Center for Research in Computer Vision

UNIVERSITY OF CENTRAL FLORIDA

FINAL ORAL EXAMINATION

OF

Maliha Arif

BE, NED University of Engineering and Technology, 2016
MS, University of Central Florida, 2019

FOR THE DEGREE OF

DOCTOR OF PHILOSOPHY

(COMPUTER SCIENCE)

November 15th , 2022, 2:00 PM
Virtual Defense

DISSERTATION COMMITTEE

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DISSERTATION RESEARCH IMPACT

In recent times, artificial intelligence (AI) and machine vision based algorithms have become very popular and widely used. This is due to their ability to achieve high performance and accuracy given sufficient training data and computing resources. Much has been done on color (RGB) images but other parts of the electromagnetic (EM) spectrum like infrared imagery (which enables us to see in the dark) is largely unexplored. Further many challenges exist because the physics of infrared imaging is different than that of the visible spectrum, and due to the lack of large amounts of training data.

We tackle some of these inherent challenges associated with infrared imagery and provide contributions to the society by proposing methods that help in object recognition in the dark . In particular, this dissertation investigates novel methods for training deep learning networks with fewer training images, the ability to training a network to predict new infrared views of an object, and minimizing the effect of background and clutter on infrared object recognition.

SELECTED PUBLICATIONS

1. **View prediction using manifold learning in non-linear feature subspace**, Maliha Arif, Abhijit Mahalanobis, in Eleventh International Symposium on Multispectral Image Processing and Pattern Recognition *(MIPPR)*, 2019.
2. **Infrared Target Recognition Using Realistic Training Images Generated by Modifying Latent Features of an Encoder-Decoder Network**, Maliha Arif, Abhijit Mahalanobis, in IEEE Transactions on Aerospace and Electronic Systems *(TAES)*, 2020.
3. **Few Shot Learning For Infra-Red Object Recognition Using Analytically Designed Low Level Filters For Data Representation**, Maliha Arif, Abhijit Mahalanobis, in IEEE International Conference on Image Processing *(ICIP)*, 2021.
4. **Background-Tolerant Object Classification With Embedded Segmentation Mask For Infrared And Color Imagery**, Maliha Arif, Calvin Yong, Abhijit Mahalanobis, Nazanin Rahnavard, in IEEE International Conference on Image Processing *(ICIP)*, 2022.
5. **Infrared Target Recognition using Synthetic Training Images**, Maliha Arif, Abhijit Mahalanobis, in IEEE Transactions on Image Processing *(TIPS)*, 2022. (Submitted)
6. **Background Invariant Classification on Infrared Imagery by Data Efficient Training and Reducing Bias in CNNs**, Maliha Arif, Calvin Yong, Abhijit Mahalanobis, in The Thirty-Sixth AAAI Conference on Artificial Intelligence *(AAAI)* AIBSD Workshop , 2022.

Patents:

Indirect Speech Enhancement to Avoid Speech Artifacts in Denoised Signal For Machine Consumption , 2300051IDF, 2022

DISSERTATION

TOWARDS LEVERAGING SPARSE INFRARED DATASETS FOR MULTIPLE VIEW SYNTHESIS, FEW SHOT LEARNING AND BACKGROUND INVARIANT RECOGNITION

This dissertation presents a study of modern machine learning techniques for recognizing vehicular objects in infrared images. State of the art methods for computer vision have not been widely explored for this part of the electromagnetic spectrum (EM). Challenges that arise due to the dearth of infrared training images, terrain clutter, and thermal phenomenology have not been fully addressed. This thesis attempts to address some of these important topics and proposes novel methods that work well with both infrared and color (visible band) imagery.

Since infrared sensors are not as widely used as color cameras, there is a lack of datasets with annotated infrared images. Motivated by the lack of adequate infrared training imagery, we first propose an encoder-decoder architecture for generating realistic medium wave infrared images of objects at various azimuth angles, in day or night conditions, and at different ranges using a small set of real images.

Our second study seeks to address the challenge of training a network from scratch with relatively few training images while avoiding the pitfalls of overfitting to the data. Inspired by few shot learning (FSL) and meta learning approaches, we propose 'HybridNet', a network that leverages on analytically derived filters in the lowest layer to achieve better performance than learning from scratch using a relatively small dataset.

Lastly, we perform background invariant recognition. It has been observed that networks often learn background textures, which are not relevant to the object of interest. This problem is exacerbated when the number of training images is small, as is often the case for infrared object recognition. To address this problem, we present a deep learning method called split- training along with another algorithm involving convolutional minimum mean square error (MMSE) distance classifier for determining the location of the object and classifying it.

Maliha Arif

1992	Born in Karachi, Pakistan
2012-2016	B.E Telecommunications Engg, NED University of Engineering And Technology, Karachi, Pakistan
2016-2017	Analyst Software Engineer, Afiniti, Karachi, Pakistan
2019	M.S, University of Central Florida, Orlando, FL, USA
2020	Machine Learning Intern , Ford Motor Company, Dearborn, MI,USA
2022	Deep Learning Intern, Qualcomm Inc, San Diego, CA, USA
2017-2022	Ph.D, University of Central Florida, Orlando, FL,USA

SELECTED AWARDS & HONORS

2017	UCF - ORC Fellowship
2019	Grace Hopper Scholar
2019	UCF Graduate Presentation Fellowship
2021	WiML Travel Award - ICML
2021	Google Conference Scholar - NeurIPs
2021	SGA Travel Award