Research Institute of Sciences and Engineering

Office of the Vice Chancellor for Research & Graduate Studies
University of Sharjah

The purpose of this circular is to provide summaries of selected MSc. research projects undertaken by holders of the Graduate Research Assistantships (GRAs) offered by the Research Institute of Sciences and Engineering (RISE). The following projects are highlighted in this circular:

1. Spectrally Efficient Channel and Carrier Frequency Offset Estimation for Two-way Relay Networks
2. Blockchain-Based Secure Firmware Update for IoT Devices
3. Molecular Analysis of a Consanguineous Family with Palmoplantar Keratoderma
4. Assessment of Phosphorus Removal from Water Using Al/Fe Modified Nano-Clay
5. Post-Deployment Coverage Hole Detection and Repair in Wireless Sensor Networks
6. Field Programmable Analog Arrays for Biomedical Applications
7. Comparison of DNA and Life History Traits between Local and Mediterranean Lines of Brachypodium Species
8. Experimental Study on the Shear Strength of Reinforced Concrete (RC) Beams Strengthened with Externally U-Bonded Carbon Fiber Reinforced Polymers (EB-FRP)

Spectrally Efficient Channel and Carrier Frequency Offset Estimation for Two-way Relay Networks

Abstract: Relaying is one of key technologies under development to be utilized in next generation wireless systems. Relaying is achieved by inserting an intermediate node between the sender and the receiver where the transmitted signal from the sender is sent first to the relay node before it gets retransmitted again by the relay to the receiver. The relay node along with the two transmission nodes are called a relay network. Two-way relay networks (TWRNs) provide higher spectral efficiency than one-way relay networks, by allowing source nodes to exchange data using a lower number of transmissions slots. Furthermore, the amplify-and-forward (AF) protocol is attractive in TWRNs due to the minimal processing required at the relay. An accurate channel state information knowledge, however, is required to cancel the interference effects and for coherent decoding. In addition, hardware deficiencies in the relay network cause a frequency offset during transmission. Moreover, in TWRNs, the transmitted signals from the two source nodes generally do not arrive exactly at the same time at the relay node which can cause estimation errors due to loss of orthogonality between the signals. Hence, it is important to determine the carrier frequency offsets (CFOs) and the timing offsets. In this thesis, we consider the problem of joint CFO and channel estimation for AF TWRN working under flat-fading nonreciprocal and reciprocal channels. In addressing this problem, we will consider both the time-synchronous and time-asynchronous scenarios. In terms of estimation strategy, we will consider two strategies. The first is the commonly used pilot-based estimation which relies solely on the transmission of known pilot. The second is the semi-blind strategy, which is capable of achieving higher accuracy through utilizing both pilot-carrying and data-carrying samples to extract the maximum amount of information about the unknown parameters. In particular, we focus on using the expectation maximization (EM) algorithm for the purpose of semi-blind estimation, as it is a convenient solution when maximum-

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likelihood estimation is too complex or intractable. For the scenarios under consideration we derive semi-blind joint estimation algorithms and extensively investigate their performance using simulation results. We also obtain the Cramér-Rao bound (CRB) which provides a benchmark on the performance of unbiased estimators. Our simulations show that the proposed algorithms converge to the CRB in all scenarios under consideration. The higher accuracy achieved through semi-blind estimation means that the number of pilots can be significantly reduced, leading to improved throughput and spectral efficiency.

Blockchain-Based Secure Firmware Update for IoT Devices

Abstract: The increasing reliance on smart and connected devices in our homes, company and in everyday life has led to the rapid growth of the Internet of Things (IoT) technology. While some IoT devices communicate without the involvement of users, their functionalities must be protected against various attacks. This thesis proposes and implements the delivery of a secure firmware update to IoT devices. This is a fundamental security challenge for the embedded devices in IoT. The process of ensuring secure firmware update should be implemented using a trusted network. In our thesis, we chose blockchain to be our trusted network. The approach is based on securely verifying the firmware version of the IoT device, validating the integrity of the firmware file and then downloading the latest version of the firmware update. The main thesis objective is to mitigate the attacks targeting the firmware update process of embedded devices by guaranteeing the firmware is up-to-date and not altered in the IoT devices.

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Molecular Analysis of a Consanguineous Family with Palmoplantar Keratoderma

Abstract: Palmoplantar keratoderma (PPK) is a heterogeneous group of skin disorders where there is a persistent thickening of the palms of the hands and sometimes soles of the feet. PPK can be classified into many types, including diffuse, transgredient and focal or striate type where the areas of palmoplantar skin are alternatively thickened. Mutations in three main genes, Keratin 9 (KRT9), Keratin 1 (KRT1), Desmoglein (DSG1) and Desmoplakin (DSP), have shown to be associated with PPK. Striate PPK (SPPK) is commonly caused by mutations in DSG1. However, DSP and KRT1 gene mutations have been identified in some cases. In this study, fragment and sequencing analysis were performed for a large Syrian family with dominant SPPK.

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Segregation analysis showed a linkage with the DSG1 gene. Direct Sanger sequencing identified a new mutation c.dup165_168AGCA. This frameshift mutation was heterozygous in all affected family members and absent in all normal individuals. To the best of my knowledge, this is the first identified DSG1 mutation causing SPPK in the Arabian region.

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Assessment of Phosphorus Removal from Water Using Al/Fe Modified Nano-Clay

Abstract: Nanomaterials are suitable adsorbents due to their high surface areas and presence of active functional groups on their surfaces. Specifically, modified nano-clays may be useful as phosphorus adsorbents. In this study, bentonite clay samples were modified with Al or Fe poly-cations, ball-milled to produce nan-clays, then used to assess their capacity to remove phosphorus from water. The various bentonite adsorbents preparations were characterized for particle size distribution, zeta potential, metal contents, and crystalline structure by X-ray powder diffraction (XRD). The results demonstrated that modified bentonite samples of smaller particles size achieved higher phosphorus adsorption capacities. Also, Fe-modified bentonite (Fe-Bnt) achieved relatively higher phosphorus adsorption capacities than Al-modified bentonite (Al-Bnt). The raw bentonite (Bnt) samples without Al or Fe modification achieved insignificant phosphorus adsorption capacities. The achieved maximum adsorption capacities at pH 5 were in the following order: Fe-Bnt (12.53 mg/g) > Al-Bnt (11.06 mg/g) > Bnt (1.62 mg/g). Similarly, the maximum adsorption capacities at pH 7 were in the following order: Fe-Bnt (10.78 mg/g) > Al-Bnt (9.42 mg/g) > Bnt (1.28 mg/g). The adsorption results were best fitted using Langmuir model compared with the Freundlich model, with the Langmuir coefficient of determination (R^2) value ranging from 0.98 to 0.99. In terms of adsorption kinetics, the pseudo-second order model better fitted the experimental data compared to Pseudo-first order with R^2 ranging from 0.90 to 1.00. Approximately 85 – 95 % of phosphorus removal occurred during the first two hours of adsorption. At pH 5, the order of adsorbents based on their initial phosphorus adsorption rate was as follows: Al-Bnt > Fe-Bnt > Bnt with initial adsorption rates in the range of 0.642 to 0.009 mg/g.min. At pH 7, the order was as follows: Al-Bnt > Fe-Bnt > Bnt with rates in the range of 0.244 to 0.008 mg/g.min.

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Post-Deployment Coverage Hole Detection and Repair in Wireless Sensor Networks

Abstract: The most fundamental job of the wireless sensor network is to monitor a specified region of interest. Regardless of original deployment method, the emergence of coverage holes – that is, the rise of unmonitored areas in the region of interest – is completely unavoidable due to the nature of the surrounding environment. Sensor nodes may fail due to energy depletion, physical damage, or external attacks. As such, it is important to have an ongoing mechanism for coverage maintenance because coverage holes can have debilitating effects on network performance if left unattended. Such a mechanism is useful in the absence of readily available replacement nodes. It is an optimization effort given the currently available resources. In this thesis, we aim to address two key issues: hole detection and hole area recovery. Our work aims to detect and recover from coverage holes that appear when nodes start to fail post-deployment, after the network has been working for some time. We present a novel distributed self-healing algorithm called Dynamic Hole Detection and Repair (DHDR), that handles hole detection and recovery using only nodes already deployed in the network. First, our algorithm can dynamically detect a coverage hole as it occurs, and accurately estimate its position and size. The appearance of a new coverage hole is discovered when a node failure is detected. Hole estimation is then done by calculating intersection points of sensing radii among neighbors of the failed node and sharing this information amongst themselves so that each node has a comprehensive view of the hole area. Second, the algorithm selects suitable nodes from the vicinity which will maximize coverage by moving to strategic locations, and simultaneously minimize energy consumption by sharing key information and coordinating their movements. The selected nodes relocate in a way that restores the void area of a coverage hole without disrupting their existing coverage. Each node independently makes the decision whether to join in the hole-healing process based on local information. Similarly, the distance and direction of movement for each node is calculated independently. The information is then shared among the nodes, and any conflict can be resolved by an eligibility ranking system before the final movements are made. The performance of the proposed approach is evaluated through simulation experiments. It is compared against two state-of-the-art algorithms and has been shown to outperform both in terms of improved coverage, more stable connectivity, and lower energy consumption.
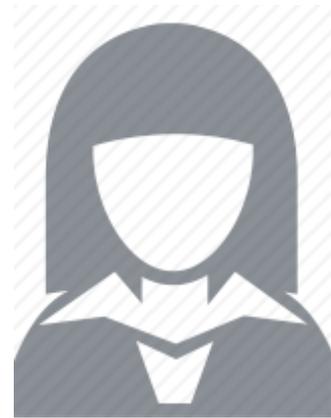
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Field Programmable Analog Arrays for Biomedical Applications

Abstract: The healthcare sector has witnessed considerable improvements in recent years due to emerging technologies in the biomedical field. The continuous enhancements of biomedical systems steer the design towards compact, portable devices with low power consumption. This thesis proposes a novel field programmable analog array (FPAA) for biomedical application, that provides a single reconfigurable platform for the implementation of various biomedical circuits. Two FPAA structures are proposed, the first FPAA can implement two LPF with embedded variable gain amplifier (VGA), providing an option of cascading. The second FPAA is an extension of the first providing an extra section for the implementation of notch filters based on even-order elliptic response and the VGA at the input stage, allowing the realization of analog front-end (AFE) for detection of biopotential signals. The presented novel structure of the FPAA is specifically designed to implement various biopotential circuits, using the operational transconductance amplifier (OTA) as a building block of different configurable analog blocks (CABs). The thesis also presents a direct generation method for odd/even nth-order elliptic OTA-C low pass filters (LPF) based on algebraic decomposition method. The proposed filters have fully balanced symmetrical OTA-C structure using differential input balanced output operational transconductor amplifiers (OTAs), and grounded capacitors providing circuit realization using minimum number of components for a balanced structure. The filter generation method is used to design different filters with variable gain and variable bandwidth for application in AFE achieving very low power consumption of 2.65-4.5 nW. Fourth-order elliptic LPF is proposed based on the synthesis method with notch frequency at 50 Hz to attenuate power-line interference signal with attenuation of 51 dB. The filter is designed for low-power portable detection systems of EEG, ECG, and EMG signals. The improved response provides variable gain, notch frequency, and bandwidth. The proposed filters are used to design the AFE, where both individual filters and the AFE were implemented on the proposed FPAA architecture. The proposed filters and FPAA are designed and simulated in LTspice using 90 nm CMOS model BSIM4 (level 54) technology under ± 0.6V voltage supply.

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Comparison of DNA and Life History Traits between Local and Mediterranean Lines of Brachypodium Species

Abstract: Brachypodium species complex is a model plant from the family of all kinds of cereals, Poaceae. It consists of three species; B. distachyon (2n=10), B. stacei (2n=20), and B. hybridum (2n=30), which have previously been considered as three cytotypes with different autopolyploid levels of one species and classified under the same botanical name; B. distachyon. But later it was found that they should be considered as three separated species. Brachypodium was reported in mountains of the United Arab Emirates (UAE) and defined as B. distachyon. In this study, two different molecular approaches were performed to compare the Brachypodium accession presented in the

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UAE with six lines of the three complex species growing in the Mediterranean region in order to identify the local accession related taxon. DNA barcoding approach using four barcodes;.Internal Transcribed Spacer (ITS) region, trnL (UAA) intron – trnL(UAA) exon – trnL(UAA)/trnF(GAA) spacer (trnL-F) region, Ribulose Bisphosphate Carboxylase Large (rbcL) gene and maturase K (matK) gene. In addiotion, microsatellite analysis approach using four markers; ALB165, ALB311, BdSSR330 and R2-3-ABI. Both approaches suggested that the local accession is most likely related to B. hybridum taxon. Moreover, several seedlings morphological traits were compared between local and Mediterranean accessions under cooler conditions of upper latitudes. The results indicate the ability of the local accession to grow well under the cooler environment. In addition, the results concluded the difficulty of depending on morphological traits solely for species discrimination. Germination response to different environmental factors was evaluated for the local accession and compared with that of other Mediterranean accessions from the available literatures. The final germination percentage of the local sample was significantly greater at 15/25°C and 20/30°C than at 25/35°C and in light rather than in darkness. Seeds that matured at 15/25°C attained greater germination rates and faster germination than those that matured at 20/30°C. One-year of storage enhanced the final germination percentage and reduced photoperiod requirements. Finally, the local seeds tolerated drought of up to –0.8 MPa polyethylene glycol. Understanding factors responsible for seed dormancy in the genetic model Brachypodium accession will help in overcoming dormancy problems in economically important cereal crops. To the best of my knowledge this is the first work that investigated the taxon of Brachypodium in the UAE by molecular studies, as well as studied germination response of B. hybridum to different environmental factors.

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Experimental Study on the Shear Strength of Reinforced Concrete (RC) Beams Strengthened with Externally U-Bonded Carbon Fiber Reinforced Polymers (EB-FRP)

Abstract: The capacity of reinforced concrete (RC) beams deficient in terms of shear support can be enhanced using externally bonded fiber-reinforced polymer (EB-FRP) sheets. Although several studies have been conducted on the shear strengthening of beams using EB-FRP, the behavior of such beams is still not fully understood. For instance, large scattering exists between the existing experiment data and the existing predictive models, such as the ACI 440 model. The focus of this research project was to investigate the interaction between various parameters, such as the steel stirrups and FRP strips applied, and their effects on the beam response to a static load. Two sets of full-scale RC T-beams were tested. Set 1 is no-stirrups beams, consisting of six specimens without shear stirrups to obtain the contribution of concrete with FRP. Set 2 consists of five transverse reinforced beams with steel stirrups at a spacing of d/2. All specimens were strengthened using EB-FRP discrete strips in a U-jacketing configuration, with one and two layers of EB-FRP bonded in two different locations relative to the transverse shear reinforcement

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locations (i.e., between two stirrups, and on the steel stirrups). The beam specimens were properly instrumented and tested in a simply supported configuration using a hydraulic actuator. This research aimed at studying the shear strength contribution of steel stirrups and the EB-FRP at different steel and FRP ratios. The experimental results were used to assess the prediction accuracy of the existing models, with particular focus on the ACI 440 and fib models. It was discovered that the addition of an extra layer of FRP has no structural benefit when the failure of the FRP components is specifically from debonding. Beams enforced with single-layer strips seem to have the same behavior and resistance as beams with two-layer FRP strips. In addition, it is clear that, in beams in which the FRP strips were placed between the stirrups, each stirrup and FRP strip contributed to the shear resistance, and all had either yielded or debonded. As a result, these beams showed the highest ultimate load-carrying capacity. The results from this test indicate that the beams were compositely reinforced with both steel stirrups and FRP strips, and exhibited the yielding and debonding of all stirrups and strips, respectively, thereby indicating that the contributions of both were at maximum. In addition, in beams where FRP strips were placed on top of the steel stirrups, it was observed that the FRP strips had in fact carried the shear load instead of the steel stirrups until the beam yielded, which occurred even before the steel stirrups yield. The values of the theoretical results of both the ACI and fib codes are less than that of the experiment results, which confirms the fact that these code-based equations require modification to adjust the resulting load capacity. It should be noted that the additive property assumed over the values of Vs and Vf is incorrect, which is due to the nonlinear relationship between the steel and FRP contribution. Moreover, the code should address more parameters in the equation, such as the locations of the FRP strip application with respect to the location of the stirrups, because such variation has been proven critical to the results of the load-carrying capacity.

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