Literature on real-time AI-empowered echocardiography

Miguel Xochicale

December 9, 2021

Contents

1 Introduction

In the last decades the use of echocardiography is a crucial clinical approach in Intensive Care Units (ICU) because of the advances of smaller US clinical devices, US image quality and its real-time capabilities to access cardiac anatomy [3, 10, 9, 1]. However, despite the previous advances there is still challenges on finding standard views from experienced sonograpehrs that sometimes such quantifcations are qualitative and subjective [3]. Similarly, automatic quantification of left ventricular ejection fraction (LVEF) is still challenging at the point of care due to variation of protocols, skills levels [4] and the nature of proving feedback on real-time [8].

1.1 Image Quality Assessment

[6] considers chamber clarity, depth gain, on-axis attributes, apical foreshoredness.

1.2 Clustering techniques

Zhang et al. mentioned that 23 view classes from 7168 individually labeled videos that ware classified with a 13-layer CNN to then viewed with the use of t-Distributed Stochastic Neighbor Embedding [12]. Kusunose et al. mentioned that other authors have reached an acciracy of 91-94 for 15-view classification while their work mentioned a 98.1 accuracy for five-prederminted views [5].

1.3 Auto-encoders

Laumer et al. proposed a novel autoencoder-based framework to learn human interpretable representation of cardiac cycles from cardiac ultrasound data [7],

1.4 Others

Rank-2 non-negative matrix factorization [11] to generate End-Systole and End-Diastole for apical 4 view. Recently Robust Non-negative Matrix Factorization seems to be implement low-computation cost algorithms to automatic segment mitral valve [2].

2 Methods and materials

References

[1] S. J. Campbell, R. Bechara, and S. Islam. Point-of-care ultrasound in the intensive care unit. *Clinics in Chest Medicine*, 39(1):79–97, 2018. ISSN 0272-5231. doi: https://doi.org/10.1016/j.ccm.2017.11.005. URL `https://www.sciencedirect.com/science/article/pii/S0272523117301168`. Interventional Pulmonology: An Update.

[2] Y. Dukler, Y. Ge, Y. Qian, S. Yamamoto, B. Yuan, L. Zhao, A. L. Bertozzi, B. Hunter, R. Llerena, and J. T. Yen. Automatic valve segmentation in cardiac ultrasound time series data. In E. D. Angelini and B. A. Landman, editors, *Medical Imaging 2018: Image Processing*, volume 10574, pages 493 – 504. International Society for Optics and Photonics, SPIE, 2018. URL `https://doi.org/10.1117/12.2293255`.

[3] H. Feigenbaum. Evolution of echocardiography. *Circulation*, 93(7):1321–1327, 1996. doi: 10.1161/01.CIR.93.7.1321. URL `https://www.ahajournals.org/doi/abs/10.1161/01.CIR.93.7.1321`.

[4] L. C. Field, G. J. Guldan, and A. C. Finley. Echocardiography in the intensive care unit. *Seminars in Cardiothoracic and Vascular Anesthesia*, 15(1-2):25–39, 2011. doi: 10.1177/1089253211411734. URL `https://doi.org/10.1177/1089253211411734`. PMID: 21719547.

[5] K. Kusunose. Steps to use artificial intelligence in echocardiography. *Journal of Echocardiography*, 19(1):21–27, Mar 2021. ISSN 1880-344X. doi: 10.1007/s12574-020-00496-4. URL `https://doi.org/10.1007/s12574-020-00496-4`.

[6] R. B. Labs, M. Zolgharni, and J. P. Loo. Echocardiographic image quality assessment using deep neural networks. In B. W. Papież, M. Yaqub, J. Jiao, A. I. L. Namburete, and J. A. Noble, editors, *Medical Image Understanding and Analysis*, pages 488–502, Cham, 2021. Springer International Publishing. ISBN 978-3-030-80432-9.

[7] F. Laumer, G. Fringeli, A. Dubatovka, L. Manduchi, and J. M. Buhmann. Deepheartbeat: Latent trajectory learning of cardiac cycles using cardiac ultrasounds. In E. Alsentzer, M. B. A. McDermott, F. Falck, S. K. Sarkar, S. Roy, and S. L. Hyland, editors, *Proceedings of the Machine Learning for Health NeurIPS Workshop*, volume

136 of *Proceedings of Machine Learning Research*, pages 194–212. PMLR, 11 Dec 2020. URL https://proceedings.mlr.press/v136/laumer20a.html.

[8] X. Liu, Y. Fan, S. Li, M. Chen, M. Li, W. K. Hau, H. Zhang, L. Xu, and A. P.-W. Lee. Deep learning-based automated left ventricular ejection fraction assessment using 2-d echocardiography. *American Journal of Physiology-Heart and Circulatory Physiology*, 321(2):H390–H399, 2021. doi: 10.1152/ajpheart.00416.2020. URL https://doi.org/10.1152/ajpheart.00416.2020. PMID: 34170197.

[9] S. Singh and A. Goyal. The origin of echocardiography: a tribute to inge edler. *Texas Heart Institute journal*, 34(4):431–438, 2007. ISSN 0730-2347. URL https://pubmed.ncbi.nlm.nih.gov/18172524. 18172524[pmid].

[10] A. Vieillard-Baron, M. Slama, B. Cholley, G. Janvier, and P. Vignon. Echocardiography in the intensive care unit: from evolution to revolution? *Intensive Care Medicine*, 34(2):243–249, Feb 2008. ISSN 1432-1238. doi: 10.1007/s00134-007-0923-5. URL https://doi.org/10.1007/s00134-007-0923-5.

[11] B. Yuan, S. R. Chitturi, G. Iyer, N. Li, X. Xu, R. Zhan, R. Llerena, J. T. Yen, and A. L. Bertozzi. Machine learning for cardiac ultrasound time series data. In A. Krol and B. Gimi, editors, *Medical Imaging 2017: Biomedical Applications in Molecular, Structural, and Functional Imaging*, volume 10137, pages 617 – 624. International Society for Optics and Photonics, SPIE, 2017. URL https://doi.org/10.1117/12.2254704.

[12] J. Zhang, S. Gajjala, P. Agrawal, G. H. Tison, L. A. Hallock, L. Beussink-Nelson, M. H. Lassen, E. Fan, M. A. Aras, C. Jordan, K. E. Fleischmann, M. Melisko, A. Qasim, S. J. Shah, R. Bajcsy, and R. C. Deo. Fully automated echocardiogram interpretation in clinical practice. *Circulation*, 138 (16):1623–1635, 2018. doi: 10.1161/CIRCULATIONAHA.118.034338. URL https://www.ahajournals.org/doi/abs/10.1161/CIRCULATIONAHA.118.034338.