T-SYNTH: A Knowledge-Based Dataset of Synthetic Breast Images

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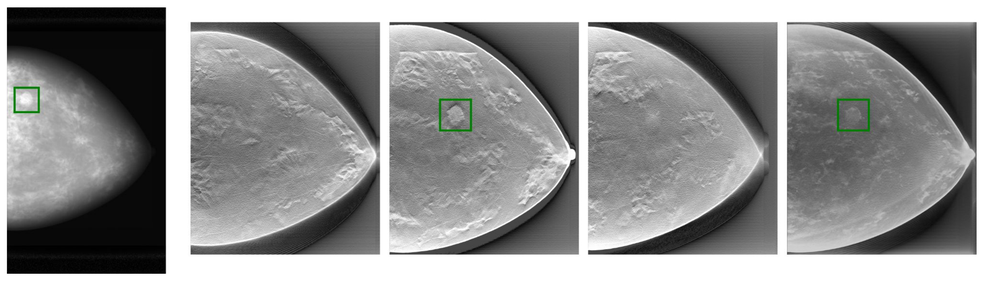
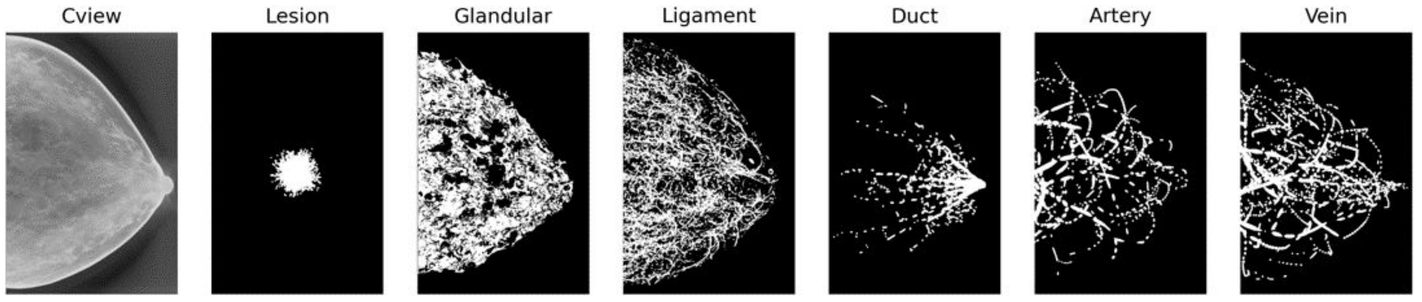
Motivation

Robust breast image dataset are required for developing computer-aided diagnosis for breast cancer. Data synthesized with deep generative models are limited by the demographic characteristics of the original training data and the ground-truth information captured in the imaging system [1,2]. Here, we release T-SYNTH, a large-scale open-source synthetic dataset of paired digital mammography (DM) and digital breast tomosynthesis (DBT) images generated with a knowledge-based (KB) model. T-SYNTH contains 9,000 images and is designed to complement the M-SYNTH DM dataset [6].



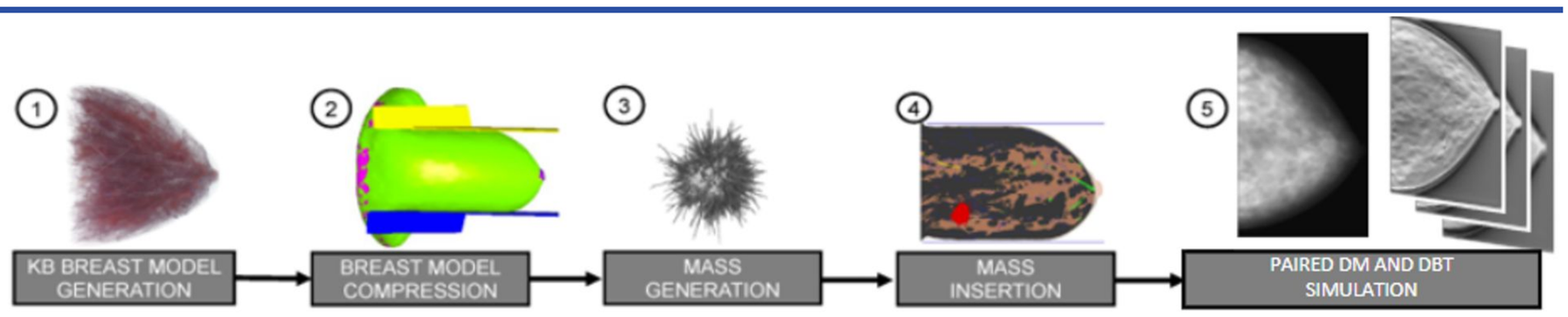
DM (left) with lesion (green), three slices of the corresponding DBT (middle), and cview image (right) for a T-SYNTH image



Example c-view image with the corresponding tissue masks available in T-SYNTH.

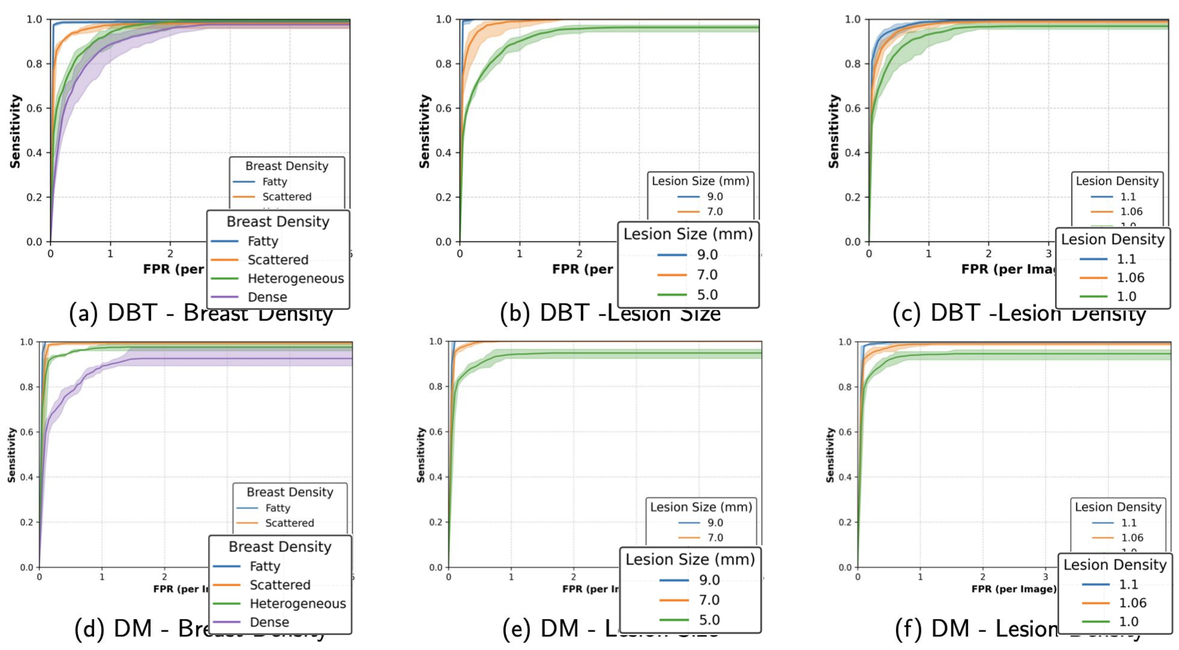
Methods

Using a KB simulation, 150 positive DBT and DM images were generated for each combination of the factors: breast density (fatty, scattered, heterogeneous, dense), lesion diameter (5, 7, 9mm), and lesion density (1.0, 1.06, 1.1x glandular density). Corresponding lesion-absent images were also synthesized. Faster R-CNN [3] was trained for lesion detection and evaluated with free-response ROC curves, with results aggregated across five trials.



A knowledge-based simulation pipeline for generating T-SYNTH. 1-2: The open source Virtual Imaging Clinical Trials for Regulatory Evaluation (VICTRE) was used to generate breast tissue models and simulate compression [5, 6]. 3-4: Lesion growth is modeled with advection-reaction-diffusion equations and accounts for surrounding tissue stiffness [5, 7]. 5: For each phantom, DM and DBT images were simulated with MC-GPU, designed to replicate Siemens Mammomat Inspiration 5. C-view images were approximated from DBT volumes using the method from Klein, et al [8].

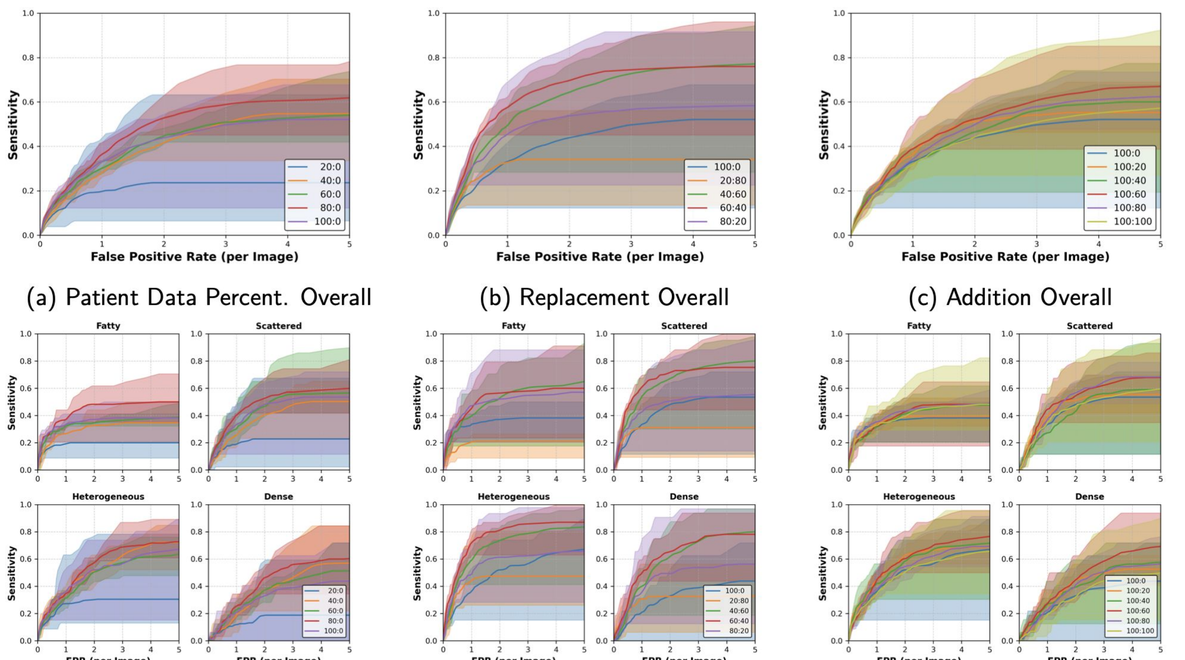
Results



(a) DBT - Breast Density (b) DBT -Lesion Size (c) DBT -Lesion Density

(d) DM - Breast Density (e) DM - Lesion Size (f) DM - Lesion Density

*FROC curves for models trained and evaluated on synthetic data (**Synthetic Subgroup Analysis**). Shaded region represents minimum and maximum bounds. Both DBT (top) and DM (bottom) shows expected trends (performance increases with decreased breast density, increased lesion size, and increased lesion density.*



(a) Patient Data Percent. Overall (b) Replacement Overall (c) Addition Overall

(d) Patient Data Percent. Subgroup (e) Replacement Subgroup (f) Addition Subgroup

*FROC curves on patient test set for models trained with a combination of patient and synthetic data (**Patient Data Augmentation**). (a) model has only a fraction of patient training data available, (b) a proportion of patient data is replaced with synthetic data, (c) a proportion of synthetic data is added to the full available patient training set. The addition of T-SYNTH data improves performance, particularly for scattered and dense breast examples.*

Contributions

- T-SYNTH is a large synthetic breast image dataset with paired DM and DBT images and a balanced representation of patient subgroups.
- The KB approach used for simulation T-SYNTH allows release of detailed pixel-level segmentation masks for lesions and other tissues
- Evaluation when training and testing a detection model on T-SYNTH yields expected performance differences among subgroups, increasing our confidence in the model's efficacy.
- All data and pretrained models and training code are publicly available at: **https://huggingface.co/datasets/didsr/tsynth** **https://github.com/DIDSR/tsynth-release**

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