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<tr><th>authors</th><td>K. Shukla
P. C. D. Leoni
J. Blackshire
D. Sparkman
G. Karniadakis</td></tr>
<tr><th>title</th><td>Physics-Informed Neural Network for Ultrasound Nondestructive Quantification of Surface Breaking Cracks</td></tr>
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<tr><th>volume</th><td>39</td></tr>
<tr><th>doi</th><td>10.1007/s10921-020-00705-1</td></tr>
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<tr><th>abstract</th><td>We introduce an optimized physics-informed neural network (PINN) trained to solve the problem of identifying and characterizing a surface breaking crack in a metal plate. PINNs are neural networks that can combine data and physics in the learning process by adding the residuals of a system of Partial Differential Equations to the loss function. Our PINN is supervised with realistic ultrasonic surface acoustic wave data acquired at a frequency of 5 MHz. The ultrasonic surface wave data is represented as a surface deformation on the top surface of a metal plate, measured by using the method of laser vibrometry. The PINN is physically informed by the acoustic wave equation and its convergence is sped up using adaptive activation functions. The adaptive activation function uses a scalable hyperparameter in the activation function, which is optimized to achieve best performance of the network as it changes dynamically the topology of the loss function involved in the optimization process. The usage of adaptive activation function significantly improves the convergence, notably observed in the current study. We use PINNs to estimate the speed of sound of the metal plate, which we do with an error of 1\%, and then, by allowing the speed of sound to be space dependent, we identify and characterize the crack as the positions where the speed of sound has decreased. Our study also shows the effect of sub-sampling of the data on the sensitivity of sound speed estimates. More broadly, the resulting model shows a promising deep neural network model for ill-posed inverse problems.</td></tr>
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