A framework for simulating ultrasound imaging based on first order nonlinear pressure–velocity relations. - DTU Orbit (09/11/2017)

A framework for simulating ultrasound imaging based on first order nonlinear pressure–velocity relations.

An ultrasound imaging framework modeled with the first order nonlinear pressure–velocity relations (NPVR) based simulation and implemented by a half-time staggered solution and pseudospectral method is presented in this paper. The framework is capable of simulating linear and nonlinear ultrasound propagation and reflections in a heterogeneous medium with different sound speeds and densities. It can be initialized with arbitrary focus, excitation and apodization for multiple individual channels in both 2D and 3D spatial fields. The simulated channel data can be generated using this framework, and ultrasound image can be obtained by beamforming the simulated channel data. Various results simulated by different algorithms are illustrated for comparisons. The root mean square (RMS) errors for each compared pulses are calculated. The linear propagation is validated by an angular spectrum approach (ASA) with a RMS error of 3% at the focal point for a 2D field, and Field II with RMS errors of 0.8% and 1.5% at the electronic and the elevation focuses for 3D fields, respectively. The accuracy for the NPVR based nonlinear propagation is investigated by comparing with the Abersim simulation for pulsed fields and with the nonlinear ASA for monochromatic fields. The RMS errors of the nonlinear pulses calculated by the NPVR and Abersim are respectively 2.4%, 7.4%, 17.6% and 36.6% corresponding to initial pressure amplitudes of 50 kPa, 200 kPa, 500 kPa and 1 MPa at the transducer. By increasing the sampling frequency for the strong nonlinearity, the RMS error for 1 MPa initial pressure amplitude is reduced from 36.6% to 27.3%.

General information

State: Published
Organisations: Department of Electrical Engineering, Biomedical Engineering, Center for Fast Ultrasound Imaging, Shenzhen University, Shenzhen Mindray Bio-Medical Electronics Co. Ltd
Authors: Du, Y. (Ekstern), Fan, R. (Ekstern), Li, Y. (Ekstern), Chen, S. (Ekstern), Jensen, J. A. (Intern)
Pages: 152–165
Publication date: 2016
Main Research Area: Technical/natural sciences

Publication information

Journal: Ultrasonics
Volume: 69
ISSN (Print): 0041-624X
Ratings:
BFI (2017): BFI-level 1
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 1
Scopus rating (2016): SJR 0.871 SNIP 1.755 CiteScore 2.51
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.711 SNIP 1.729 CiteScore 2.23
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.848 SNIP 2.22 CiteScore 2.41
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.668 SNIP 1.801 CiteScore 2.12
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.69 SNIP 1.978 CiteScore 2.09
ISI indexed (2012): ISI indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 0.718 SNIP 1.789 CiteScore 2.2
ISI indexed (2011): ISI indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.754 SNIP 1.509
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 0.588 SNIP 1.33
Web of Science (2009): Indexed yes

BFI (2008): BFI-level 1
Scopus rating (2008): SJR 0.584 SNIP 1.083
Scopus rating (2007): SJR 0.682 SNIP 1.038
Scopus rating (2006): SJR 0.714 SNIP 1.73
Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 0.748 SNIP 1.141
Scopus rating (2004): SJR 0.803 SNIP 1.492
Scopus rating (2003): SJR 0.688 SNIP 0.914
Web of Science (2003): Indexed yes
Scopus rating (2002): SJR 0.718 SNIP 1.296
Web of Science (2002): Indexed yes
Scopus rating (2001): SJR 0.574 SNIP 0.763
Scopus rating (2000): SJR 0.399 SNIP 1.067
Web of Science (2000): Indexed yes
Scopus rating (1999): SJR 0.637 SNIP 0.975
Original language: English
Nonlinear pressure–velocity relation, Nonlinear wave propagation, Channel data simulation
DOIs:
10.1016/j.ultras.2016.03.015
Publication: Research - peer-review › Journal article – Annual report year: 2016