Center for Research in Computer Vision

UNIVERSITY OF CENTRAL FLORIDA

FINAL ORAL EXAMINATION

OF

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FOR THE DEGREE OF

DOCTOR OF PHILOSOPHY

(COMPUTER SCIENCE)

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HEC 101

DISSERTATION COMMITTEE

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DISSERTATION RESEARCH IMPACT

Obesity is one of the most prevalent health conditions. About 30% of the world's and over 70% of the United States' adult populations are either overweight or obese, causing an increased risk for cardiovascular diseases, diabetes, and certain types of cancer. Among all cancers, lung cancer is the leading cause of death whereas pancreatic cancer has the poorest prognosis among all major cancers. Early diagnosis of these cancers can save lives. This dissertation contributes towards the development of computer-aided diagnosis tools in order to aid clinicians in establishing the quantitative relationship between obesity and cancers. This dissertation proposes: (1) an automatic body region detection and whole-body fat quantification approach for subcutaneous, visceral and brown fats; (2) supervised learning methods for the diagnosis of lung and pancreatic cancers; (3) unsupervised strategies for cancer diagnosis without explicit labeling.

SELECTED PUBLICATIONS

1. **Deep Multi-Modal Classification of Intraductal Papillary Mucinous Neoplasms (IPMN) with Canonical Correlation Analysis.** Sarfaraz Hussein, P. Kandel, J. Corral, C. Bolan, M. Wallace, Ulas Bagci. *IEEE International Symposium on Biomedical Imaging (ISBI) 2018.*

2. **How to Fool Radiologists with Generative Adversarial Networks? A Visual Turing Test for Lung Cancer Diagnosis.** M. Chuquicusma, Sarfaraz Hussein, J. Burt, Ulas Bagci. *IEEE ISBI 2018.*

3. **Automatic Segmentation and Quantification of White and Brown Adipose Tissues from PET/CT Scans.** Sarfaraz Hussein et al. *IEEE Transactions on Medical Imaging (TMI) 2017.*

4. **Risk Stratification of Lung Nodules using 3D CNN based Multi-task Learning.** Sarfaraz Hussein, K. Cao, Q. Song, Ulas Bagci. *Information Processing in Medical Imaging (IPMI) 2017.*

5. **TumorNET: Lung Nodule characterization using Multi-view Convolutional Neural Network with Gaussian Process.** Sarfaraz Hussein, R. Gillies, K. Cao, Q. Song, Ulas Bagci. *IEEE ISBI 2017.*

6. **Brown adipose tissue detected by PET/CT imaging is associated with less central obesity.** A. Green, Ulas Bagci, Sarfaraz Hussein, P. Kelly, R. Muzaffar et al. *Nuclear Medicine Communications (NMC) 2017.*

7. **Context Region Discovery for Automatic Motion Compensation in Fluoroscopy.** Y. Xia, Sarfaraz Hussein, V.Singh, M. John, Y. Wu, T. Chen. *Information Processing in Computed Assisted Interventions (IPCAI) 2016.*

PATENTS

1. **System and methods for Image-based quantification of white and brown adipose tissue at the tissue, organ, and body-region levels.** Sarfaraz Hussein and Ulas Bagci. 2017 (filed)

2. **Robust calcification tracking in fluoroscopic imaging.** T. Chen, Sarfaraz Hussein, M. John, V. Singh. 2016 (filed)

DISSERTATION

LEARNING ALGORITHMS FOR FAT QUANTIFICATION AND TUMOR CHARACTERIZATION

This dissertation explores learning algorithms that can be used to extract imaging markers reliably so that obesity-cancer relationship can be studied. The novel learning algorithms developed in the dissertation are general and can be modified for other applications similar to those examined here. More specifically, we first investigate the automatic detection of white and brown adipose tissues using Positron Emission Tomography/Computed Tomography (PET/CT) scans, and develop methods for the quantification of these tissues at the whole-body and body-region levels. We propose a patient-specific automatic adiposity analysis system. In the first chapter of the dissertation, we detect white adipose tissue (WAT) and its two sub-types from CT scans: Visceral Adipose Tissue (VAT) and Subcutaneous Adipose Tissue (SAT). Our novel framework is based on an unsupervised learning method to separate VAT from SAT. This step is followed by a context driven label fusion algorithm through sparse 3D Conditional Random Fields (CRF) for volumetric adiposity analysis.

In the second chapter of the dissertation, we automatically detect, segment, and quantify brown adipose tissue (BAT) using PET scans because unlike WAT, BAT is metabolically active. After identifying BAT regions using PET, we perform a co-segmentation procedure utilizing asymmetric complementary information from PET and CT. Finally, we present a new probabilistic distance metric for differentiating BAT from non-BAT regions. We also perform automatic body-region detection using one-shot learning. Experimental evaluations conducted on 111 PET/CT scans achieve state-of-the-art performances in brown adiposity quantification.

In the third chapter, we propose different supervised strategies for the characterization of lung nodules and Intraductal Papillary Mucinous Neoplasms (IPMN). We propose a new end-to-end trainable multi-view deep Convolutional Neural Network (CNN) for nodule characterization. The trained network is used to extract features from the input image followed by a Gaussian Process (GP) regression to obtain the malignancy score. We next propose a 3D Convolutional Neural Network (CNN) based nodule characterization strategy. We acquire the task dependent feature representation for six high-level nodule attributes and fuse this complementary information via a Multi-task learning (MTL) framework. For the diagnosis of IPMN, we propose a CNN based computer aided diagnosis (CAD) system by utilizing multi-modal MRI (T1-weighted and T2-weighted). Moreover, we employ canonical correlation analysis (CCA) to perform a fusion operation at the feature level, leading to discriminative canonical correlation features.

Finally, we propose an unsupervised learning strategy for the diagnosis of lung nodules and IPMN. Since the task of annotating medical images is laborious, expensive and time-consuming, we explore the potential of unsupervised learning approaches for developing CAD systems. First, we perform clustering on the appearance features obtained from the images to estimate an initial set of labels. Using the obtained initial labels, we compute label proportions corresponding to each cluster. We finally train a proportion-SVM classifier using the label proportions and clusters to obtain the final classification.

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1988	Born in Karachi, Pakistan
2011	B.E., Electronic Engineering, NED University, Karachi
2011	Application Engineer, Avanceon Ltd. Karachi
2014	Computer Vision Intern, Siemens Corporation, Princeton, NJ
2016	Research Intern, CuraCloud Corporation, Seattle, WA
2012-18	Ph.D., University of Central Florida, Orlando, FL.

SELECTED AWARDS

2015	NIPS Machine Learning for Healthcare Travel Award
2016	Gerald R. Langston Endowed Scholarship
2017	Merit Award from Radiological Society of North America
2017-18	Graduate Presentation Fellowship
2018	WACV 2018 PhD Forum Award
2018	CVPR 2018 Doctoral Consortium Award