



Announces the Ph.D. Dissertation Defense of

## **Ali Abidalkareem**

for the degree of Doctor of Philosophy (Ph.D.)

### **PREDICTIVE ANALYTICS IN ONCOLOGY AND OPHTHALMOLOGY: MACHINE LEARNING APPLICATIONS FOR DIABETIC RETINOPATHY AND BREAST CANCER**

**March 30<sup>th</sup> , 11:00 AM**  
**Engineering East, Room 405**  
**777 Glades Road**  
**Boca Raton, FL**

DEPARTMENT: Electrical Engineering and Computer Science

ADVISOR: Hanqi Zhuang, Ph.D

PH.D. SUPERVISORY COMMITTEE: Aalo Valentine, Ph.D, Xingquan Zhu, Ph.D. Mihaela Cardei, Ph.D. Ali Ibrahim, Ph.D

#### ABSTRACT OF DISSERTATION:

THE CONVERGENCE OF ARTIFICIAL INTELLIGENCE AND HEALTHCARE REPRESENTS ONE OF THE MOST TRANSFORMATIVE DEVELOPMENTS IN MODERN MEDICINE, WITH DEEP LEARNING TECHNOLOGIES EMERGING AS POWERFUL TOOLS FOR ADDRESSING COMPLEX DIAGNOSTIC CHALLENGES. THIS DISSERTATION DEVELOPS AND VALIDATES MACHINE LEARNING FRAMEWORKS THAT ADDRESS CRITICAL CHALLENGES IN MEDICAL DIAGNOSIS THROUGH INNOVATIVE APPROACHES TO DATA AUGMENTATION, FEATURE LEARNING, AND CLASSIFICATION, FOCUSING ON TWO FUNDAMENTAL PROBLEMS: DIABETIC RETINOPATHY (DR) SEVERITY CLASSIFICATION USING MULTI-MODEL CONVOLUTIONAL NEURAL NETWORKS (CNNs), AND BREAST CANCER STAGE IDENTIFICATION USING MICRORNA (MIRNA) GENE EXPRESSION BIOMARKERS.

FOR DIABETIC RETINOPATHY CLASSIFICATION, THIS WORK PROPOSES AN ENSEMBLE DEEP LEARNING FRAMEWORK THAT INTEGRATES VARIATIONAL AUTOENCODER (VAE)-BASED SYNTHETIC DATA GENERATION WITH CONTRASTIVE LEARNING AND MULTI-MODEL CNN ARCHITECTURES. THE VAE-BASED AUGMENTATION ADDRESSES THE SCARCITY OF ANNOTATED FUNDUS IMAGES BY LEARNING PROBABILISTIC LATENT REPRESENTATIONS THAT ENABLE SYNTHESIS OF REALISTIC SAMPLES RETAINING CRITICAL PATHOLOGICAL FEATURES. CONTRASTIVE LEARNING OPTIMIZES REPRESENTATION

V  
LEARNING BY MAXIMIZING SIMILARITY BETWEEN AUGMENTED VIEWS OF THE SAME IMAGE WHILE MINIMIZING SIMILARITY WITH DIFFERENT IMAGES, ENHANCING DISCRIMINATIVE CAPACITY FOR SUBTLE INTER-CLASS VARIATIONS. THE MULTI-MODEL ENSEMBLE LEVERAGES COMPLEMENTARY STRENGTHS OF DIFFERENT NETWORK ARCHITECTURES THROUGH DECISION-LEVEL FUSION, PROVIDING IMPROVED GENERALIZATION AND REDUCED VARIANCE COMPARED TO SINGLE-MODEL SYSTEMS.

FOR BREAST CANCER STAGE CLASSIFICATION, THIS DISSERTATION IMPLEMENTS AND COMPARES FEATURE SELECTION ALGORITHMS INCLUDING NEIGHBORHOOD COMPONENT ANALYSIS (NCA)



AND MINIMUM REDUNDANCY MAXIMUM RELEVANCE (MRMR) TO IDENTIFY OPTIMAL MIRNA BIOMARKER SETS FROM THE CANCER GENOME ATLAS (TCGA) DATASET. NCA PRESERVES LOCAL NEIGHBORHOOD STRUCTURE WHILE MRMR EXPLICITLY MINIMIZES REDUNDANCY BETWEEN SELECTED FEATURES WHILE MAXIMIZING RELEVANCE TO CLASSIFICATION TARGETS. THE IDENTIFIED BIOMARKERS ARE INTEGRATED WITH MACHINE LEARNING CLASSIFIERS TO ACHIEVE SUPERIOR CANCER STAGING ACCURACY, DEMONSTRATING HOW ADVANCED FEATURE SELECTION METHODS DIRECTLY TRANSLATE TO IMPROVED CLINICAL PREDICTION PERFORMANCE. EXPERIMENTAL VALIDATION DEMONSTRATES THAT THE PROPOSED FRAMEWORKS ACHIEVE CLINICALLY RELEVANT ACCURACY LEVELS EVEN WITH LIMITED TRAINING DATA. THE DR CLASSIFICATION SYSTEM ACHIEVES COMPETITIVE PERFORMANCE ON BENCHMARK DATASETS INCLUDING APTOS 2019, EYEPACS, AND MESSIDOR-2, WHILE THE MIRNA-BASED BREAST CANCER CLASSIFIER EFFECTIVELY DISTINGUISHES BETWEEN CANCER STAGES USING OPTIMIZED BIOMARKER PANELS. COMPARATIVE ANALYSES AGAINST EXISTING METHODS AND CLINICAL DIAGNOSTIC TECHNIQUES QUANTIFY THE PERFORMANCE GAINS OF BOTH PROPOSED MODELS. THESE RESULTS SUGGEST POTENTIAL FOR ENABLING AUTOMATED DIABETIC RETINOPATHY SCREENING IN RESOURCE-CONSTRAINED ENVIRONMENTS AND IMPROVING MOLECULAR-BASED BREAST CANCER STAGING THROUGH SYSTEMATIC BIOMARKER IDENTIFICATION.

#### BIOGRAPHICAL SKETCH

BORN IN IRAQ

BSC COMPUTER ENGINEERING – UNIVERSITY OF TECHNOLOGY IRAQ

MSC COMPUTER NETWORKS – UNIVERSITY OF PORTSMOUTH UK

MSC ELECTRICAL ENGINEERING – FLORIDA ATLANTIC UNIVERSITY

#### CONCERNING PERIOD OF PREPARATION

& QUALIFYING EXAMINATION

**Time in Preparation: Spring 2015-fall 2016**

**Qualifying Examination Passed: Yes**

#### Published Papers:

- **Diabetic retinopathy (DR) severity level classification using multimodal convolutional neural networks:** <https://ieeexplore.ieee.org/abstract/document/9175606/>
- **Identification of gene expression in different stages of breast cancer with machine learning:** <https://www.mdpi.com/2072-6694/16/10/1864>