1	14.90	12.67	21.71	20.10
#S2	14.41	12.27	19.59	17.36
#S3	15.48	13.47	21.47	19.42
#S4	15.64	13.49	19.59	17.43
#S5	15.00	12.82	23.44	21.90
#S6	15.70	13.45	21.82	19.75
#S7	16.64	14.84	21.11	19.06
#S8	16.23	13.39	19.28	15.81
#S9	17.48	15.25	21.55	18.98
#S10	17.15	14.00	21.91	18.53

Table S3 Comparison of the RMS values between the ROI and the noise region for TFM and BS-TFM. All values are normalized to the peak image amplitude of the 1 mm crack within the same grain structure.

Sample	ROI (0.25 mm crack)		ROI (no defect)		Noise region	
	TFM	BS-TFM	TFM	BS-TFM	TFM	BS-TFM
#S1	0.16	0.15	0.13	0.09	0.20	0.08
#S2	0.20	0.19	0.18	0.16	0.19	0.11
#S3	0.22	0.21	0.18	0.14	0.17	0.08
#S4	0.25	0.26	0.18	0.21	0.18	0.13
#S5	0.22	0.15	0.16	0.13	0.24	0.10
#S6	0.19	0.12	0.17	0.12	0.24	0.10
#S7	0.12	0.18	0.21	0.15	0.23	0.10
#S8	0.32	0.24	0.32	0.24	0.28	0.19

#S9	0.17	0.12	0.17	0.12	0.19	0.10
#S10	0.31	0.18	0.26	0.18	0.18	0.10

Table S4 Noise RMS values of the true and predicted grain images and their shape similarity measured by Pearson correlation coefficient for samples #S11—#S20 which have inhomogeneous grain structures.

Metric	#S11	#S12	#S13	#S14	#S15	#S16	#S17	#S18	#S19	#S20
RMS (true)	0.60	0.64	0.45	0.56	0.60	0.57	0.48	0.47	0.52	0.41
RMS (predicted)	0.58	0.63	0.57	0.69	0.60	0.62	0.57	0.46	0.58	0.56
Correlation coefficient	0.46	0.52	0.38	0.44	0.52	0.44	0.68	0.65	0.49	0.61

Table S5 SNR results (in dB) for cracks of different sizes, computed from TFM and BS-TFM images for simulated grain structures #S11—#S20.

Sample	TFM					BS-TFM				
	1 mm	0.75 mm	0.5 mm	0.25 mm	No Defect	1 mm	0.75 mm	0.5 mm	0.25 mm	No Defect
#S11	15.34	14.10	12.51	8.33	6.62	20.97	19.65	17.62	14.70	12.70
#S12	16.89	15.40	12.32	4.61	4.54	20.36	19.60	18.13	10.88	10.27
#S13	16.37	15.60	13.65	6.11	4.52	20.14	19.61	17.67	11.32	9.30
#S14	16.77	15.92	13.04	4.33	5.01	20.39	20.51	19.68	15.93	12.06
#S15	18.53	18.09	15.62	6.60	5.76	22.39	23.09	22.71	16.33	10.45
#S16	16.38	15.60	12.95	7.06	7.65	19.37	19.54	17.95	13.43	13.18
#S17	12.91	11.98	8.99	4.81	5.46	17.18	16.90	14.99	9.15	7.85
#S18	15.31	14.35	12.31	7.26	6.31	17.95	17.43	15.62	8.97	7.95
#S19	16.63	15.84	13.17	7.33	6.28	16.48	15.51	13.51	11.14	10.46
#S20	14.63	13.79	11.86	5.64	5.66	17.33	16.94	15.91	12.18	8.47