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Project Title: Optimizing Wireless Sensor Networks for Medical Applications

Medical applications such as remote patient monitoring are considered to be very promising application areas of wireless sensor networks. In order to build a smart healthcare environment for patients, different kinds of sensors (e.g. video camera, ECG sensor) are adopted. These heterogeneous sensors generate data of different types and in different rates. Because there is a lack of considering heterogeneity in the current sensor network design, this heterogeneity represents a new challenge to sensor network optimization. The main objective of this project is to find new sensor network optimization solutions by considering the differentiation of sensed data in terms of their traffic patterns and QoS requirements.

Publications:

Name: Nguyen Trung Hieu

Tittle: Ph.D Candidate
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Project Title: Robust Communication for Wireless Sensor Networks

Wireless sensor networks with a large number of sensors distributed in a geographical area have many potential applications. The applications can be identification and tracking of military targets, monitoring the environment measuring quantities such as temperature, pollution levels, etc. Recently, there has been attention on applying wireless sensor networks in medical applications where medical sensors are placed both on and inside the human body. This enables continuous monitoring of the patient’s physiological variables with enhanced mobility for both the patient and the hospital staff. This technology can be extended to in-home healthcare as well as to emergency response systems. There are still many challenging problems in wireless sensor networks.

The challenges come from their critical requirements on both technical and non-technical issues including low cost, low complexity, low power consumption, low transmission bandwidth, and high reliability. So far, a lot of research work has been carried out to develop energy efficient algorithms at each protocol layer of wireless sensor networks.

My research will focus on improving the robustness of communication links between the sensors and the fusion center in wireless sensor networks such that the information measured by sensors can be delivered to the desired destination reliably. In addition, low complexity transceiver is also considered in this framework since low cost and compact sensors are also design parameters of interest in wireless sensor networks.

Publication:
Project Title: UWB medical radar with spatial selectivity
Radar detection of cardiac movement has been reported in a number of scientific publications. However, there is apparently little consensus regarding what phenomena are observed in reality. Manifestations of physiological motion in measured time-series could stem from the heart muscle itself, surrounding tissue or originate from the chest surface. Ultra wideband (UWB) radar has gained special interest as a candidate for medical applications due to the potentially higher range resolution as compared to conventional narrowband solutions. The large fractional bandwidth of a UWB radar and the ability to perform using low power emissions, offer significant protection to interference-susceptible systems and an inherent immunity towards external electromagnetic radiation. Means to distinguish between spatial regions that are comparable to relevant organ sizes is
believed to enable a more accurate analysis of mechanical heart activity and possibly allow medical UWB radar imaging. The approach is to apply array signal processing to focus on different volumes of space, and thus achieve spatial selectivity. This project concerns the development of a new UWB medical radar at the Norwegian Defense Research Establishment (FFI). The goal is to realize a UWB radar setup with a flexible antenna array that can be configured to suit a vast number of experiments. Effort will be made to demonstrate that array signal processing of UWB radar backscatter can provide a more detailed analysis of the mechanical activity of the heart muscle, than a system employing only a single signal chain.

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PROJECTS

Written by Eric Ngale agbor
Friday, 08 January 2010 08:42 - Last Updated Monday, 14 February 2011 13:20

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PROJECT TITLE: Distributed Detection and Estimation for Implant Sensors.

Signals coming from implant sensors are subject to very stringent pathloss, which makes it difficult to recover the signal using conventional signal processing methods. As a simple rule in estimation, adding more independent observation provides better estimation variance. To take advantage of this property distributed estimation ads up to the number of sensors to provide more independent observations. At the same time applying distributed methods for estimation and detection brings in new challenges such as the trade off between quantization accuracy in sensors and estimation performance in fusion center. Considering a wireless channel between sensors and the fusion center makes the problem more complicated. Channels inside body can be considered as time invariant but with very high pathloss outside the body channels show more common wireless behavior. Since there are different channels between each sensor and fusion center the better observation does not necessarily mean better estimation at fusion center. Our objective in this project is to derive an optimal solution for implant sensors while we consider the wireless channel in and outside the body according to the derived model. We also want to examine the detection performance while we implement localized consensus.
PROJECTS

Written by Eric Ngale agbor
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Publications

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Name: Lars Erik Solberg, Siv. Eng

Title: Ph. D. Fellow

Address: The Interventional Center-IVS-, Rikshospitalet
PROJECT TITLE

Ultrawide Band (UWB) Medical Radar for Aorta Blood Pressure Measurements.

The objective of the project is to establish a non-invasive method for the estimation of blood pressure using radar techniques and probably, although not restricted to using ultrawide band signals.

The hypothesis is that it will be possible to estimate the diameter of the aorta as a function of time at one or two points along the aorta - depending on approach; and to relate the diameter traces to blood pressure. A search in medical articles suggests two approaches for relating diameter variations to blood pressure: one uses the direct linear relationship between instantaneous diameter and pressure. The second uses a relationship between pressure pulse propagation speed and the elasticity of the aorta, and further the claimed non-linear relationship between elasticity and mean arterial pressure.

Human tissue are generally very lossy materials, and more so with increasing frequency. On the other hand, larger center frequency and especially bandwidth may be beneficial to diameter estimation through the use of doppler processing and increased resolution. Hence, finding the best signal selection is a key part of the work. Further stages include identifying an efficient and robust estimation procedure, and developing phantom models in order to test performance and better understand system behaviour.
Publications


Name: Raul Chavez-Santiago, Dr. Eng

Title: Postdoctoral Fellow
PROJECT TITLE: Cognitive UWB sensor networks.

This work corresponds to the WP6 of the MELODY Project. In it, the design of a wireless body area network (WBAN) for medical applications is being pursued. The best way of interconnecting in-body, on-body, and external sensors (medical radars) by using ultra wideband (UWB) radio interfaces is going to be defined. Our WBAN architecture is based on the concept of cognitive sensor network, where cross-layer and/or non-layer optimization and resource allocation are to be considered. In this architecture, the cognitive functions are performed by a network controller and not by individual sensor nodes. Since accurate knowledge of the radio channel is necessary for an efficient radio design, a realistic in-body
UWB channel model has been developed, in which the living human tissue dielectric characteristics are taken into consideration. This model characterizes statistically the propagation of electromagnetic waves coming from an UWB sensor located at different depths inside the chest. Concurrently, artificial intelligent algorithms for fast “cognition” are being developed. Cooperative localization of relative distance among nodes based on the network topology may be included in the cognitive process. Several biomedical scenarios are going to be studied, and the correct performance metrics that allow fair comparison of different algorithms in such scenarios will be identified.

Publications:


Name: Alex Cartagena Gordillo

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PROJECT TITLE: UWB Communications in the Implant - On-body Environment.

In this project, we are trying to address many issues found in the communications environment between implant nodes and on-body ones. Different from other environments, here we have high attenuation and possibility of harming living tissue if high levels of electromagnetic radiation are employed. In addition there are limitation in size and available power in the implant nodes. UWB is well-known for its low demands in terms of energy, however it is also well-known that because of its ultra wideband, it is exposed to interference from existing narrowband system. Therefore, in this project we are trying to optimize all the related variables to obtain a high reliable communications system that is required for bio medical applications.
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**PROJECT TITLE:** Ultra wideband (UWB) medical radar for heartbeat detection and monitoring.

In this project we will look at using UWB radar for wireless remote monitoring of heartbeats. Radars work by emitting electromagnetic waves and recording reflections of these. The reflections are caused by the wave hitting interfaces with differences in electromagnetic impedance. Thus the interface between air and body as well as heart muscle/blood, chest/lung and other interfaces inside the body can provide reflections recorded by radar. Throughout a heartbeat the topology and position of both heart and chest varies.

Using UWB radars developed at Forsvarets forskningsinstitutt(FFI), we conduct experiments and record data. These data are used to analyze the radar output of the mechanical movement of the heart, and characterize the possibilities of radar as a heartbeat monitoring device. Among our objectives are characterizing the scattering properties of the human heart during a heartbeat over different frequencies. A large part of the project is the development of digital signal processing algorithms for heartbeat detection and heartbeat rate estimation. The goal is an optimal detector that can extract heartbeats from respiration and movement in a person. The possibilities of vital sign detection radar are many: heartbeat detection, monitoring mechanical activity in the heart and through the wall people detection are among the proposed applications in the literature.
ALUMNI

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The emerging wireless sensor networks and services have some of the following features: mobility, diffusion of heterogeneous nodes and devices, mass digitization, resource constraints, multi-federated operations, scalability, dependability, context awareness, security, probability, new forms of user centered content provisioning, new models of service and the interaction with improved security and privacy. These features produce new technologies and networking architectures and exhibit huge challenges to render robust services, security and management. Therefore new management standard, architectures, theory and technologies should be investigated to match the current requirements to manage wireless sensor networks and their services. A set of enabling technologies is recognized as potential candidates for the management of wireless sensor networks and can be based on policy-based management strategies, artificial intelligence techniques, probabilistic approaches, bio-inspired approaches, etc. The project aims to investigate efficient strategies and technologies to improve the management of sensor networks and eventually to obtain autonomic management,
context-aware management and self-management systems in which technology itself is used to manage technology.

Publications:

Books:


Papers:


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Project Title: Design of Multi-Objective Geographic Wireless Sensor Network Routing Protocol for Biomedical Applications

This project focuses on the design of QoS routing protocol for medical applications of wireless sensor networks. It considers the scenario of patient monitoring in a hospital, where sensors may be deployed in the body (in-vivo) or outside it (ex-vivo) to make the appropriate measurements and. These sensors are interconnected through wireless links to provide the medical staff with the required information, and possibly to react automatically to some crucial events (actuations). Each body includes several tiny biomedical sensors, connected (wirelessly or through cables) to a micro sensor, which is larger and more powerful, and thus acts as a body cluster-head. This cluster-head can be a sensor mote such as the ones of Crossbow. It is in charge of relaying traffic from the body cluster-head to the sink. For this purpose, an appropriate routing protocol is required.

Power management is a central issue in medical applications, since replacing sensor batteries
(if possible) is an overwhelming operation. QoS (quality of service) is also important in the targeted application, especially for critical situations and real-time data that are delay sensitive and must be transported as quickly as possible, and may require high reliability. Packet priority must then be defined. The use of localization information in routing is a promising technique that avoids heavy procedures for route establishment. This concept has been exploited recently to build power efficient routing. The aim of this project is to design a multi-objective routing protocol that optimize power consumption as well as end to end delay and packet reception rate (QoS), while considering the biomedical application features, and exploiting position information. The project also involves studying the current technology used to deploy WSN, which will enable making some implementations and tests of the proposed solutions.

**Publications:**


