Naji Khosravan

1992	Born in Esfahan, Iran.
2015	B.S., Tehran Polytechnic, Tehran, Iran.
2018-19	Computer Vision Scientist Intern, Netflix, Los Gatos, CA.
2019	Computer Vision Research Intern, Sighthound, Orlando, FL.
2015-19	Ph.D., University of Central Florida, Orlando, Florida.

TALKS

2019	*Projective Adversarial Learning for 3D Medical Image Segmentation*, **Medical Image Processing Group, University of Pennsylvania**, Philadelphia, PA.
2019	*Capturing 3D Semantics Through 2D Projections,* **Samsung Research**, San Diego, CA.
2018	*Virtual Radiologists: Current Status of Deep Learning in Radiology and Its Future Trends,* **104th Scientific Assembly and Annual Meeting, Radiological Society of North America (RSNA),** McCormick Place, Chicago, IL.

PATENTS

2018	**Techniques for Audio-Visual Synchronization**, *US Patent number: 62/769,515, Filed Nov 19, 2018 with Netflix.*
2018	**Fast and Reliable Detection and Diagnosis of Lung Cancers from CT Scans**, *US Patent number: 62/755,018, Filed Nov 2, 2018 with UCF.*

UCF | Center for Research in Computer Vision

UNIVERSITY OF CENTRAL FLORIDA

FINAL ORAL EXAMINATION

OF

Naji Khosravan

B.S., AMIRKABIR UNIVERSITY OF TECHNOLOGY
(TEHRAN POLYTECHNIC), 2015

FOR THE DEGREE OF

DOCTOR OF PHILOSOPHY

(COMPUTER SCIENCE)

5, November, 2019, 1:15 P.M.
UCF, ENG2 - 202A

DISSERTATION COMMITTEE

Professor Ulas Bagci, *Chairman, bagci@crcv.ucf.edu*
Professor Mubarak Shah, *shah@crcv.ucf.edu*
Professor Abhijit Mahalanobis, *amahalan@crcv.ucf.edu*
Professor Gita Sukthankar, *gitars@eecs.ucf.edu*
Professor Mark Neider, *mark.neider@ucf.edu*

DISSERTATION RESEARCH IMPACT

Although radiology screening is proved to be a vital step for cancer detection in many applications, human errors stay as a significant issue in this process. Missing cases and over-diagnosis can have serious outcomes and increase mortality rate. In this dissertation, we propose novel machine learning algorithms for high-risk medical imaging applications. Specifically, we tackle current challenges in radiology screening process and introduce cutting-edge methods for image-based diagnosis, detection and segmentation. We incorporate expert knowledge through eye-tracking, making the whole process human-centered.

This dissertation contributes to machine learning, computer vision, and medical imaging research by: 1) introducing a mathematical formulation of radiologists level of attention, and sparsifying their gaze data for a better extraction and comparison of search patterns. 2) proposing novel, local and global, image analysis algorithms. Imaging based diagnosis and pattern analysis are "high-risk" Artificial Intelligence applications. A standard radiology screening procedure includes detection, diagnosis and measurement (often done with segmentation) of abnormalities. We hypothesize that having a true collaboration is essential for a better control mechanism, in such applications. In this regard, we propose to form a collaboration medium between radiologists and machine learning algorithms through eye-tracking. Further, we build a generic platform consisting of novel machine learning algorithms for each of these tasks.

SELECTED PUBLICATIONS

1. **PAN: Projective Adversarial Network for Medical Image Segmentation**; N. Khosravan, A. Mortazi, M.Wallace, U. Bagci. 22nd International Conference on Medical Image Computing and Computer Assisted Intervention (**MICCAI), 2019**.
2. **Weakly Supervised Segmentation by A Deep Geodesic Prior**; A. Mortazi, N. Khosravan, D. A Torigian, S. Kurugol, U. Bagci. 10th International Workshop on Machine Learning in Medical Imaging (MLMI) at MICCAI **(MLMI Workshop at MICCAI), 2019**.
3. **Cross-modality Knowledge Transfer for Prostate Segmentation from CT Scans;** Y. Liu, N. Khosravan, Yu. Liu, J. Stember, J. Shoag, U. Bagci, S. Jambawalikar. Domain Adaptation and Representation Transfer (DART): Learning Transferable, Interpretable, and Robust Representations at MICCAI **(DART Workshop at MICCAI), 2019**.
4. **On Attention Modules for Audio-Visual Synchronization;** N. Khosravan, S. Ardeshir, R. Puri. Sight and sound, IEEE Conference on Computer Vision and Pattern Recognition **(Sight and sound Workshop at CVPR), 2019**.
5. **A Collaborative Computer Aided Diagnosis (C-CAD) System with Eye-Tracking, Sparse Attentional Model, and Deep Learning**; N. Khosravan, H. Celik, B. Turkbey, E. Jones, B. Wood, U. Bagci. Medical Image Analysis journal (**MedIA), 2018**.
6. **S4ND: Single-Shot Single-Scale Lung Nodule Detection**; N. Khosravan, U. Bagci. 21st International Conference on Medical Image Computing and Computer Assisted Intervention (**MICCAI), 2018**.
7. **Semi-supervised multi-task learning for lung cancer screening;** N. Khosravan, U. Bagci. 40th IEEE International Engineering in Medicine and Biology Conference (**EMBC), 2018**. (**Oral**)
8. **How deep can hand crafted features be?**; N. Khosravan, W. L. Richey, U. Bagci. 40th IEEE International Engineering in Medicine and Biology Conference (**EMBC), 2018**.
9. **Deep Learning Beyond Cats and Dogs: Recent Advances in Diagnosis Breast Cancer with Deep Neural Networks;** J. R. Burt, N. Torosdagli, N. Khosravan, H. RaviPrakash, A. Mortazi, C. Rogers, F. Tissavirasingham, S. Hussein, U. Bagci. British Journal of Radiology (**BJR), 2018**.
10. **Eye Tracking System for Prostate Cancer Diagnosis Using Multi-Parametric MRI;** H. Celik, B. Turkbey, P. Choyke, R. Cheng, E. McCreedy, M. McAuliffe, N. Khosravan, U. Bagci, B. Wood. Conference of International Society for Magnetic Resonance in Medicine (**ISMRM), 2017**.
11. **Gaze2Segment: A Pilot Study for Integrating Eye-Tracking Technology into Medical Image Segmentation;** N. Khosravan, H. Celik, B. Turkbey, R. Cheng, E. McCreedy, M. McAuliffe, S. Bednarova, E. Jones, X. Chen, P. L. Choyke, B. J. Wood, U. Bagci. Medical Computer Vision, 19th International Conference on Medical Image Computing and Computer-Assisted Intervention **(MCV workshop at MICCAI), 2016**.

DISSERTATION

COLLABORATIVE ARTIFICIAL INTELLIGENCE ALGORITHMS FOR MEDICAL IMAGING APPLICATIONS

Radiology screening is proved to be a vital step for cancer detection in many applications. However, human errors stay as a significant issue in this process. Missing cases and over-diagnosis can have serious outcomes and increase mortality rate. Computer aided diagnosis (CAD) tools help radiologists to reduce diagnostic errors such as missing tumors and misdiagnosis.

In this dissertation, we aim to develop a paradigm shifting CAD system, called collaborative CAD (C-CAD), that unifies CAD and eye-tracking systems in realistic radiology room settings. We propose a novel graph based analysis as our collaboration medium between the radiologist and our machine learning algorithms for medical image analysis.

We first developed an *eye-tracking* interface providing radiologists with a real radiology reading room experience. Further, we develop a graph based clustering and sparsification algorithm to transform eye-tracking data (gaze) into a graph model to interpret gaze patterns quantitatively and qualitatively. This algorithm will be used as a bridge between the radiologist and our machine learning algorithms.

Second, we develop a *local* image analysis algorithm. Once we extracted radiologists' ROIs using our graph formulation we incorporate our deep learning algorithm to locally analyze radiologists ROIs. We first show this process with a pilot study. Then, we develop a semi-supervised multi-task network to perform segmentation and diagnosis of abnormalities in the ROIs jointly and at the same time. The specific design of our algorithm, in this step, targets two critical challenges in medical image analysis: generalization and lack of large scale annotated data for training.

Finally, we introduce two *global* image analysis modules. The global image analysis modules will help for a better screening by handling the areas that are totally missed by radiologists during the screening. The goals of global modules are: 1) Capturing tiny abnormalities that can be missed during the screening process, and 2) performing structure/organ segmentation to better guide the radiologists for high risk areas in case of abnormalities in organs with complex shape.

Our first global module is *S4ND*: Single-Shot Single-Scale Lung Nodule Detection. This module is designed specifically to capture tiny abnormalities in the lung, which can be easily missed by radiologist during the screening process. Our second global module is *PAN*: Projective Adversarial Network for Medical Image Segmentation. *PAN* is a novel framework which captures 3D shape information through 2D projections and incorporates that in the segmentation using an adversarial learning process. Segmentation of 3D complex organs can be a vital first step to limit and guide their search space to more high-risk regions in medical images.