Artificial Intelligence Robotic-Based Navigation Framework for Autonomous Cardiac Ultrasound Scanning

Nicolai H. Jensen[1], PhD Student
Supervisors: Thiusius R. Savarimuthu[1], Bruno Oliveira[1], Preman Kumarathurai[2]

University of Southern Denmark

OUH
Odense Universitetshospital
Svendborg Sygehus

Motivation

Cardiovascular diseases are the leading cause of death worldwide ($\sim$ 19.8 million annually), driving increasing demand for echocardiography [3]. In the Region of Southern Denmark alone, over 45,000 ambulatory exams are performed each year. Combined with workforce shortages and an ageing population, this creates significant capacity challenges and delays in diagnosis.

Project Description

This PhD project aims to develop an AI-powered robotic system for autonomous echocardiography. The system integrates real-time recognition of cardiac views and probe motion with a robotic arm ensuring precise positioning, stable contact, and safe force application. We hypothesize that the system can achieve image quality comparable to cardiologists while improving efficiency. Automation can improve patient flow and accessibility, reduce waiting lists, and further reduce costs.

Echo Procedure

Echocardiography is a largely standardized yet operator-dependent workflow, visualized in figure blocks A-D below: (A) probe placement in cardiac windows, (B) acquisition of standard views through coordinated probe motions, (C) recording of cardiac cycles using B-mode and Doppler, and (D) extraction of quantitative measurements [6].

Project Workflow

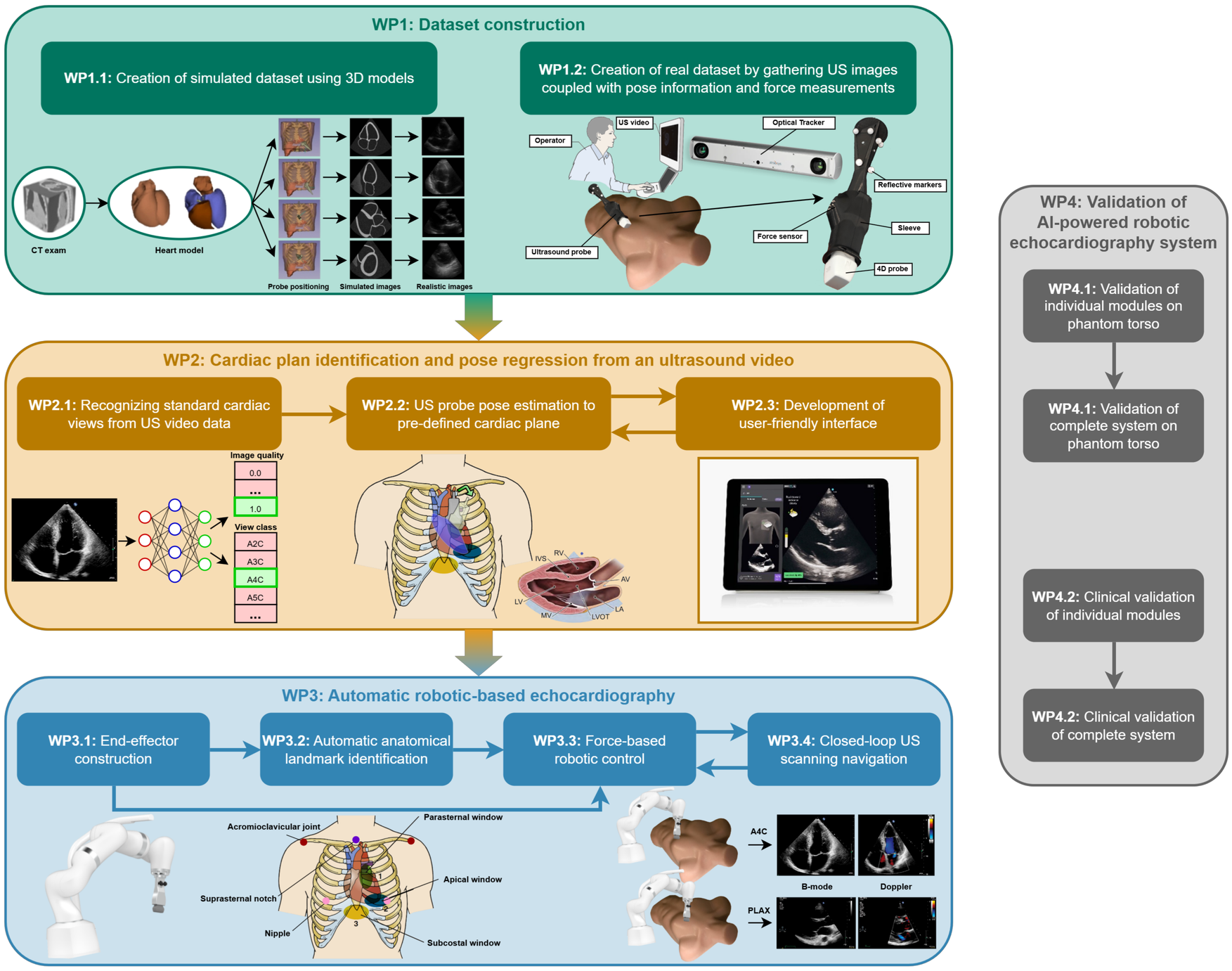
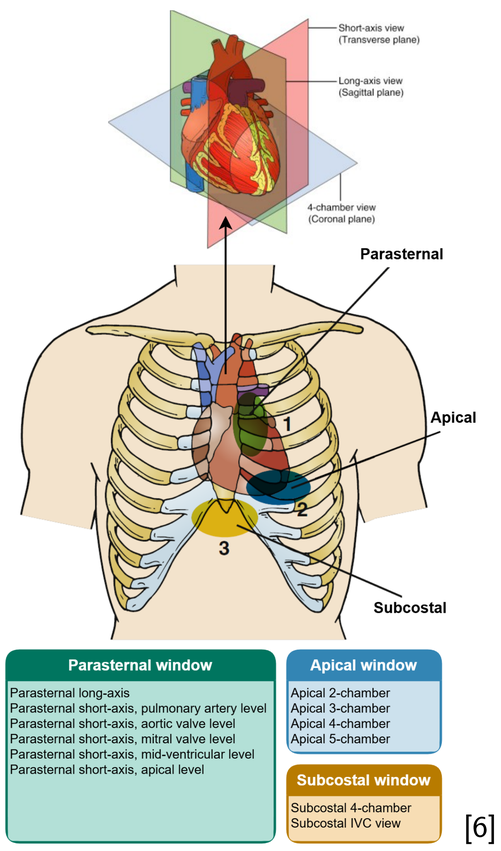


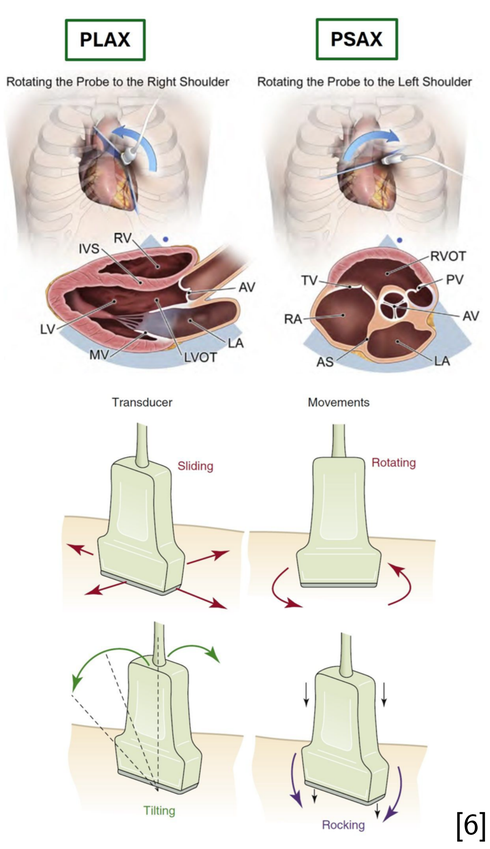
Figure 1: Overview of the proposed workflow for the PhD project, including the four work packages (WPs) [6], [29], [32].

A) Cardiac Plane Detection



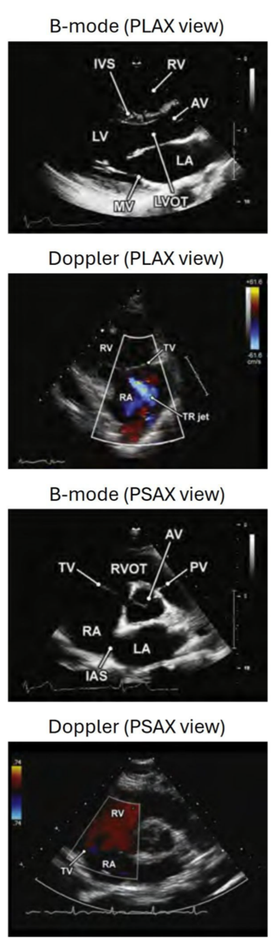
[6]

B) Local Probe Adjustment



[6]

C) Views to Record



...

[6]

D) Measurements to Extract

B-mode (PLAX view):

- LV end-diastolic diameter
- LV end-systolic diameter
- LV wall thickness
- LA diameter
- MV and AV motion

Doppler (PLAX view):

- AV blood flow
- MV blood flow
- Peak LVOT flow velocity
- Relaxation time
- Contraction time
- Ejection time

B-mode (PSAX view):

- AV diameter
- AV opening
- PV motion
- RVOT diameter
- RA size
- LA size

Doppler (PSAX view):

- Peak AV flow velocity
- Peak PV flow velocity
- PV acceleration time
- RVOT blood flow
- AV and PV timing

References

[3] Cardiovascular diseases (CVDs). Accessed: March 30, 2026. [Online]. Available: https://www.who.int/news-room/fact-sheets/detail/cardiovascular-diseases-(cvds)

[6] Guidelines for Performing a Comprehensive Transthoracic Echocardiographic Examination in Adults. C. Mitchell et al., Journal of the American Society of Echocardiography, vol. 32, no. 1, pp. 1–64, Jan. 2019, doi: 10.1016/j.echo.2018.06.004

[29] Automatic multi-view pose estimation in focused cardiac ultrasound. J. Freitas, J. Gomes-Fonseca, A. C. Tonelli, J. Correia-Pinto, J. C. Fonseca, and S. Queirós, Medical Image Analysis, vol. 94, p. 103146, May 2024, doi: 10.1016/j.media.2024.103146

[32] ARTHUR • ROPCA ApS. Accessed: March 30, 2026. [Online]. Available: https://ropca.com/arthur/

Affiliations

[1] SDU Robotics, Maersk McKinney Moller Institute, University of Southern Denmark, Odense, Denmark

[2] Department of Cardiology, Odense University Hospital, Odense, Denmark