RECONSTRUCTION OF 3D FLOW FROM MULTIPLE ECHO DOPPLER VIEWS

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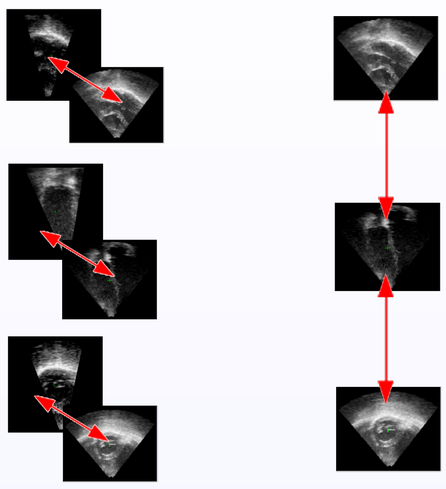
Abstract

We present a new method to reconstruct 3D flow from multi-view 3D Doppler echo. Doppler images only measure a 1D projection of velocity[1, 2]. Our method uses 3+ Doppler views. Angles between these views are calculated with 3D registration. 3D flow vectors are then calculated using a Least Mean Squares approach. We investigate the effect on accuracy caused by spatio-temporal averaging + altering view angle. Simulation and phantom data results show with angles between views $> 40°$, 3D vectors may be reconstructed with $\sim 15\%$ magnitude and $15°$ angle error.

Method

- Image Registration



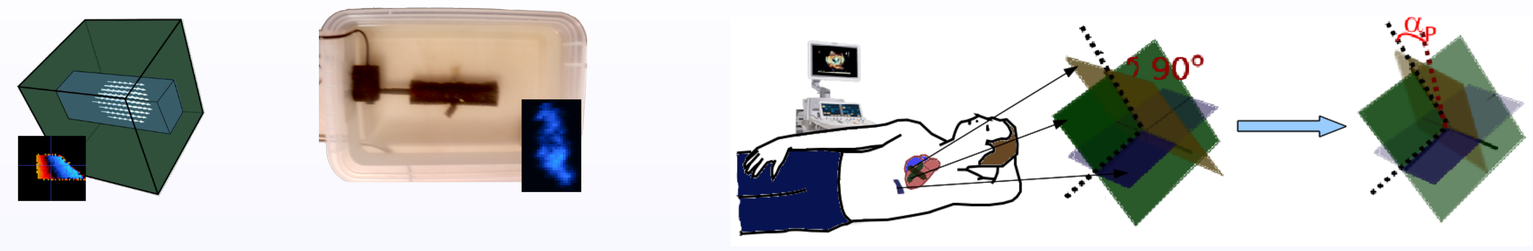
- 3D Vector field reconstruction

$$\begin{bmatrix} m_1 \\ \vdots \\ m_N \end{bmatrix} = \begin{bmatrix} \vec{d_1} \\ \vdots \\ \vec{d_N} \end{bmatrix} \vec{v} + \begin{bmatrix} g_1 \\ \vdots \\ g_N \end{bmatrix}$$

m_i	$\equiv$	measured velocity along the beam direction $\vec{d_i}$
$\vec{v}$	$\equiv$	true velocity vector
N	$\equiv$	number of images
g_i	$\equiv$	additive Gaussian noise

Experiments on Simulated + Phantom Data

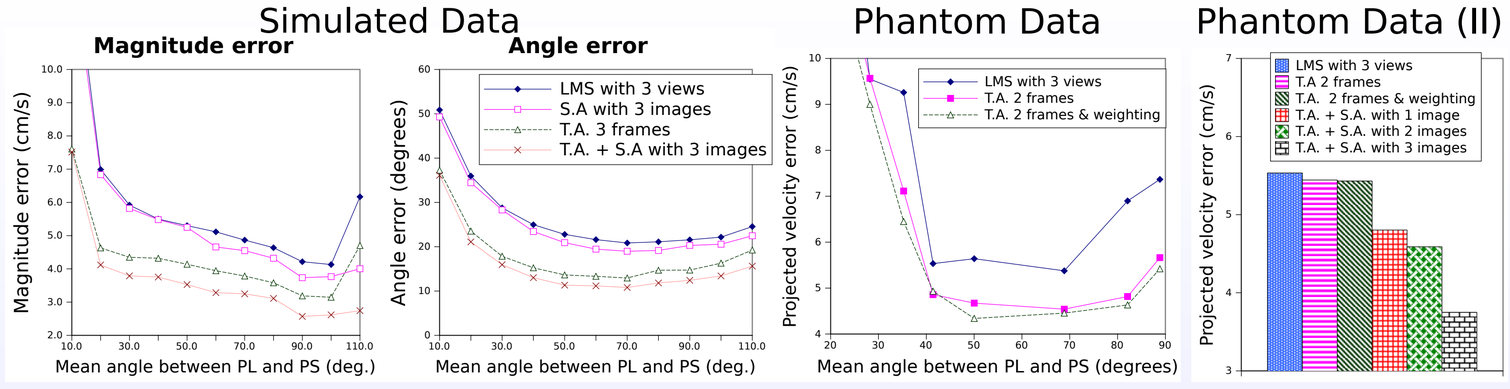
Synthetic data Flow Phantom Aquisition protocol



- One Apical View, two Parasternal Views with a separation angle of α_p.
- Angle α_p was given values from $10°$ to $110°$.
- Zero mean Gaussian noise measured from real data was added to synthetic data.

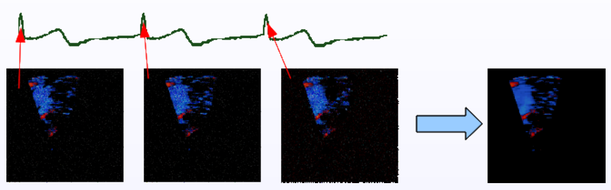
Results

Simulated Data Phantom Data Phantom Data (II)



Methods to Improve SNR

1. Temporal Averaging



2. Spatial Averaging: using more than 3 clinical views.

Conclusions

- Reconstruction error remains approximately constant if $40° < \alpha_p < 90°$. In discussion with clinicians we believe that it is possible to achieve a value of $\alpha_p > 40°$ in a clinical acquisition.
- Two clinically compatible strategies to improve SNR were investigated. These were able to improve the reconstruction accuracy by up to 50%.
- Flow can only be reconstructed where all the Doppler images intersect.
- Future work will include validation on clinical data, incorporation of physical knowledge of flow behaviour to the problem and extension to 3D+T flow recovery.

References

[1] M. Arigovindan, M. Suhling, C. Jansen, P. Hunziker, M. Unser, and E. P.F de Lausanne, Full motion and flow field recovery from echo doppler data, in *IEEE Trans. Med. Imag.*, 2007

[2] S. Xu, H. Ermert, and R. Hammentgen, Phased array pulse doppler tomography, in *IEEE Proc. Ultrasonics Symposium*, 1991

Acknowledgements

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