Fully automatic AI-based valve motion parameter extraction on long axis CINE images – application on N=11000 patient datasets

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Declaration of interest

- **PhD stipend from Siemens Healthcare GmbH**

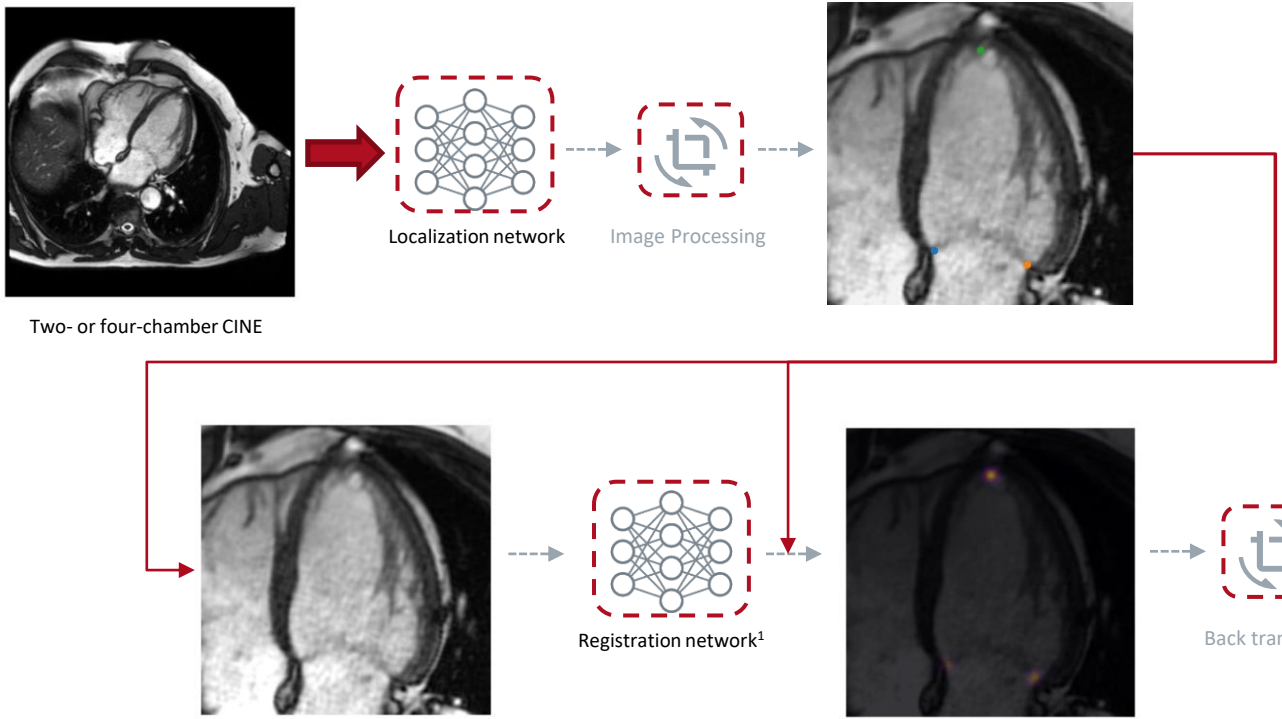
Introduction

- **CINE images may contain potentially clinically relevant parameters beyond typically extracted measures**

- **Manual extraction hampers their validation**

➢ **Fully automated DL-based motion parameter extraction system, applied to the mitral valve**

Methods



[1]Dalca A. et al. MedIA 2019.

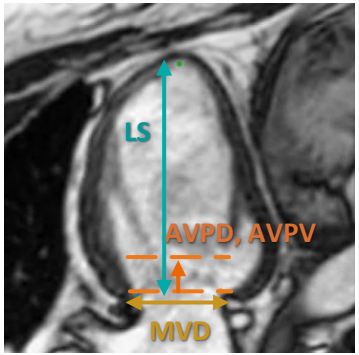
Parameters of interest

Atrioventricular plane *displacement* (AVPD):

- Perpendicular distance of the MV plane from the first cardiac phase

Atrioventricular plane *velocity* (AVPV):

- Time-resolved discrete derivate of AVPD



Mitral valve *diameter* (MVD):

- Euclidean distance between MV insertion points

Mitral annular plane systolic excursion (MAPSE)[1]

Longitudinal shortening (LS)[2]

[1]Xue H. et al. JAHA 2022;11(4) [2]Saba SG. et al. JCMR 2014;16:35

Data sets

- **Training set**
  - N = 166 multivendor, 1.5T & 3T
  - Medical experts' ground-truth annotation
  - Cardiac Atlas Project challenge datasets[1]

- **Test set**
  - 11000 data sets acquired on 1.5T Siemens scanners[2]
  - Single vendor, single institution

[1]Fonseca CG. et al. *Bioinformatics* 2011

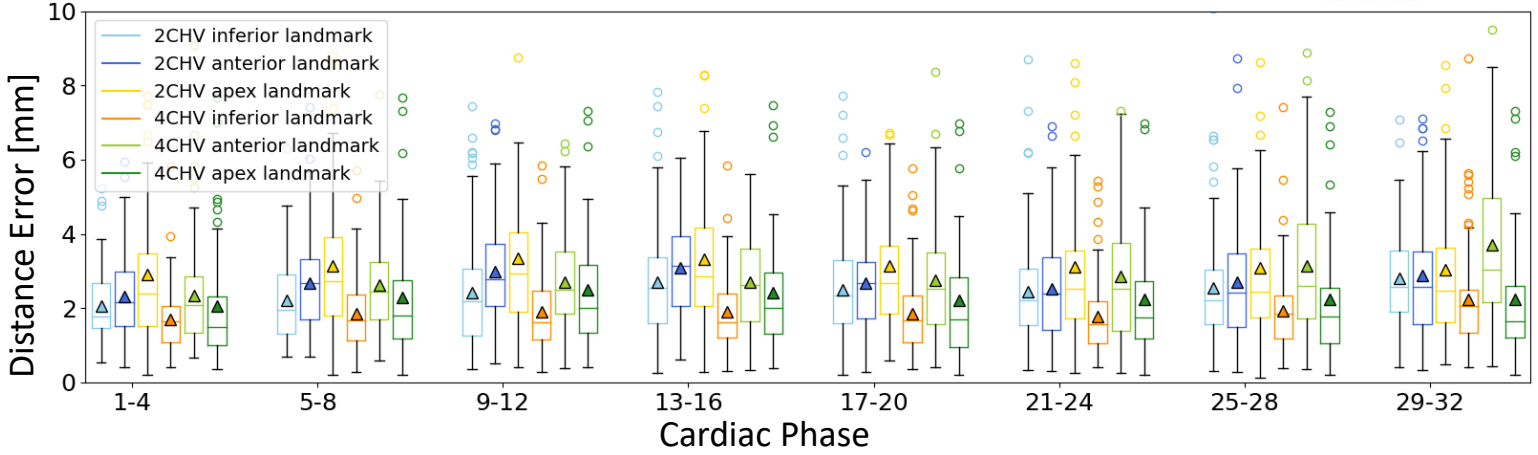
[2]Pezel T. et.al. *Archives of Cardiovascular Diseases* 2021

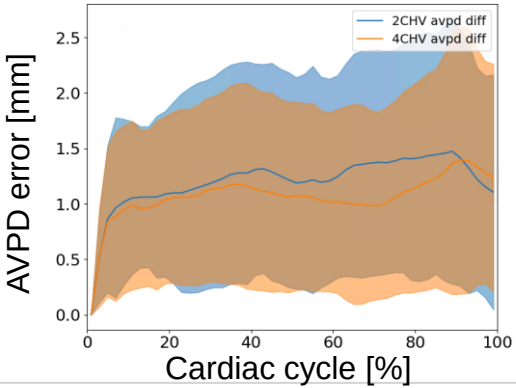
Evaluation

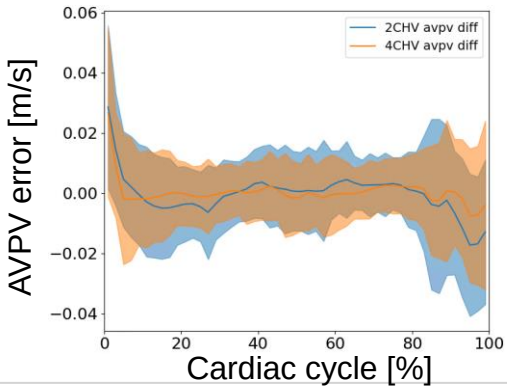
- **Network performance analysis**
  - Semi-automatically annotated (n=200) data sets
  - Error quantification for landmarks & parameters

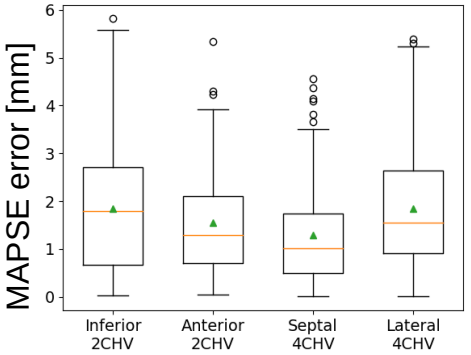
- **Parameter analysis & statistics on n=11000 data sets**
  - Automatic AVPD, AVPV, MVD, MAPSE, LS extraction
  - Parameter statistics (mean, std, histrogram)
  - Visualisation of extreme cases

Results

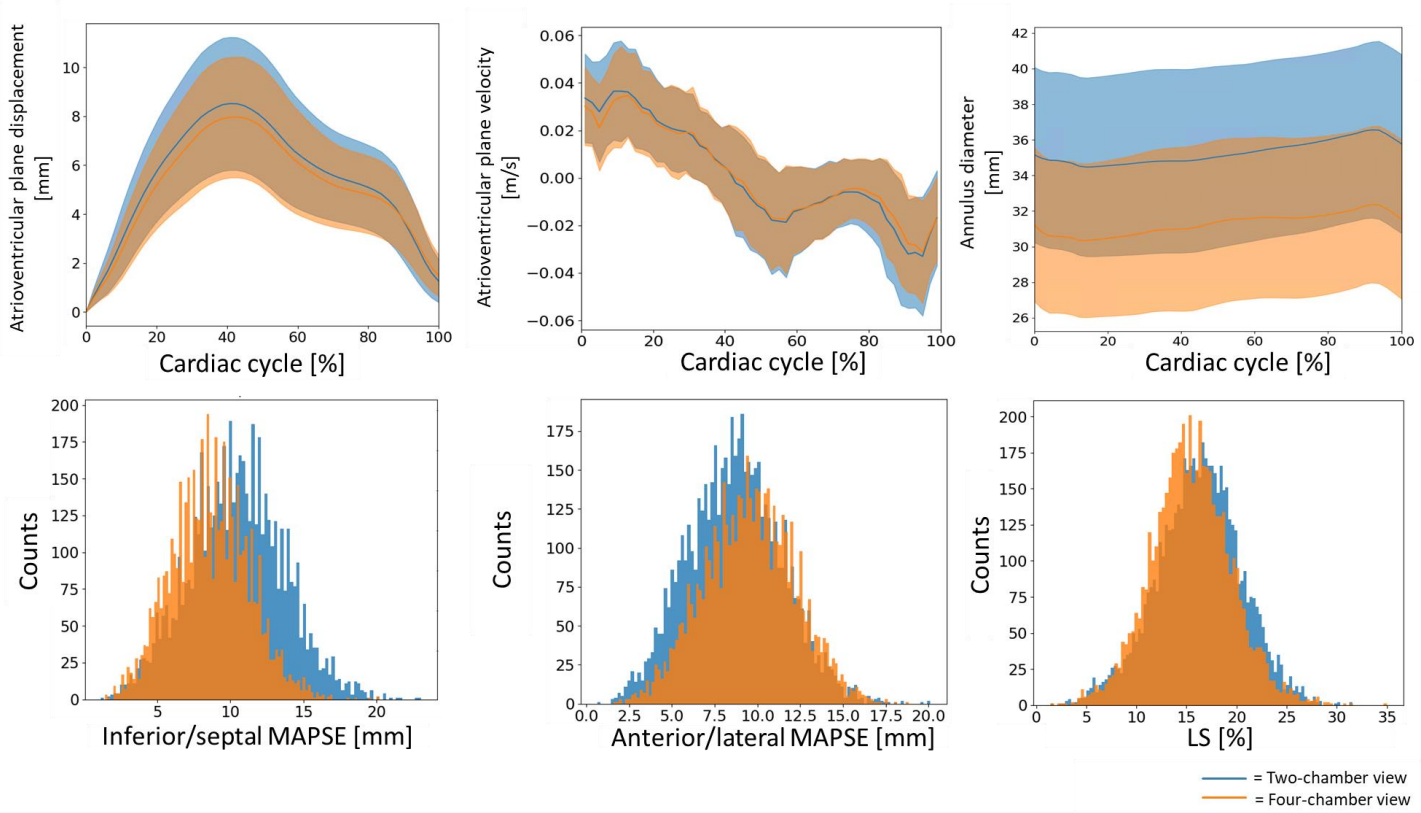

2CHV inferior landmark
2CHV anterior landmark
2CHV apex landmark
4CHV inferior landmark
4CHV anterior landmark
4CHV apex landmark
Distance Error [mm]
0
2
4
6
8
10
1-4
5-8
9-12
13-16
17-20
21-24
25-28
29-32
Cardiac Phase


2CHV avpd diff
4CHV avpd diff
AVPD error [mm]
0.0
0.5
1.0
1.5
2.0
2.5
0
20
40
60
80
100
Cardiac cycle [%]

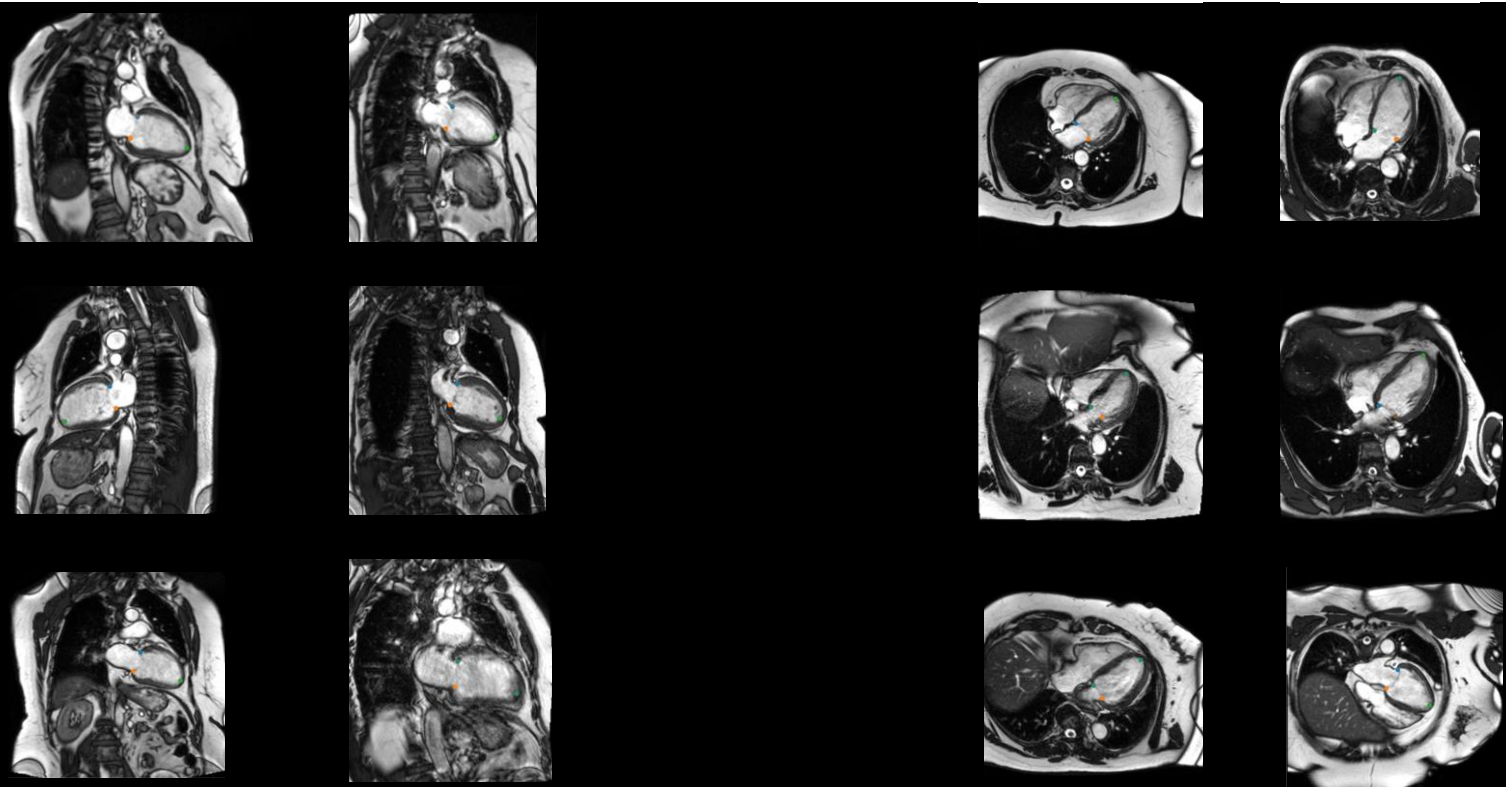

2CHV avpv diff
4CHV avpv diff
AVPV error [m/s]
0.06
0.04
0.02
0.00
−0.02
−0.04
0
20
40
60
80
100
Cardiac cycle [%]


MAPSE error [mm]
0
1
2
3
4
5
6
Inferior 2CHV
Anterior 2CHV
Septal 4CHV
Lateral 4CHV

Results


Atrioventricular plane displacement [mm]
Cardiac cycle [%]
Atrioventricular plane velocity [m/s]
Cardiac cycle [%]
Annulus diameter [mm]
Cardiac cycle [%]
Counts
Inferior/septal MAPSE [mm]
Counts
Anterior/lateral MAPSE [mm]
Counts
LS [%]
= Two-chamber view
= Four-chamber view

Results



Extreme MAPSE cases

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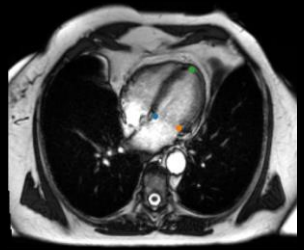
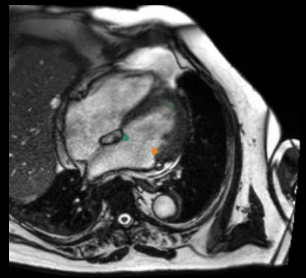
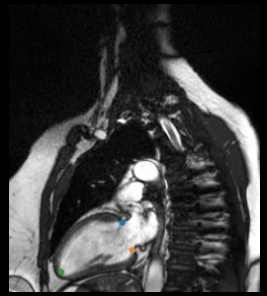
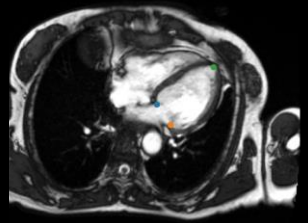
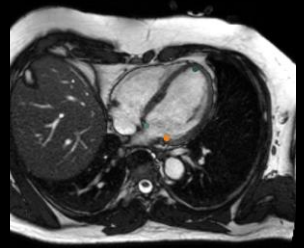
Low



High



Conclusion & Outlook

- Mean absolute distance errors ~ 2mm
- Successful on largely varying morphologies and image qualities
- Statistics on 11000 cardiac patient data sets
- Clear representation of expected MV motion parameters (velocity e & a waves)
- Self-supervised data mining – correlation with biometrics, clinical outcome, …
- Evaluation of further landmarks (TAPSE, …)