Perception and Computer Vision with Alternate Sensors

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Cutting edge advances and state-of-the-art work is being made in the growing field of computer vision and pattern recognition beyond the visible spectrum. This field involves research in sub-areas of image processing, machine vision, pattern recognition, machine learning, robotics, and augmented reality.

The computer vision community has typically focused mostly on the development of vision algorithms for object detection, tracking, and classification associated with visible range sensors in day and office-like environments. In the last decade, infrared (IR), depth, IMU, thermal and other non-visible imaging sensors were used only in special areas like medicine and defense. The relatively smaller amount of interest in those sensors for computer vision was due in part to their high cost, low resolutions, poor image quality, lack of widely available data sets, and/or lack of consideration of the potential advantages of the non-visible part of the spectrum. These historical objections are becoming less relevant as sensory technology is advancing rapidly and the sensor cost is dropping dramatically. Image sensing devices with high dynamic range and high sensitivity have started to appear in a growing number of applications ranging from defense and automotive domains to home and office security.

In order to develop robust and accurate vision-based systems that operate beyond the visible spectrum, not only existing methods and algorithms originally developed for the visible range should be improved and adapted, but also entirely new algorithms that consider the potential advantages of non-visible ranges are certainly required. The fusion of visible and non-visible ranges, like radar and IR images, depth images or IMU information, or thermal and visible spectrum images as well as acoustic images, is another dimension to explore for higher performance of vision-based systems. Non-visible light is widely employed in night vision-based systems, and many detection and recognition systems available today in the market are relying on physiological phenomena produced by infrared and thermal wavelengths.

This talk explains three of the applications of computer vision outside of the visible spectrum, including their use in robotic perception, video game interaction, and medical imaging.

Computer vision outside of the visible spectrum is used for robotic perception, primarily through ladar (lidar) but also through radar for robotic vehicles. From radar signals we can perceive a micro-Doppler signature, which is a distinctive characteristic of the intricate frequency modulations generated from each component part of a target and is represented in the joint time and Doppler frequency domain. Micro-Doppler signatures provide unique target features that are highly complementary to those made available by optical and infrared video. I will show some robotic radar sensing and some micro-Doppler signatures of pedestrians for automotive radar.

Video games use computer vision to determine the 3D motion of participants in Kinect-like sensors. These sensors determine rudimentary point clouds which can be skeletonized into rough human motions. These can then be perceived and recognized, and I will demonstrate how including “expert” ontological data can significantly improve the feature set and the resulting perception.

In medical imaging, computer vision from outside of the visible spectrum uses x-rays to penetrate the human body and detect the existence and position of potential cancers in the body. However, the penetration tends to make noisy images that can be significantly improved using computer vision techniques. In this work, a particularly difficult type of highly malignant cancer is isolated and recognized using custom features, clustering, and learning techniques.

Bio:

Dave Tahmoush's primary research has been in medical and radar imaging, databases, and analysis. He published a book in 2014, edited a successful journal special issue in 2015, and a 2015 journal paper has been a “top 20” paper for the past few months. He is an experienced grant writer with grants above $1200K, and an effective teacher with experience teaching multiple classes as well as a teaching award. He was a Fulbright scholar and 'Top Young Radar Engineer' with degrees from Caltech, MIT, and the University of Maryland. He was a principal investigator for robotic perception (ladar, video, radar) in human teaming with emphasis on real-time analysis of human activities and ontological analysis. He designed and implemented classification of radar micro-Doppler video and developed automated target recognition approaches for dismount detection and behavioral recognition. He also researched pedestrian and vehicle tracking and counting, as well as multi-sensor performance. He led the team that produced ARCHIMEDES, an archive for medical images and information, and he designed and produced a mammogram analysis system for diagnosing breast cancer including determination of asymmetry which outperformed both commercial and academic systems at image prescreening. He also improved ultrasound measurements of artery thickness.