PhD thesis proposal

Title: Machine Learning for DBT Reconstruction and Analysis for Computer Aided Diagnosis.

Abstract

Breast tomosynthesis, also called three-dimensional (3-D) mammography and digital breast tomosynthesis (DBT), is an advanced form of breast imaging, or mammography, that uses a low-dose x-ray system and computer reconstructions to create three-dimensional images of the breasts. Breast tomosynthesis aids in the early detection and diagnosis of breast disease.

An x-ray (radiograph) is a noninvasive medical test that helps physicians diagnose and treat medical conditions. Imaging with x-rays involves exposing a part of the body to a small dose of ionizing radiation to produce pictures of the inside of the body. X-rays are the oldest and most frequently used form of medical imaging.

While mammography is the best screening tool for breast cancer available today, it does not detect all breast cancers. Breast tomosynthesis overcomes some of the limitations of standard mammography, but it is not yet available in all imaging facilities.

A conventional x-ray examination of the breast, called a mammogram, is two-dimensional: two x-ray images are taken of the breast, from top-to-bottom and from angled side-to-side, while the breast is compressed between a clear plastic paddle and an imaging detector. Although compression is necessary to obtain breast images, it may cause overlapping of the breast tissue in which abnormal tissue can be hidden and superimposed normal tissue can appear abnormal.

In breast tomosynthesis, the x-ray tube moves in an arc over the compressed breast capturing multiple images of each breast from different angles. These digital images are then reconstructed or "synthesized" into a set of three-dimensional images by a computer. These 3D image sets help minimize the tissue overlap that can hide cancers or make it difficult to distinguish normal overlapping breast tissue from tumors.

The aim of this PhD is to investigate the use of advanced machine learning approaches, namely deep learning, for reconstructing and analyzing DBT images in a CAD system to automatically detect possible breast issues with patients. All the works published in the literature focuses on 2D mammograms [1] and not DBT [2], as the latter is a not widely available technology.

The goal of this PhD is to explore recent advances in machine learning, specifically deep learning techniques and their applications both in DBT 3D image reconstruction from the individual scans and its analysis for nodules detection and characterization into malignant or benign tumors. This is in the context of developing a decision support system that can be used by doctors and radiologists for better, faster and more accurate breast cancers detection.

This PhD will be a continuation of our work done on medical image enhancement and analysis in the projects: HyPerCept, IQ-MED and HiPerNav. It will be linked to the existing PhDs co-supervised by Prof. Azeddine Beghdadi and Prof. Faouzi Alaya Cheikh: Rafael Palomar (thesis defended in 2018), Congcong Wang (to be defended in December 2019), Rabia Nasseem and Zohaib Khan (thesis to be defended in 2020). The new PhD student will benefit from the support and expertise of these PhD students and Post-Doc Rafael, who is affiliated with NTNU.

Outcomes of this collaboration:

- Strengthen the existing collaboration between L2TI and Colourlab on the different projects related to image and video analysis (H2020 MSCA-ITN HiPerNav), Medical image enhancement, segmentation and analysis, (Norwegian department of science and education grant), medical image processing and analysis (IKTPluss Norwegian Research Council Funded project IQMED).
- Strengthen the existing Erasmus student exchange program (possibility to host master students from UP13 for internship or master cursus at NTNU) and post-doc/senior researcher mobility.
- Enhance the potential and opportunities to launch new projects

References:

[1] Rodriguez-Ruiz, Alejandro, et al. "Stand-alone artificial intelligence for breast cancer detection in mammography: comparison with 101 radiologists." (2018).
[2] Houssami, Nehmat, et al. "Artificial Intelligence (AI) for the early detection of breast cancer: a scoping review to assess AI's potential in breast screening practice." *Expert review of medical devices* (Accepted for publication in 2019).

Direction de la thèse

Directeur de thèse: Azeddine Beghdadi (Université Paris 13)
Codirecteur: Faouzi Alaya-Cheikh (NTN at Gjovik, Norway)

Financement

Cofinancement garanti par NTNU à hauteur de 50% du budget global de l'allocation doctorale en France (voir lettre d'engagement)

Historique de la collaboration (UP13 – NTNU)

- Collaboration dans le cadre de projets internationaux et la codirection de sept thèses de doctorat depuis 2011.

Liste des thèses codirigées

1. Mohib Ullah, "Multi-Target Tracking and Segmentation for Video Surveillance", PhD thesis at NTNU Gjøvik, Norway, Thesis defended on May 2, 2019.
2. Congcong Wang, "Medical Image Enhancement and Segmentation", PhD thesis at NTNU Gjøvik, Norway, To be defended on December, 2019.
3. Rabia Naseem, "Multi-modal Medical Image Enhancement", PhD thesis at NTNU Gjøvik, Norway, Thesis to be defended in 2020.

4. Zohaib Khan, “Medical Images Quality Assessment for Enhancement, Segmentation and Registration”, PhD thesis at University Paris 13, Sorbonne Paris Cité, Thesis to be defended in 2020.
5. Bilel Sdiri, “Video enhancement and analysis for video-guided surgery”, PhD Co-tutelle thesis at University Paris 13, Sorbonne Paris Cité and NTNU Gjøvik, Norway, Thesis defended on February 6, 2018.
6. Rafael Palomar, “Geometric Modeling for Planning of Liver Resection Procedures” PhD Co-supervised thesis at University Paris 13, Sorbonne Paris Cité and NTNU Gjøvik, Norway, Thesis defended on February 6, 2017.
7. Walid Hachicha, “Towards efficient methods for stereo image processing, coding and quality assessment”, PhD thesis at University Paris 13, Sorbonne Paris Cité, defended on 9 December 2014.

Implication dans l’organisation de conférences internationales et projets internationaux/nationaux

- Prof. Faouzi Alaya Cheikh est membre du comité de pilotage du workshop (EUVIP : European Workshop on Visual Information Processing) depuis sa création par Azeddine Beghdadi en 2008 à l’université Paris 13 (http://euvip.org/)
- Prof. Faouzi Alaya Cheikh a été le président du programme technique de EUVIP2010 organisée par le laboratoire L2TI à Paris. Il a également été « Special Sessions Chair » à EUVIP2018 et Azeddine Beghdadi co-general chair.
- Prof. Faouzi Alaya Cheikh a été ”Program co-chair “ de Colour and Visual Computing Symposium 2015 (CVCS 2015) et Azeddine Beghdadi “invited speaker” et member du comité technique.
- Azeddine Beghdadi et Faouzi Alaya Cheikh sont/étaient partenaires dans plusieurs projets (H2020 MSCA-ITN HiPerNav, Hypercept, IQMed, EU-COST Action en attente de réponse finale, etc.) et un autre projet ICTPluss en cours de préparation.