Adjusting Dimension of Echo Acquisition to Enhance US Perfusion Imaging

Michael F. Insana, MinWoo Kim, Wawrzyniec L Dobrucki, Jamila Hedhli, Craig K Abbey*

> University of Illinois at Urbana-Champaign *University of California Santa Barbara

ILLINOIS

Q. How can we increase the sensitivity of US power Doppler methods for perfusion imaging without contrast enhancement?





A. Modify temporal sampling in ways that increase the measurement sensitivity to slow flow. Then filter data-array dimensions independently to isolate the perfusion signals



1-D US Doppler Processing (One RBC)



1-D US Doppler Processing (Vascular Flow)





US Doppler Processing (Perfusion)





Experiment: Ischemic Hindlimb Mouse Model



Acquisition Parameters

- VisualSonics (Vevo 2100)
- 24 MHz linear array transducer • 1cycle B-mode, 2-4 cycle-Colormode

Bilateral measurements

- Image before right-femoral ligation ٠
- Post-ligation from 10-90 min
- Post-ligation 1d, 2d, 7d, 14d
- Model for healthy revascularization
- Compare to laser Doppler and SPECT



Laser Doppler Results





CD Acquisition Data







HOSVD Processing of 3-D Acquisitions



- Unlike laser Doppler, we see volumetric perfusion Applications include monitoring the progression of microvascular diseases (diabetes) and
- treatments; tumor perfusion; any application
- 00 where flow is steady over 1-10 s.





Dynamic Range Studies at 5 MHz

Hindlimb Perfusion at 24 MHz

Conclusions

- Echo sampling must be designed to maximize the sensitivity of echoes to blood perfusion
- Use HOSVD to manage increases in noise and clutter that accompanies the enhanced blood perfusion signal
- Method can be applied to any commercial system with access to beamformed RF signals
- Fast HOSVD algorithms...well suited to GPU processors

N. Vannieuwenhoven, R. Vandebril, K. Meerbergen, "A new truncation strategy for the higher-order singular value decomposition," SIAM J Sci Comp 34(2): A1027 – A1052, 2012.

SPECT Studies

SPECT images estimate angiogenic and hypoxic responses using

- ^{99m}Tc-labeled radiotracer targeted at $\alpha_v \beta_3$ integrin (NC100692, GE Healthcare, UK)
- ^{99m}Tc-labeled 2-nitroimidazole retained in hypoxic tissue (BRU-5921 Bracco USA)

Hua J, Dobrucki LW, et al. "Noninvasive imaging of angiogenesis with a ^{99m}TC-labeled peptide targeted at alpha-v-beta-3 integrin after murine hindlimb ischemia." Circulation 111(24):3255-3260, 2005.

Dobrucki LW, Meoli DF, et al. "Regional hypoxia correlates with the uptake of a radiolabeled targeted marker of angiogenesis in rat model of myocardial hypertrophy and ischemic injury." J Physiol Pharmacol. 60:(Suppl 4):117-123, 2009.

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