Project Management and Software Development for Medical Applications

Image Processing for Digital Breast Tomosynthesis

Requirements Presentation
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Technische Universität München + Johns Hopkins Whiting School of Engineering

Section 01

Background and Motivation

Technische Universität München

Johns Hopkins Whiting School of Engineering

Digital Breast Tomosynthesis

Mammography

- 2D X-ray projection image

Digital Breast Tomosynthesis [1]

- 3D image
- Reconstructed from 2D X-ray projection images
- Projections with limited angular range
- Cross-sectional visualization via slices

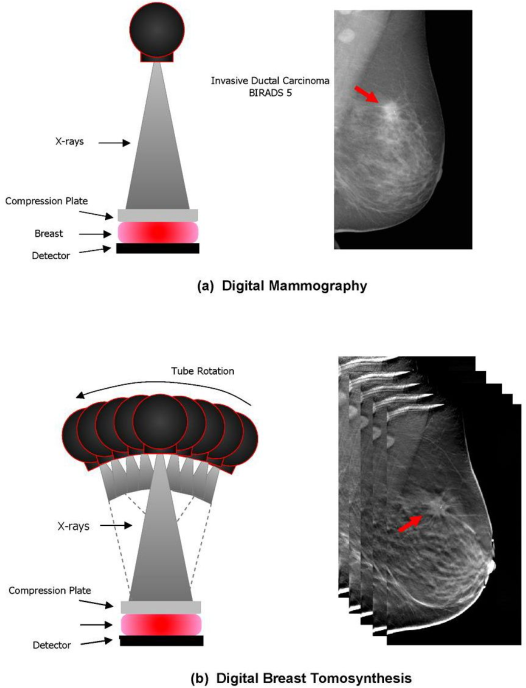


Figure 1. Acquisition Geometry of Digital Breast Tomosynthesis [2]

[1] "Breast Imaging Diagnosis and Screeningin Korea," *Breast Imaging, 12th International Workshop IWDM*, Gifu City, Japan, 2014, pp. xxvii-xxviii, doi: 10.1007/978-3-319-07887-8.

[2] D. Kontos, P. R. Bakic, and A. D. A. Maidment, "Texture in digital breast tomosynthesis: a comparison between mammographic and n tomographic characterization of parenchymal properties," in Proc. SPIE, vol. 6915, Mar. 17, 2008, p. 69150A. doi: 10.1117/12.773144.

Advantages

- not having tissue super-positioning [1], [3]
- volume analysis [3]
- improve cancer detection [4]

Disadvantages

- longer interpretation time per patient [4]
- storage [3], [4]
  e.g. up to 1 GB instead of 50 MB
- noisier images

[1] "Breast Imaging Diagnosis and Screeningin Korea," *Breast Imaging, 12th International Workshop IWDM*, Gifu City, Japan, 2014, pp. xxvii-xxviii, doi: 10.1007/978-3-319-07887-8.
[3] F. Diekmann, H. Meyer, S. Diekmann et al., "Thick Slices from Tomosynthesis Data Sets: Phantom Study for the Evaluation of Different Algorithms," *Journal of Digital Imaging*, vol. 22, no. 5, pp. 519-526, Oct. 2009, doi: 10.1007/s10278-007-9075-y.
[4] A.C. Pujara, A.I. Joe, S.K. Patterson, C.H. Neal, M. Noroozian, T. Ma, et al. “Digital breast tomosynthesis slab thickness: impact on reader performance and interpretation time.” *Radiology 2020*, vol. 297, no. 3, pp. 534–42, Oct. 2020, doi: 10.1148/radiol.2020192805.

Slabbing

Slices:

- 1 mm thickness for standard protocol [3], [5]
- very high image noise level [3]

Slabs:

- 10 mm thickness for standard protocol
- various slabbing techniques
  e.g. 6 mm slabs with 3 mm overlap [4]
- less interpretation time

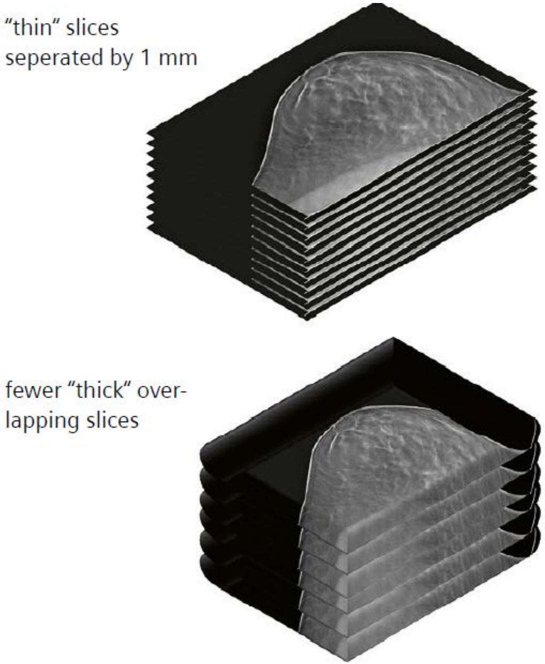


Figure 2. Slabbing slices [6]

[5] M. Dustler, P. Timberg, A. Tingberg, and S. Zackrisson, "Image Quality of Thick Average Intensity Pixel Slabs Using Statistical Artifact Reduction in Breast Tomosynthesis," *in Breast Imaging, 12th International Workshop IWDM*, 2014, pp. 544-549, doi: 10.1007/978-3-319-07887-8.

[6] HealthManagement.org, “Digital Breast Tomosynthesis in screening – approaches to reduce reading time,” HealthManagement, https://healthmanagement.org/c/decision-support/whitepaper/digital-breast-tomosynthesis-in-screening-approaches-to-reduce-reading-time (accessed May 13, 2023).

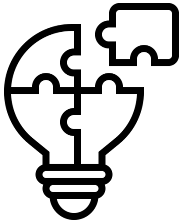
Section 02

Problem Statement

Problem Statement

Problem

- The review of slice images are difficult and requires long time.
- Automated algorithms trained on mammography cannot perform well enough.



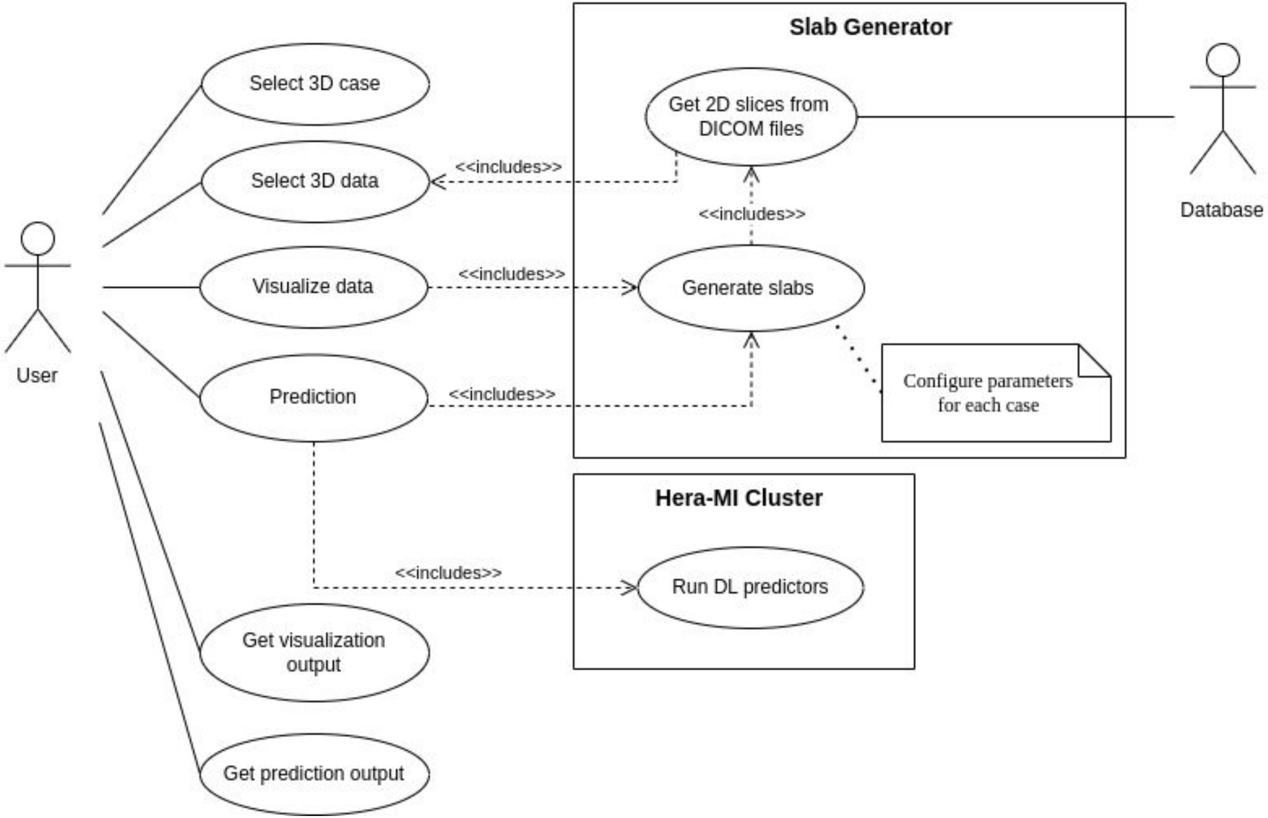
Solution

Design a projection algorithm for slabbing

Results

- Better image quality
- Better clinical interpretability
- Improved performance of predictions

UML Use Case Diagram



Slab Generation Techniques

Maximum intensity projection (MIP) [3], [5]

- high contrast
- high noise level
- low contrast-to-noise ratio
- better for micro-calcifications

Average intensity projection (AIP) [3], [5]

- low contrast
- low noise level
- smoothing images, worse for micro-calcifications

softMIP [3]

- optimized performance between MIP and AIP
- weighted projection function

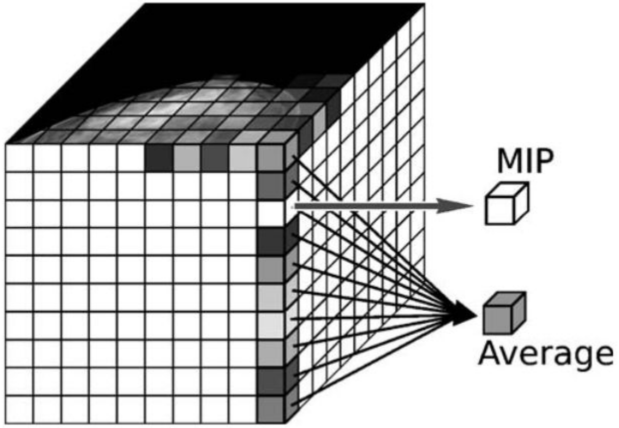


Figure 3. Maximum intensity projection and average intensity projection [3]

[3] F. Diekmann, H. Meyer, S. Diekmann et al., "Thick Slices from Tomosynthesis Data Sets: Phantom Study for the Evaluation of Different Algorithms," *Journal of Digital Imaging*, vol. 22, no. 5, pp. 519-526, Oct. 2009, doi: 10.1007/s10278-007-9075-y.

[5] M. Dustler, P. Timberg, A. Tingberg, and S. Zackrisson, "Image Quality of Thick Average Intensity Pixel Slabs Using Statistical Artifact Reduction in Breast Tomosynthesis," *in Breast Imaging, 12th International Workshop IWDM*, 2014, pp. 544-549, doi: 10.1007/978-3-319-07887-8.

Section 03

Stakeholders

Stakeholders

Developer

Software Medical Device Manufacturer

Radiologists

Tutors

Section 04

Requirement Specifications

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Clinical Requirements

Image reading sessions

- clinical perception
- preference of readers
- performance of readers
- interpretation time per patient

Industrial Requirements

Performance metrics for the DL classifiers

- Sensitivity
- Specificity
- AUC
- Confusion matrix

Image quality assessment metrics

- SNR (signal-to-noise ratio)
- CNR (contrast-to-noise ratio)

Section 05

Gantt Chart

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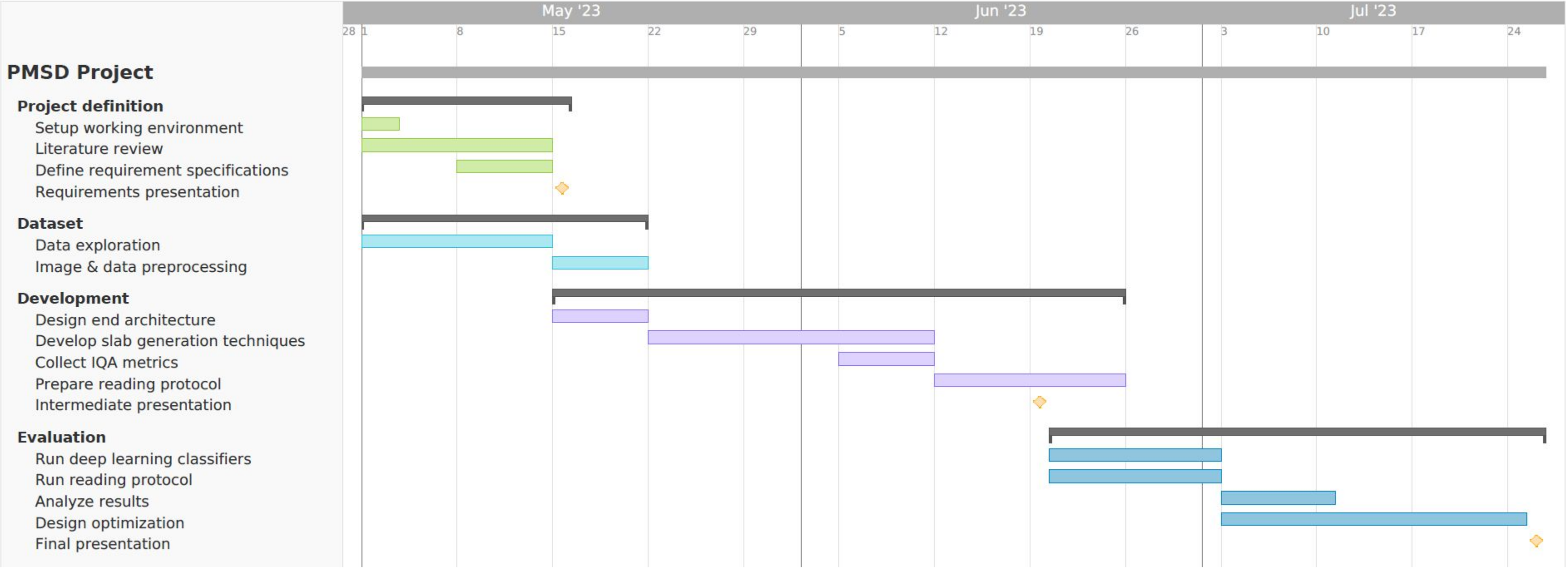
Gantt Chart


May '23
Jun '23
Jul '23
28 1 8 15 22 29 5 12 19 26 3 10 17 24
PMSD Project
Project definition
Setup working environment
Literature review
Define requirement specifications
Requirements presentation
Dataset
Data exploration
Image & data preprocessing
Development
Design end architecture
Develop slab generation techniques
Collect IQA metrics
Prepare reading protocol
Intermediate presentation
Evaluation
Run deep learning classifiers
Run reading protocol
Analyze results
Design optimization
Final presentation

Thank you!

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