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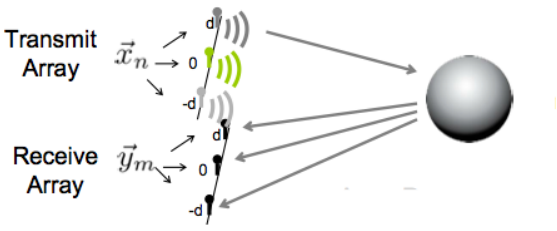
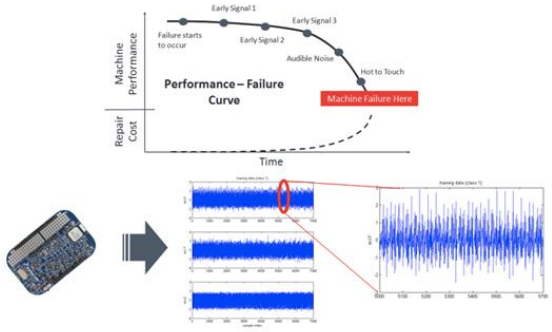
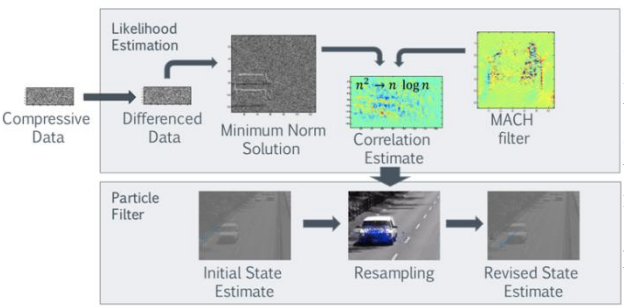
SenSIP I/UCRC Industry Projects:



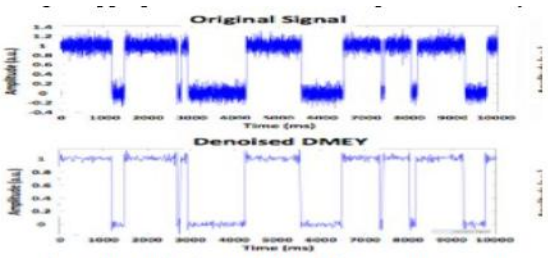
Array Processing Using Virtual Array Concepts
Virtual array and matrix filling algorithm can improve the resolution of a radar array. Previous work in active sensing includes multiple-input multiple-output (MIMO) radar. For passive sensing, examples include building virtual arrays by using higher order cummulants. We extend these approaches by considering a general set of signal separation approaches to develop larger number of degrees of freedom. We investigate general bounds on performance.
Sponsor: Raytheon
Keywords: Array Processing, MIMO Radar, Virtual Arrays



Minimally Supervised Machine Learning for Machine Condition Monitoring
The aim of this project is to enable low-touch development and deployment of monitoring systems which predict machine failures before they occur. To this end, we will develop standardized work flows which leverage: (1) libraries of predefined solutions allowing for easy definition of normal and abnormal signatures for specific situations; and (2) focus on the use of inertial, magnetic, and pressure sensors. We will investigate methods to select features and specific sensors that provide best results. We will select machine learning algorithms and begin to adapt them to our application.
Sponsor: NXP.
Keywords: Embedded Sensors, Machine Learning. Condition Monitoring

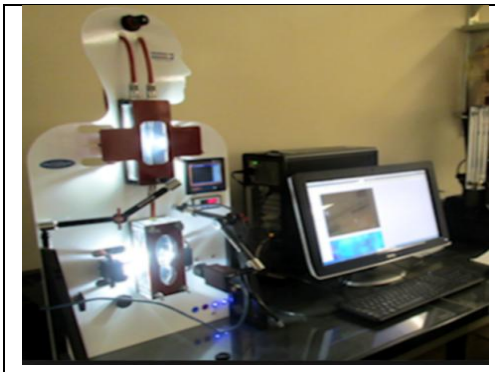


Understanding Activity Beyond the Visible Spectrum
Compressive sensing of high-dimensional image data offers novel advantages in terms of low-cost and low-data rate acquisition especially in the infrared wavelengths. The proposed project investigates moving target detection and tracking using compressive cameras for both visible and infra-red sensing devices. The technical objective is to accomplish target detection and tracking in the *compressed domain*, without requiring image reconstruction.
Sponsor: Raytheon
Keywords: Compressive Sensing, Target Tracking, Security

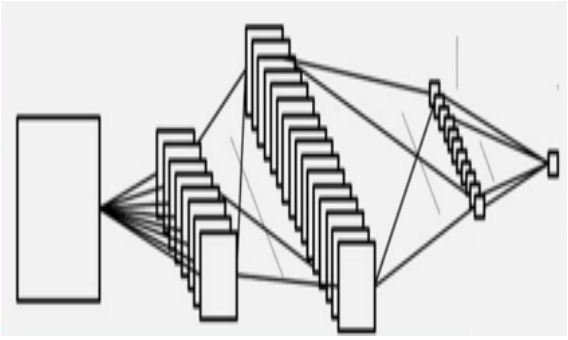


The noisy and enhanced signal for a nanopore sensor.

Signal Processing for Ion Channel Sensors
ASU faculty demonstrated the feasibility for stochastic sensing based on changes in the nanopore gating. Although stochastic sensing based on analysis of the current fluctuations in the intermediate time scale has been demonstrated, the interpretation signals from nanopores can be ambiguous. However, there is potential for advances in our understanding of nanopore currents if signal analysis techniques can be applied to study these stochastic signals. We propose stochastic analysis of nanopore signals using a new and custom Wavelet basis along with advanced classification methods**.** We investigate identification of stochastic signatures of nanopore sensors that correlate with events associated with specific agents. Applications include detection of biothreats, biomedical sensors detecting at the molecule level, and water quality assessment.
Sponsor: NCSS/SenSIP
Keywords: Ion Channel Sensors, Nanopore sensors, Sensing at the Molecule level

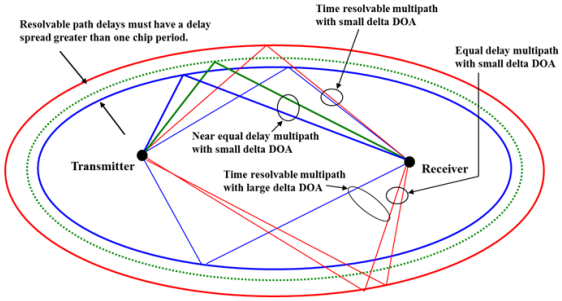


Networked Interactive Flow Sensors
Networked sensing for Flow visualization is a long standing scientific challenge. Applications are in predicting aneurism and other health related problems. Imaging sensors for particle image velocimetry (PIV) provides a solution whereby particles within physical flow fields are imaged in order to quantify localized flow velocities. However, a PIV system is only as capable as the sensing and image processing the underpin the velocimetry process. The networked sensing and flow models developed for Flowcoach will form the basis for further development of the Hemoflow models
Sponsor: IFS (SBIR)
Keywords: Imaging, Predicting Aneurism

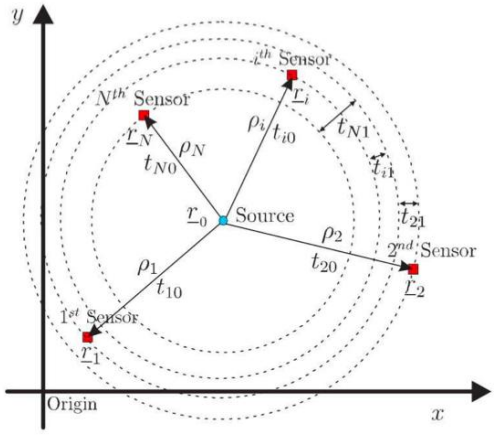


Deep Learning Based Computer Vision
Object detection and tracking find application in surveillance, security, assistive technologies, robotics, self-guided navigation, risk assessment, and hazard prevention, to name a few. In real-world applications, there is need to perform object detection and tracking in real-time under varying environmental conditions (changes in weather, lighting, background noise, etc), which can significantly affect the quality of the captured video and the performance of the deployed computer vision algorithms. This project investigates the development and deployment of deep learning based computer vision algorithms that are resilient to variations in environmental conditions and video quality with applications to scene understanding and assistive technologies.

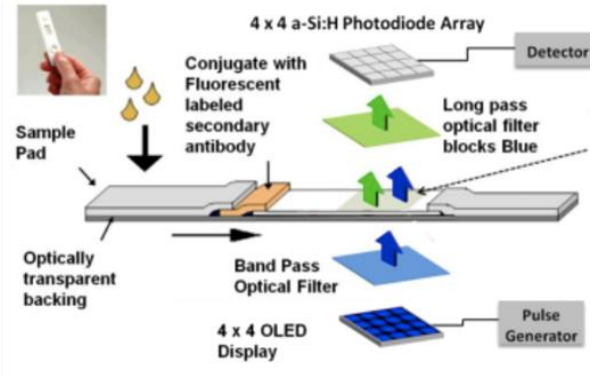
Sponsor: Intel
Keywords: Deep Learning, Navigation, Image Processing



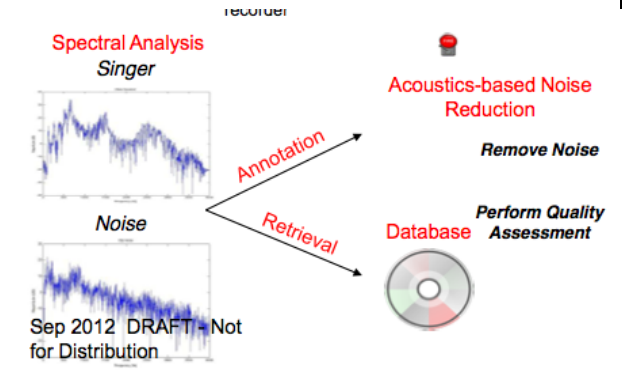
GPS Multipath Mitigation Algorithms
Global Navigation Satellite Systems (GNSS) provide the enabling technology for real-time, autonomous vehicle navigation and control in such diverse applications as construction, mining, farming, and fishing. All GNSS receivers estimate a satellite's signal time of arrival to solve for position and time. The quality of these time-of-arrival (TOA) estimates are directly dependent upon accurate tracking of the direct sequence spread spectrum (DSSS) code and carrier phase. Unfortunately, *multipath is a dominant error source* within these systems since it corrupts the signal phase estimates with a time-varying bias. This proposal will investigate multipath mitigating techniques that are power efficient, optimized for digital implementation and suitable for either binary phase shift keyed or binary offset carrier signaling techniques that may or may not include interleaved pilot and data channels.
Sponsor: Aperio DSP
Keywords: GPS receiver design, Channel Estimation



Sequential Localization in a Low Power Wireless Sensor Network
Wireless sensor network applications often require deployment in large areas that are subject to impulsive noise. Robust performance, scalable and reconfigurable clusters with long network lifetime and the ability to compute functions of measured values is also very desirable. Hence sensor networks and associated algorithms must be designed to be low power, location-aware, and capable of robust parameter and distributed function computation in the presence of channel noise. Due to the reconfigurable nature of the clusters, such systems must complete computations without relying on fixed clusterheads or fusion centers. Such a design requires a fully distributed consensus systems for in-network computation. **Sponsor:** Sprint
Keywords: Distributed Estimation, Sensor Fusion, Mobile Phone Localization

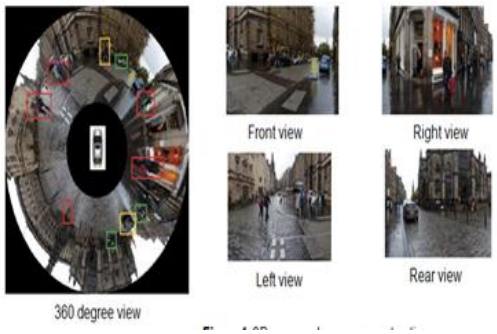


Integrated Flexible Sensor Device and Signal Processing Algorithm Design Sensors have become ubiquitous in our lives, but most users are unaware of how their performance can be affected by environmental changes that must be compensated with corrective signal processing and machine learning. Research in sensor design will focus on basics of mobile and wearable sensor characterization, accuracy, sensitivity. These devices are particularly sensitive to environmental variations, since not only the devices but the samples themselves have properties that depend on temperature and ionic concentrations (charge). The devices also suffer from drift which is composed of several types of drift, each dependent on environmental factors as well. Research will focus on algorithms as well as soft and hard calibration techniques and corrective digital signal processing (DSP) that can be used to mitigate the effects of variations on sensors.
Sponsor: NXP
Keywords: Flexible Sensor Design, Machine Learning



Speech Analytics for Net Centric Applications
Speech signatures are used in many Net Centric analytics for security and health related applications to identify words, the state of emotion or speech pathologies. In many networked speech classification and tasks, the effects of speaker-specific parameters are dominant because of the small sets of training data. This is especially problematic in tasks involving pathological speech where obtaining data from large numbers of speakers is costly and time-consuming. We propose a novel algorithm for feature selection that aims to minimize the effects of speaker- specific features (e.g., fundamental frequency) and maximize the effects of pathology-specific features (e.g., vocal tract distortions and speech rhythm). We derive a new cost function for feature selection that simultaneously trades off between these two competing criteria and develop an efficient algorithm for solving it.

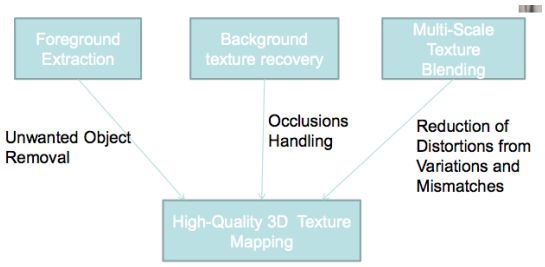
Sponsor: NCSS Proposal
Keywords: Speech Analysis, Emotion Estimation from Speech



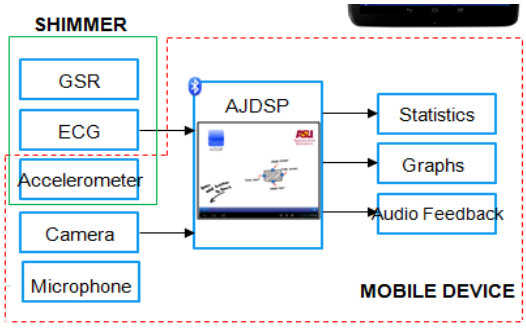
Video-based Localization & Scene Analysis for Driver Assist Systems
This work will develop context-aware networked computer vision systems, encompassing visual sensors and processing components with the goal to augment the limited, selectively attentive human perception with a focus on Advanced Driver Assist Systems (ADAS). This in turn will help in increasing human awareness of the surrounding environment and in alerting a human driver of potential nearby hazards. The visual sensors include in-vehicle fisheye cameras (e.g., front, side, and rear). The processing components include depth estimation, object detection and recognition, and visual sensor fusion for panoramic view generation.
Sponsor: Intel, NCSS
Keywords: Advanced Driver Assist Systems, Autonomous Vehicles

Sensors & Machine Learning for Internet of Things (IoT) Applications
Internet of Things (IoT) is a rapidly emerging area with several state-of-the-art mobile and cloud computing applications. We chose IoT as a central topic for this collaborative project as IoT poses several grand challenge problems at the overlap of machine learning, big data, sensor systems and low power secure computing. The project will target specifically IoT and other applications of interest to consortium members. Both cloud-based machine learning (ML) algorithms, and compact ML algorithms for embedded sensor systems boards will be studied. Strategies will be studied for two scenarios including: a) seamless offline training that involves large amounts of data and cloud computing and b) on-the-fly on-board decision ML policy updates. Proper preliminary data processing on sensor boards will also be considered to achieve a balance in computing and communication tradeoffs. **Sponsor:** NCSS - Multisite
Keywords: Internet of Things, Machine Learning

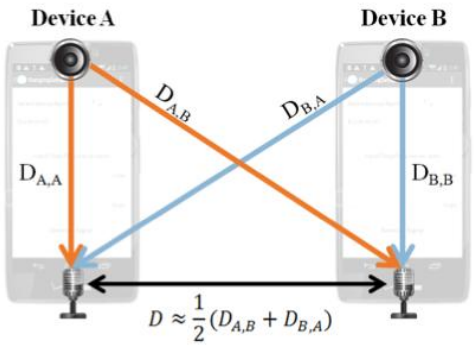
Intelligent Networked Sensors for Solar Panel Array Management
This project addresses several new Photovoltaic (PV) data processing, sensing, modeling and control engineering methods for controlling PV arrays using smart sensors that sense and actuate at the individual panel level. The proposed project seeks to improve photovoltaic (PV) array performance and efficiency and ultimately reduce the cost of energy produced by utility-scale solar systems. This is achieved by (a) Intelligent fault detection by using data collected from each PV module; (b) PV array reconfiguration to make the best use of available modules; (c) Inverter optimization to track the MPPT and reduce inverter losses; and (d) Development of robust communications between sensors.
Sponsor: Poundra, ACT
Keywords: Sensors for Solar Arrays, Machine



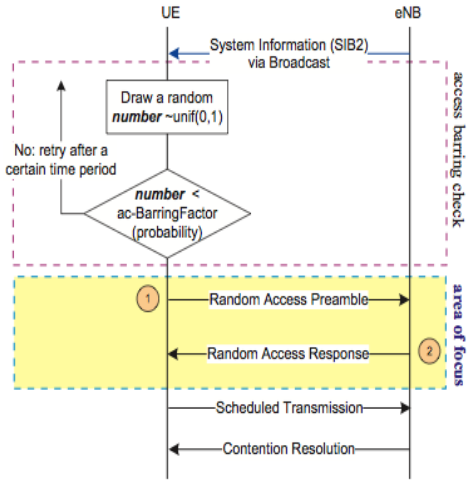
MultiView Texture Mapping, for Digital Camera Applications
This projects addresses the following problems: a) Texture blending: given two or more views and 3D geometry (polygonal faces), determine the optimal blending function and weights for the final texture from multiple photos b) Detecting background and foreground objects in the photos and removing unwanted foreground objects from the final texture. In the urban area, it is of interest to remove unwanted objects such as people, cars, and traffic signs from the facade texture. If applicable, for each photo in the set, detect self-occluded regions and fill them from the other photos.
Sponsor: Brainstorm Technology
Keywords: Camera sensors, 3D imaging, object detection



Interfacing Physiological Sensors to Mobile Android Devices
In this work, multiresolution methods are used to analyze ECG and PPG signals. The discrete wavelet transform (DWT) using the Daubechies wavelets was selected to analyze both the ECG and Photoplethysmogram (PPG) signals acquired from SHIMMER and the mobile camera respectively. Signal processing algorithms are developed to extract features such as R-R interval, Heart Rate Variability and instantaneous heart rate vectors. High-frequency noise is removed by automatically selecting the number of scales of signal decomposition based on the sampling rate of Android devices. In addition, machine learning algorithms to estimate oxygen saturation (SpO2) from PPG and to classify physical activity from accelerometer signals were developed
Sponsor: Sprint
Keywords: Sensors for Healthcare, Wavelets, Android Implementation



Android Acoustic Ranging
This research addresses es the design and implementation of a mobile application (app) for acoustic ranging developed for the Android platform. The ranging strategy used is based on the acoustic "BeepBeep" method. Using only the speaker and microphone hardware in Android devices, indoor ranging precision under a 0.1 centimeter variance is achieved at distances up to 4.5 meters. In addition, preliminary outdoor tests show accuracy at distances as large as 50 meters when there is a strong line of sight component. The app has been designed to be an accessible and customizable tool various applications, and features options for optimizing its accuracy in various environments.
Sponsor: NSF I/UCRC FRP, Sprint
Keywords: Android app, Microphone Sensors, Phone Localization

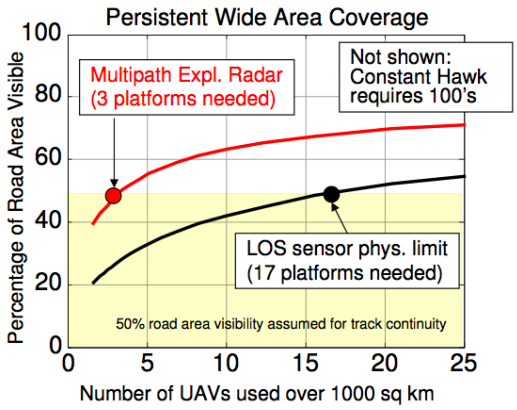


Impact of Retransmission Limit on Contention in LTE-Advanced Network

LTE-Advanced networks employ random access based on preambles transmitted according to slotted Aloha principles. Random access is controlled through a limit W on the number of transmission attempts and a timeout period for uniform backoff after a collision. We model the LTE-Advanced random access system by formulating the equilibrium condition for the ratio of the number of requests successful within the permitted number of transmission attempts to those successful in the first attempt. We prove that for $W \leq 8$ there is only one equilibrium operating point and for $W \geq 9$ there are three operating points if the request load ρ is between load boundaries $\rho 1$ and $\rho 2$. We analytically identify these load boundaries as well as the corresponding system operating points. We analyze the throughput and delay of successful requests at the operating points and validate the analytical results through simulations.

Sponsor: LG Electronics

Keywords: Internetworking, LTE, Slotted Aloha, Throughput-Delay Analysis.



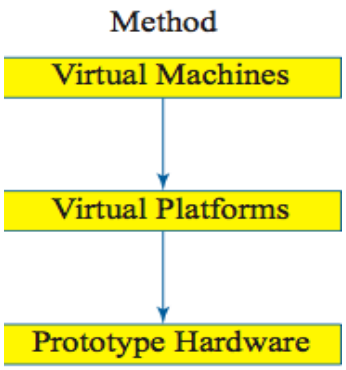
(Figure from DARPA)

Adaptive Waveform Design and Multipath Exploitation for MIMO Radar

Signal processing algorithms are developed to improve tracking performance by adaptively designing the multiple-input and multiple-output (MIMO) transmitter waveforms and by scheduling the MIMO radar sensors. We use: (a) adaptive waveform design to minimize the tracking mean-squared error; (b) scheduling to optimally configure transmitters; and (c) combined adaptive waveform and transmitter configuration optimization to improve tracking performance. The effectiveness of combining MIMO radar technology with adaptive waveform design and sensor scheduling is demonstrated using simulations. Multipath exploitation radar methods are also considered to exploit the benefits of extracting target information from multipath returns and enhance radar coverage and scene visibility in urban terrain.

Sponsor: Lockheed Martin

Keywords: MIMO Radar, Adaptive Waveform Design



Virtual Design of an Audio Lifelogging System

Implementing Internet of things (IoT) distributed systems with many computing elements is likely to encounter many design problems .These problems must be considered at an early stage, before much expense has been incurred in creating custom chips. To help solve these problems we introduce virtual design methods. Virtual design combines simulation techniques with a top-down design methodology. Using simulation it is possible to adopt a top-down design methodology, where high-level system issues get analyzed first and details are added later. Overall, the process reduces the risks involved with designing complex systems. To show how these techniques work in practice, we applied them to new ideas for an IoT audio-based product concept.

Sponsor: Intel

Keywords: Internet of Things, Embedded Systems, Audio Processing