Deep learning for ultrasound surface echo detection

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Ultrasound array imaging techniques are often applied using a coupling medium to transmit waves from the transducer to the scanned component. In this type of test the echoes generated by wave reflection at the component surface contain information that can be used to estimate the surface shape and its position relative to the probe, which are needed to compute the imaging focal laws. The most interesting feature to extract from surfaces echoes is its Time of Flight (TOF) in each reception channel. TOF measurement in acoustic signals is a problem that frequently arises not only in Non Destructive Testing (NDT), but also in medical imaging, geophysics and other fields. The surface echo in a signal is usually identified as the first high amplitude peak, and is traditionally detected with standard methods as threshold crossing, peak search or matched filters. All this methods are easily affected by Signal to Noise Ratio, which might be high in some channels, for example if the ray arrives at the corresponding element at a low sensibility angle. Moreover, spurious echoes from bubbles, the emission signal tail or echoes from other parts of the component can be incorrectly labelled as surface echoes. This kind of outliers are difficult to filter by conventional means and, thus, there is a need for more robust surface estimation methods. In this work, we study the application of a deep Convolutional Neural Network (CCN) to detect surface echoes in Full Matrix Capture (FMC) ultrasound data. The CNN is trained using signals acquired with a matrix array and a reference component, using a robotic arm set-up to measure the probe position and orientation relative to the component. Thus, with knowledge of the set-up geometry a model is used to compute the theoretical surface echo TOFs, which are used to label the data for training. The model was tested with a validation set, presenting good agreement with the ground truth. The results were compared with the threshold crossing method observing a significant reduction of outliers in the TOF estimation.