

**MIDDLE EAST TECHNICAL UNIVERSITY
DEPARTMENT OF ELECTRICAL AND
ELECTRONICS ENGINEERING**

2015 Graduate Research Workshop

GRW 2015

5,6,13 March 2015



Graduate Research Workshop (GRW 2015)
5,6,13 March 2015

Department of Electrical and Electronics Engineering
Middle East Technical University
Ankara, Turkey

Proceedings
Edited by Özgür Ergül

Message From the Chairperson



Dear Students, Research Assistants and Professors,

The Second Graduate Research Workshop of the Department of Electrical and Electronics Engineering (*GRW-2015*) was organized in March 2015. Posters presenting the research outcomes of our graduate students (MS and PhD) were displayed in the Department on March 5 and 6. Then, six of those posters were selected for oral presentations (scheduled on March 13) for further evaluation.

The purpose of this workshop has been twofold: First of all, our graduate students had a chance to present their thesis research in an academic platform to get feedback not only for the technical content of their presentations but also for their written and oral communication skills.

Second, we all might get a chance to establish new and fruitful collaborations between different research groups by sharing our research interests within the department.

Research papers presented in poster and oral presentation sessions of this event revealed the breadth and depth of the graduate-level research studies conducted in our department. We have been all proud to witness many successful presentations of international conference quality. We also had a chance to introduce our graduate research activities to our undergraduate students as the posters were displayed in Building A where most of the undergraduate courses are taught. It was so encouraging to see the interest of our undergraduates in posters.

My special thanks go to Assoc. Prof. Dr. Özgür Ergül, Prof. Dr. Özlem Aydın Çivi, and IEEE Student Branch of METU for all their efforts to make this flawless organization possible, and to the referees who made time to evaluate our students' research. Thanks also go to all attending students and their advisors, who shared their successful research findings with us. Finally, I sincerely congratulate our finalists, Çağrı Çetintepe, Gökhan Gültekin, Orçun Kiriş, Yağmur Demircan, Hasan Uluşan, Eren Aydın, and Can Önel.

I am looking forward to future *Graduate Research Workshop* organizations as this event turns into a well-established departmental tradition to keep stimulating our graduate research studies.

Best Regards,

Prof. Dr. Gönül Turhan-Sayan
Department Chair

Message From the GRW-2015 Committee



Dear METU EEE Members,

We are delighted to organize the 2nd Graduate Research Workshop of our department. The aim of this workshop was to share novel research studies conducted in our department and to give graduate students an opportunity to develop their written and oral presentation skills. This year, we received a total of 42 abstracts. 32 of them were presented as posters during 5 and 6 March, and these abstracts are included in this GRW Proceedings. The poster presentations attracted a lot of attention from undergraduate and graduate students, as well as from faculty. Based on the evaluators' feedbacks, six finalists were selected for oral presentations. Following the oral presentations on 13 March, three of them were

awarded. Even though we were restricted to give awards only to a few top presentations, evaluators' feedbacks clearly indicated that most of the presentations were indeed of very high quality.

We thank IEEE METU Student Branch for their contributions in the organization of GRW 2015. We would like to thank all participants for their contributions to GRW 2015, which made it a high-quality workshop. We are grateful to all evaluators for their time and efforts in reviewing presentations and providing very valuable feedback to our graduate students.

Kind Regards,

Özlem Aydın Çivi and Özgür Ergül
GRW 2015 Organization Committee

MIDDLE EAST TECHNICAL UNIVERSITY
DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING
2015 EEE Graduate Research Workshop
GRW 2015

GRWPW 2015 Committee

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Özlem Aydın Çivi
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Ali Özgür Yılmaz
Melek Diker Yücel
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Aydın Alatan
Lale Alatan
Cüneyt Bazlamaççı
Cengiz Beşikçi
Çağatay Candan
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Umut Onguner
Sevinç Figen Öktem
Afşar Saranlı
Ece Güran Schmidt
Yalçın Tanık

Presentation Evaluators

Gözde Bozdağı Akar
Tolga Çiloğlu
Yeşim Serinağaoğlu Doğrusöz
Serdar Kocaman
Selçuk Yerci
Ali Özgür Yılmaz

GRW-2015 Awardees

GRW-2015 Best Presentations

1. Çağrı Çetintepe
2. Gökhan K. Gültekin
3. Yağmur Demircan

GRW-2015 Best Poster Presentations

- Eren Aydın
- Çağrı Çetintepe
- Yağmur Demircan
- Gökhan K. Gültekin
- Orçun Kiriş
- Can Önel
- Hasan Uluşan

MIDDLE EAST TECHNICAL UNIVERSITY
DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING
2015 EEE Graduate Research Workshop
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18. Kadir Üstün

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19. Yunus Can Gültekin

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A 35 GHz Single-Pole-Double-Throw (SPDT) Structure on a Glass Substrate Using Packed Capacitive Contact RF MEMS Switches

Enis Kobal

SPDT switches are widely used in RF MEMS based phase shifters. Monolithic integration of the SPDT switches with phase shifting elements provides low losses especially at the mm-wave frequencies. This paper presents a novel 35 GHz SPDT switch structure with RF MEMS technology designed to reduce the sensitivity of the electrical performance to the fabrication tolerances and hence to increase process yield. The design aims to improve the losses by minimizing the number of air-bridges used at the discontinuities, an effort which also improves the yield of the fabrication process. According to the simulation results, the designed SPDT switch offers return and insertion losses of 27 dB and 1.25 dB, respectively, at 35 GHz, with a corresponding isolation about 60 dB.

RF MEMS stands as an enabling technology considering its low insertion loss and high isolation characteristics at microwave and millimeter-wave frequencies. RF MEMS switches are the most important contribution of this technology, which enable us to design more complicated structures. An SPDT switch is one of these complicated structures. They can be used in switched-line phase shifters. This paper presents a novel 35 GHz SPDT switch.

Fig. 1 illustrates a schematic view of the SPDT switch. The switch employs a coplanar waveguide (CPW) structure as the transmission medium, and comprises a CPW T-junction followed by right-angled CPW bends. Series MIM capacitors isolate the output ports in terms of their DC bias. Two RF MEMS switches set the path of the signal among the two output ports. The SPDT switch is designed at 35 GHz on a 500 μm -thick glass substrate ($\epsilon_r=4.6$, $\tan\delta=0.015$ at 35 GHz).

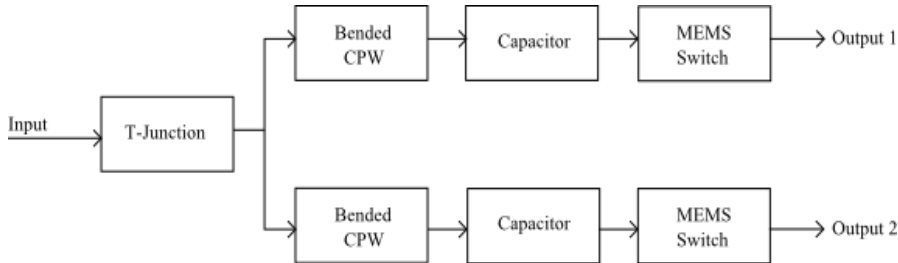


Fig 1: Illustration of the SPDT switch and its components.

MEMS switches that are used in the design have the same layout but they operate in opposite states in order to separate the outputs. This switch topology is also novel since it is the first packed switch produced at METU MEMS Research and Application Center with an indoor process.

CPW discontinuities might introduce a potential difference between the ground planes and cause undesired modes to propagate down the transmission line. In order to prevent such detrimental effects, one typically uses air-bridges at CPW discontinuities. These air-bridges, however, cause an increased return/insertion loss due to their parasitic capacitance. To mitigate the effect of air-bridges on the RF performance, the switch design uses a minimum number of air-bridges with proper impedance compensation.

This study is motivated with the requirement of a switching element for a 4-bit switched-line phase shifter application at 35 GHz. The proposed SPDT switch, as well as the mentioned phase shifter, will be fabricated at METU MEMS Research and Application Center.

Far-Field DOA Estimation and Near-Field Localization for Multipath Signals

Ahmet M. Elbir

Multipath distortion is the main source of error in many applications including direction finding (DF). While error sources like gain/phase mismatch, mutual coupling between antennas also have an impact on the DF accuracy, multipath results in gross errors. Multipath components of a far-field source are generated by reflection, diffraction and scattering in the region between the transmitter and receiving antenna array. Far-field multipath components are observed from the structures close to the transmitter. When the distance between the transmitter and DF array is large, the contribution of these components to DF error is limited. Hence gross errors are observed mostly due to the near-field multipath components. In Fig.1, a DF scenario is shown where the DF array receives far-field line-of-sight signal as well as the multipath reflected from the near vicinity of the antenna array. In this paper, a new method is proposed to estimate the direction-of-arrival (DOA) of the far-field source and to localize its near-field multipaths. The proposed method finds the 2D direction-of-arrival (DOA) angles for the far-field source and azimuth and range estimates for the near-field sources. Far-field source DOA estimate is found using calibration and the MUSIC algorithm. In a scenario where the DF array is placed in an arbitrary and irregular terrain, calibration is essential for parameter estimation where some of the unknowns are direction dependent.

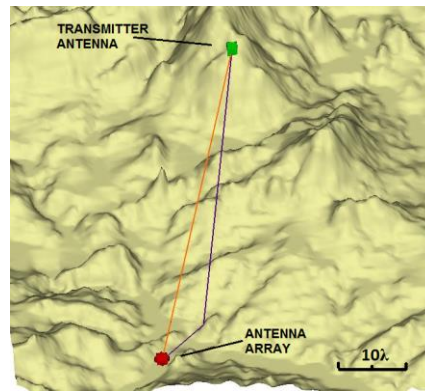


Figure 1. The placement of the DF array and transmitter antenna.

In order to estimate the near-field DOA angles, a near-field to far-field transformation (NFT) is proposed. We consider mixed signals involving both near- and far-field signals. Furthermore we consider virtual array concept in order to use circular array to obtain omnidirectional DF performance. Hence our NFT approach has two functions, namely, near-to-far and circular-to-linear array mapping. The NFT matrix is used to map uniform circular array (UCA) output to a virtual uniform linear array (ULA) in order to use forward-backward spatial smoothing (FBSS). It is shown that such a synthetic transformation matrix leads to sufficiently good results even for close-to-real world scenarios. The accuracy of the NFT matrix can be attributed to the use of exact near-field model as well as the model differences between near and far-field sources. In order to estimate the near-field range parameters, compressive sensing technique is used. A convex optimization problem for the near-field range parameter estimation is outlined. A dictionary matrix generated using the far- and near-field DOA angle estimates is used in this convex problem.

The proposed method is evaluated using two data sets. One set of data is generated in accordance with the array models where the method is based on. The other data set is obtained from Wireless Insite using a realistic scenario in an irregular terrain. It is shown that the proposed approach effectively estimates the far and near-field parameters in both ideal and close to practical cases.

Parametric Cramér-Rao Lower Bounds for Extended Target Tracking in a Random Matrix Framework

Elif Saritaş

The use of lower bounds on the achievable estimation error is a common methodology to evaluate estimator performance in estimation theory. The most well-known and important family of lower bounds is Cramér-Rao Lower Bound (CRLB) which gives a lower bound on the achievable mean-square-error (MSE) of an unbiased estimator. CRLB is the inverse of the Fisher Information which is a measure of information that a measured random variable carries about the parameter to be estimated. CRLB can be calculated for both deterministic and random parameter estimation. CRLB obtained for random parameter estimation is called as Bayesian CRLB (BCRLB). CRLB expressions are also available for state estimation in the literature. The deterministic and Bayesian CRLBs used for state estimation are called as parametric and posterior CRLBs respectively.

In conventional target tracking, targets are assumed to be points. Therefore, it is common to assume that each target generates at most a single measurement in a sensor report. On the other hand, with the recent improvements in sensor technology, this assumption is not valid any longer. For instance, the increase in radar resolution capabilities results in the fact that targets can generate more than one measurement in a single scan depending on their size, especially, in short-range applications. Therefore, with the increased sensor capability, in addition to target's kinematical state, the estimation of its extension (size) is also possible. This area of target tracking where the point target assumption does not hold is known as extended target tracking (ETT). There are different methods in literature that deals with ETT, such as spatial distributions, random matrix based methods and Monte Carlo methods. In this study, our concern will be on the random matrix based ETT algorithms. In a random matrix based ETT algorithm, the extents of the targets are assumed to be ellipsoidal and they are represented with positive definite matrices which are called as the extent states. The kinematic and extent states are estimated recursively in a Bayesian framework.

In this study, we calculate parametric CRLBs for ETT in a random matrix framework. We first obtain the analytical formulae for CRLBs for both kinematic and extent states and then compare the performance of the state-of-the-art random matrix based ETT algorithms to the calculated CRLBs. The results provide valuable insight for the performances of the recently proposed ETT algorithms and give an indication of how much size estimation capability can be expected from such methods.

Compensation of Angular Disturbances by a Reaction Wheel Based Approach During Planar One-Legged Locomotion

Neşet Ünver Akmandor

In the literature, spring-loaded inverted pendulum (SLIP) model with damping has been used to represent the dynamics of legged locomotion. A group of existing work focus on controlling the hip torque (between body and leg) in stance and in flight phases to generate stable locomotion. Most of these studies [1, 2] assume an infinite body inertia such that the applied torque does not affect the attitude of the robot body. In practice, applying time varying leg torque profiles will result in a net change in a body attitude (angle α) at the end of each stride. To compensate this angular disturbance, a compensating torque is required to be applied directly to the robot body. In this work, we discuss the feasibility of a reaction wheel based approach to this problem, since in the literature, these are commonly utilized in satellite attitude control [3, 4] as well as in some robotics examples [5, 6]. In this work, the reaction wheel is placed at the center-of-mass of the robot body (Figure 1-b). During locomotion, depending on the hybrid phase of the system (flight and stance), the dynamical equations of the planar SLIP model with reaction wheel is derived using Euler-Lagrange formulation. Furthermore, we present a physics based hybrid simulation of this model in which the leg (locomotion) controller is borrowed from [1]. We also present results of these simulations to demonstrate the feasibility of the reaction wheel to compensate for body attitude both in a feedforward (measuring and counter-acting the leg torque) as well as in a feedback (measuring and feeding back body angular state) mode of operation. The interesting scientific question for us is whether this kind of compensation is sustainable using a reaction wheel or some other related approach is necessary.

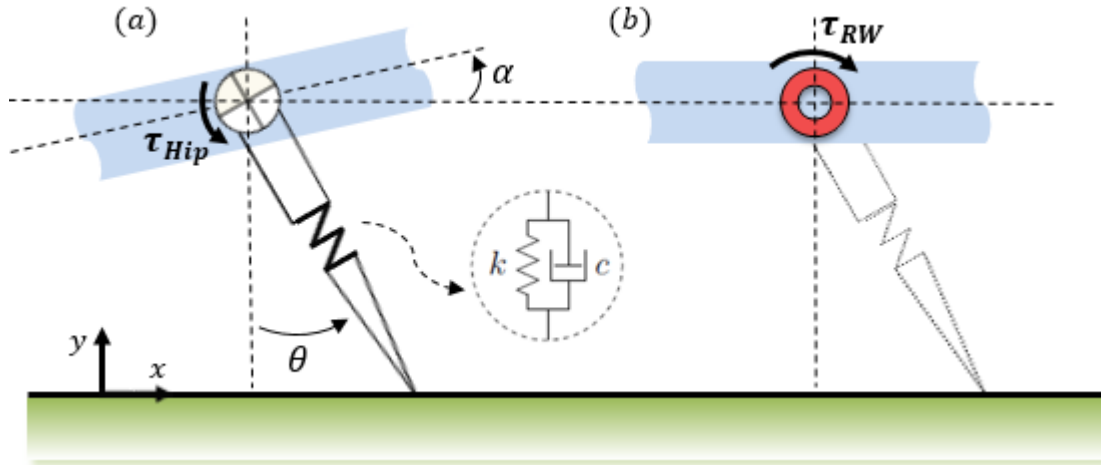


Figure 1: (a) Angular disturbance (α) due to the hip torque (τ_{hip}) and (b) the reaction wheel (red disc) based approach to stabilize the robot body using a compensation torque (τ_{RW})

Optimizations of Antennas Using Heuristic Algorithms Supported by the Multilevel Fast Multipole Algorithm

Can ÖNOL

Heuristic algorithms supported by a full-wave solver can be useful for various antenna optimization problems. Such a full-wave solver should rigorously model antennas by including their interactions very accurately, while it should also be very efficient in terms of solution time. Along this direction, the multilevel fast multipole algorithm (MLFMA) provides great advantages since it provides very fast and accurate matrix-vector multiplications that are required for iterative solutions. In this work, applications of heuristic algorithms supported by MLFMA to antenna problems involving optimizations of excitations and geometrical configurations are presented.

Optimizations of excitations of antennas for desired radiation characteristics, such as low side-lobe levels and maximum directive gain at a specific direction, are well known in the literature for array optimizations. One of the most popular ways for the optimization of antenna arrays is the array-factor approach. Although this approach provides fast and good approximations in many cases, it neglects or simplifies the mutual coupling between array elements. Thus, its accuracy may deteriorate significantly when the antennas in an array are strongly coupled. In this work, an optimization mechanism based on genetic algorithms (GAs) and the particle swarm optimization (PSO) method that are supported by full-wave simulations via MLFMA is presented. Antenna arrays are formulated with the electric-field integral equation (EFIE) in phasor domain and solved iteratively via MLFMA. Superposition principle is employed to reduce the total number of MLFMA solutions to the number of elements in the array without any simplification and assumptions such as periodicity and similarity of array elements. Complex radiated fields obtained with MLFMA-accelerated solutions are used by heuristic algorithms for optimizations of excitations to obtain desired radiation characteristics. The mutual couplings between array elements are accurately included in the optimizations. The mechanism is flexible and applicable to arrays of non-identical elements with arbitrary positions and to arrays with multi-band characteristics.

Another challenging antenna optimization problem is encountered when the optimization involves structural changes in the antenna geometry rather than excitation optimizations. When switches, connections, and the overall antenna surface are optimized for desired input and radiation characteristics of an antenna, each geometrical configuration corresponds to a new electromagnetic problem. Optimization space can be extremely large for such a design problem, and this makes heuristic algorithms more suitable options. Despite the advantage of heuristic algorithms, efficient optimizations can still be challenging due to overwhelming cost function evaluations corresponding to electromagnetic simulations. Instead of black-box interactions between optimization algorithms and the electromagnetic solver, these modules can be assembled for increasing the efficiency. In this work, we present antenna switch optimizations using a mechanism that consists of GAs and MLFMA. The state of switches (ON-OFF) is optimized with GAs for desired radiation and input characteristics of a given antenna, and the corresponding electromagnetic problems are solved efficiently and accurately by MLFMA. In the developed mechanism, data-structures that are common in different solutions, e.g., near-field interactions, are performed only once per optimization, to increase the efficiency significantly.

Comparison of Out-Of-Band Radiation for 5G Candidate Modulation Schemes at Equal Spectral Efficiency

Ali Bulut Üçüncü

Future communication systems will require much higher data rates in comparison to today's 3G and 4G systems under severe interference conditions. With regards to cognitive radio based communications, dynamic spectrum access will also be important for efficient utilization of the frequency spectrum. To achieve such goals, new modulation schemes such as Generalized Frequency Division Multiplexing (GFDM) and Windowed Cyclic Prefix based Circular Offset QAM (WCP-COQAM) were proposed for 5G as alternative to Orthogonal Frequency Division Multiplexing (OFDM), which is the core modulation type in 4G. These two modulation types are reported to have several advantages over OFDM. One advantage is that the two have smaller out-of-band (OOB) radiation compared to OFDM, which has high spectral leakage owing to its rectangular pulse shape. In addition, waveform flexibility for the two schemes enables pulse design taking into account channel parameters such as average or maximum delay spread or Doppler effects.

In this article, amongst these advantages of the aforementioned modulation techniques, OOB radiation reduction will be investigated. In literature, OOB radiation performance comparisons are made for different spectral efficiencies. However, it is considered that a fair comparison is possible only when OFDM has the same spectral efficiency as GFDM and WCP-COQAM. On the other hand, maintaining the same spectral efficiency for OFDM requires packing more subcarriers in the same bandwidth. This will result in higher CFO (Carrier Frequency Offset) vulnerability for OFDM. Therefore, CFO performances under AWGN (Additive White Gaussian Noise) channel will also be considered. As a result, it will be shown that these new modulation types have similar OOB performances compared to OFDM under the same spectral efficiency conditions. Furthermore, uncoded SER (Symbol Error Rate) results in AWGN have not presented a higher CFO immunity for the two modulations than OFDM. These findings indicate that there is no significant advantage of GFDM or WCP-COQAM modulations over OFDM, in terms of OOB radiation performances under fair comparison conditions.

Model Order Selection Using F-Test

Alper Yazar

The selection of a suitable model and its parameters is a fundamental problem arising in many signal processing applications such as pole-zero modeling of deterministic signals, inverse filtering, data analysis etc. The main problem of modeling is the selection of a simple enough mathematical expression explaining the phenomena of interest.

In this work, we focus on a sequence of nested models where the more sophisticated model (the model with a large number of parameters) encapsulates the less sophisticated ones as a special case and examine the appropriate model order. We consider the linear models with unknown parameters for this purpose. A typical example is the polynomial fitting to a set of measurements. The selection of the polynomial order can be considered as the model order selected with the nested models.

Different from the classical model order selection problem, we examine the suitability of a particular model for a given application. As an illustrative application, we may focus on the determination of zero-crossing point of the sampled data. Figure 1 presents an example for zero-crossing point estimation for a sampled sinusoid. In this figure, the noiseless and noisy samples (at SNR of 20 dB) are shown. The goal is to estimate the zero-crossing point indicated in the figure. Typically, the zero-crossing point is located by fitting a straight line to the two samples with different signs. This approach assumes that the signal is sampled “fast” enough that the line fit is sufficient to determine the zero-crossing point. In the presence of noise, the zero-crossing point is detected with some error due to errors in line parameters. A reasonable idea is to use more than 2 points in line-fitting by a least squares type method. By using more points, the zero-crossing estimation error is expected to decrease provided that the samples utilized for line-fitting are indeed on a line. As in Figure 1, using large number of points may bring an estimation bias, since the imposed line structure does not match the signal structure. The goal is to use “right” number of points to reduce the zero-crossing estimation error.

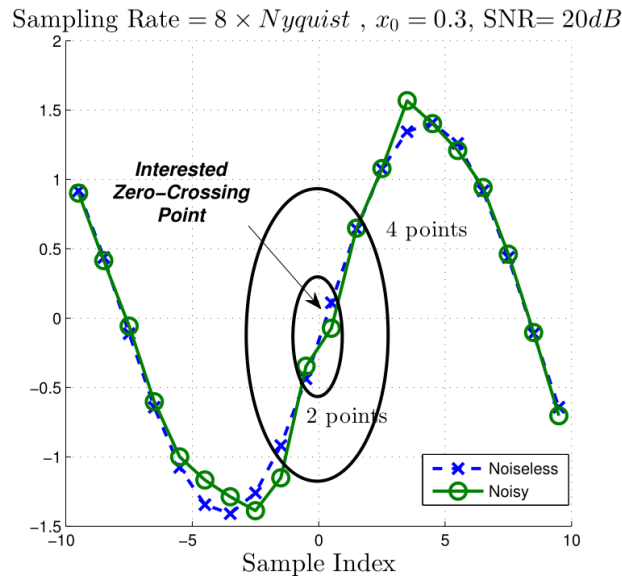


Figure 1. Noisy and Noiseless Sinusoidal Signal

In this study, we use a method known as F-Test method to check whether higher order model decreases RMSE in a significant way. In F-Test, two models are compared to each other. This comparison gives a number and that number is compared with a threshold value. Threshold is calculated based on criteria that how much RMSE difference between two models due to model order difference is acceptable. F-Test doesn't require actual expression of observed data and noise variance to determine threshold value. This is a benefit for cases where there is no a priori information about data and noise.

Label-free Detection of Leukemia Cells with a Lab-On-a-Chip System Integrating Dielectrophoresis and CMOS Imaging

Yağmur Demircan

This paper presents a fully-integrated LOC for label-free detection and real-time counting of dielectrophoretically trapped multidrug resistant (MDR) K562 cells. The system integrates a parylene-based microfluidic DEP channel on top of a CMOS image sensor. The DEP channel can trap MDR K562 cells with $9V_{pp}$ and $10\mu\text{l}/\text{min}$ flow rate, and the CMOS image sensor can detect the trapped cells as small as $3\mu\text{m}$ in diameter with a noise level of $28.3 e^-_{rms}$. DEP is a powerful tool for bioparticle manipulation that can be utilized in many POC devices. However, such systems require labeling/hemocytometer for quantification, limiting the portability and stand-alone operation. CMOS image sensors can be a potential alternative for cell capturing and quantification, but they require labor intensive surface modifications. Besides, their integration with microfluidics may require complex processes. Here, we propose a fully-integrated microfluidic DEP trapping chip utilizing a high performance CMOS imager for label-free and real-time detection of MDR leukemia cells. Figure 1a presents the proposed system, which integrates a DEP channel with a CMOS imager. Fabrication process of the DEP channel is fully compatible with the CMOS process. The feasibility of the proposed system has been verified by combining in-house fabricated DEP devices and CMOS imager chips fabricated through $0.35\mu\text{m}$ MPW run (Fig. 1b). Although this approach results in an obvious degradation of the system performance, it proves the feasibility and strength of the proposed idea. The DEP device has 27 3D-electrodes, with $40\mu\text{m}$ width and $15\mu\text{m}$ gaps in between, placed on the sidewalls of $300\mu\text{m} \times 30\mu\text{m}$ parylene microchannel, and 5 V-shaped parylene posts for hydrodynamic focusing of cells to DEP traps. The CMOS imager has 32×32 pixel array with the pixel dimension of $15\mu\text{m} \times 15\mu\text{m}$, allowing multiplexing rates up to 400kHz , which is rapid enough for many cell imaging applications. Trapping tests were performed at $10\mu\text{l}/\text{min}$ flow rate with $9V_{pp}$ at 48.64MHz (the crossover frequency of sensitive K562 cells). Cell concentration was adjusted as 10^6 cells/ml in suspension medium with a conductivity of $2.5\text{ mS}/\text{m}$. Cells were stained with fluorescein diacetate to observe them under fluorescence microscope for verification. Figure 1c shows the fluorescence microscope (i) and CMOS imager (ii) views of the trapped cells inside the channel. Throughout these tests, differential analyses were carried out. Gray-scaled pixels show the trapped cells as CMOS output. The glass substrate ($500\mu\text{m}$ thick) prevents accurate focusing and decreases the contrast, degrading the quality of CMOS images and reliability of the cell counting. This problem was overcome by peeling of the parylene-based DEP channel off the glass substrate. Figure 1d shows the fabricated flexible parylene DEP channel (i), having a thickness of $40\mu\text{m}$, and its CMOS image (ii). When the images obtained with and without glass substrate were compared, a significant increase in the quality of the images was observed. These results prove that CMOS image sensors can be fully integrated with parylene-based DEP devices, for label-free and stand-alone cell detection systems. Further studies with parylene microchannel fabricated on CMOS sensor in wafer level would significantly increase the system performance.

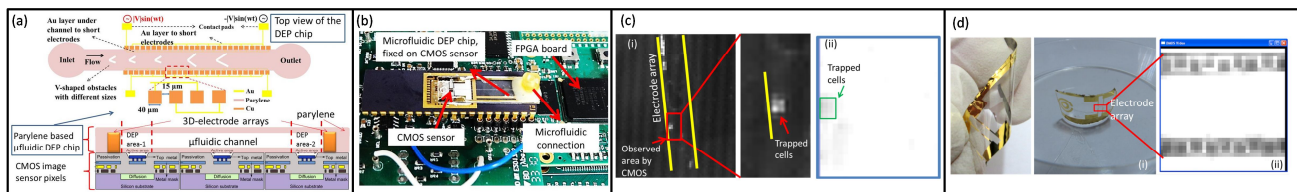


Figure 1: (a) Illustration of the proposed system, (b) integrated system under test, (c) Fluorescence microscope (i) and CMOS image sensor (ii) images of trapped MDR K562 cells inside DEP device, (d) Novel flexible parylene-based DEP devices (i) with their electrode array images, observed under CMOS image sensor (ii).

1x8 Unequal SIW Power Divider

Orçun Kiriş

A 1 x 8 substrate integrated waveguide (SIW) unequal power divider is designed, fabricated and measured at K-band to achieve -20 dB SLL Taylor distribution weights with uniform phase distribution. The schematic view of the power divider is shown in Fig 1. The power divider is designed at 25 GHz and fabricated on Rogers 3003 ($\epsilon_r = 3$, $\tan\delta = 0.0013$ @ 10 GHz) substrate with thickness of $h = 0.5$ mm. The structure has mirror-image symmetry with respect to the y-axis (red dashed-line). When the power divider is excited from Port 1, the input power is divided into eight at the output ports. The output fields have nearly the same phases and -20 dB SLL Taylor ($\tilde{n}=3$) amplitude distribution at 25 GHz. The sudden expansion of the SIW width encountered just after the input SIW part generates the higher-order modes. These modes excite the fundamental mode in the relatively narrow SIW structures which are placed at the output ports of the divider. These narrow SIW structures are designed with different lengths (like Rotman or R-KR Lenses) in order to reduce the phase differences at the output ports. The remaining small phase differences are almost eliminated by narrowing the walls using the parameters ph_1 and ph_2 . Also, the vias which are perpendicularly located at the entrance of these narrow SIW structures are utilized to adjust the desired amplitude distribution.

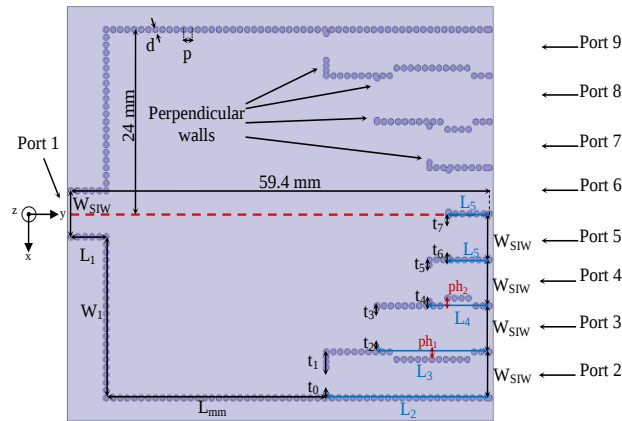


Figure 1. Designed 1 x 8 SIW power divider

Due to the limited space between the output ports, chip resistors are used in the odd numbered ports to measure the power divider. It is shown by measurement of the fabricated power divider that required amplitude taper and uniform phase distribution are obtained at 25 GHz. The performance of the power divider is also verified by the design and fabrication of 8 x 4 slotted SIW array monolithically integrated with the 1 x 8 power divider. SLL close to 20 dB is obtained. Measured and simulated radiation patterns agree each other very well.

Driver Aggressiveness Detection Using Visual Information from Forward Camera

Ömürcañ Kumtepe

Among the human related factors, aggressive driving behavior is one of the major causes of traffic accidents. On the other hand, detection and characterization of driver aggressiveness is a challenging task since there exist different psychological causes behind it. However, information about the driver behavior could be extracted from the data that is collected via different sensing devices. This work presents a method to detect driver aggressiveness using the visual information provided by forward camera. The proposed method is based on detection of the road lines and the vehicles on the road. Using this information three different features are extracted to describe the driving behavior. These features are determined as lane departure rate (LDR), speed of the vehicle and possible collision time (PCT). Lane departure rate is calculated according to position of the host vehicle on the current road lane. Speed estimation is performed by tracking the points on the road lines over the temporal dimension. Possible collision time is determined by choosing a target vehicle and calculating its distance to host vehicle. This distance over estimated speed provides the possible collision time information. Each of these features are extracted for 90 seconds long driving sessions. In order to represent the driving sessions with an efficient number of dimensions these features are represented by histograms. Then, a classifier is utilized in order to detect if driver shows an aggressive driving behavior. The proposed method is tested by a subjective testing method using 25 different driving sessions and achieved 91.3% success.

Body Surface Lead Reduction Algorithm and Its Use in Inverse Problem of Electrocardiography

Fouruogh Gharbalchi

Determining electrical activity of the heart in a non-invasive way is one of the main issues in electrocardiography (ECG). Although several cardiac abnormalities can be diagnosed by the standard 12-lead ECG, many others are not detectable by this fixed lead configuration. One alternative to compensate for the imperfection of standard 12-lead ECG in detecting many of the most informative signals is Body Surface Potential Mapping (BSPM), which measures ECG signals from a dense array of electrodes (32-256 electrodes) over the body surface.

However, besides having no standard lead-set configuration, this method suffers from the need for a large number of leads to perform with an acceptable accuracy. Therefore, despite having the potential to be used in clinical applications, BSPM has not been a practically accepted method.

This study aims to propose a specific lead-set configuration, whose acquired data is sufficient to be used in inverse problem of ECG to reconstruct epicardial potentials with high accuracy. Towards this end, in our study, a lead reduction algorithm is proposed and implemented. As a result of applying the lead reduction algorithm on 23 different data-sets related to 23 different stimulation sites on the surface of the heart, 23 exclusive lead-set configurations corresponding to these 23 data-sets are obtained. Then, by selecting the most repeated leads, two common lead-set configurations, one consisting 64 and the other consisting of 32 leads, are obtained.

To assess the performance of the proposed common lead-set configurations, inverse problem of ECG is solved using the data obtained by these lead-sets and the results are compared to those of exclusively optimal lead-sets, and the original complete lead-set. Mean and standard deviation values of Correlation Coefficient (CC) values obtained at each time instant between the true epicardial potentials and the inverse solutions are used to compare the results. By examining these mean and standard deviation of CC values, it has been observed that, instead of large number of leads, small number of leads optimally located on the surface of the torso would be sufficient to reconstruct the epicardial potentials accurately.

Additionally, inverse problem of ECG is solved using four different regularization algorithms, namely, Tikhonov Regularization, Truncated Total Least Squares (TTLS), Lanczos Truncated Total Least Squares (LTTLS), and Lanczos Least Squares QR (LLSQR), using data from the original complete lead-set, exclusively optimal and common lead-sets (32 and leads). Mean and standard deviation values of Correlation Coefficient (CC) for these inverse solutions are calculated and compared for three different data-sets. It is observed that LTTLS method reconstructs the epicardial potentials better than the TTLS and LLSQR methods.

A Novel Method for the Quantification of Coronary Artery Stenosis: A 2D QCA System

Muharrem Demiray

According to reports published by WHO, vascular diseases are leading cause of death and it is very widespread in both developing and developed countries. Therefore, diagnosis of coronary artery diseases plays an important role on health of the whole world.

Although there exist many different imaging modalities used for coronary artery imaging like CTA, DSA and MRI, the most commonly used imaging modality in clinics is XRA. Using XRA images, interventional cardiologists give a decision about the treatment planning by investigating anatomic characteristics of stenotic coronary artery. Most of the clinicians do not have QCA tools to quantify the degree of stenosis automatically and they have to inspect the stenosis visually depending on their experience. Since visual inspection of a stenosis depends on the experience of the clinicians, clinicians are not able to agree on the severity of the same stenosis. This phenomenon is called as subjective interpretation and causes wrong decisions about the treatment planning.

We propose a remedy to this phenomenon with a novel semi-automatic 2D QCA system which quantifies the stenosis severity by using the anatomical properties of the stenotic region. QCA system we have proposed is based on the deformable splines and their optimization using dynamic programming. Finally, we will compare the 2D lesion characteristics with the FFR which is a gold standard technique on the determination of functional severity of a stenosis. In this way, we will validate the proposed algorithm and investigate the correlation between 2D lesion characteristics and functional severity of a stenosis.

Towards the Multi-Frame Deblurring of Motion Blur Caused by Natural Motion of Legged Mobile Robots

Gökhan Koray Gültekin

Dexterous legged robots are highly mobile platforms that can move on variable terrain at high speeds. The locomotion of these legged platforms causes oscillations of the robot body which becomes more severe depending on the surface and locomotion speed. Camera sensors mounted on such platforms experience the same disturbances, hence resulting in motion blur. This is a corruption of the image and results in a loss of information. It is often a highly undesirable effect that severely degrades the performance of most computer vision algorithms.

The aim of this study is to deblur the motion blurred image frames captured by a moving camera. Different from other general purpose motion deblurring methods in the literature, this study focuses especially on the challenges posed by the moving robotic platform and attempts to adapt methods proposed for multi-frame deblurring [1] to our problem. We seek to relax some of the restrictive assumptions that are made by these studies to make it possible to apply for the mobile robot problem while we attempt to benefit from the presence of the natural cyclic motion of the robot.

The first part of this study presents an analysis of the video sequences captured from the camera on the robot platform together with the data from the gyro sensor that monitors the three axis rotational motion of the camera. The data shows a rich variety of motion blur content due to the changing body oscillations during walking, resulting in different PSFs at each frame. Different PSFs imply different zeros in the frequency domain, suggesting that the image content can be better recovered from a sequence of such frames.

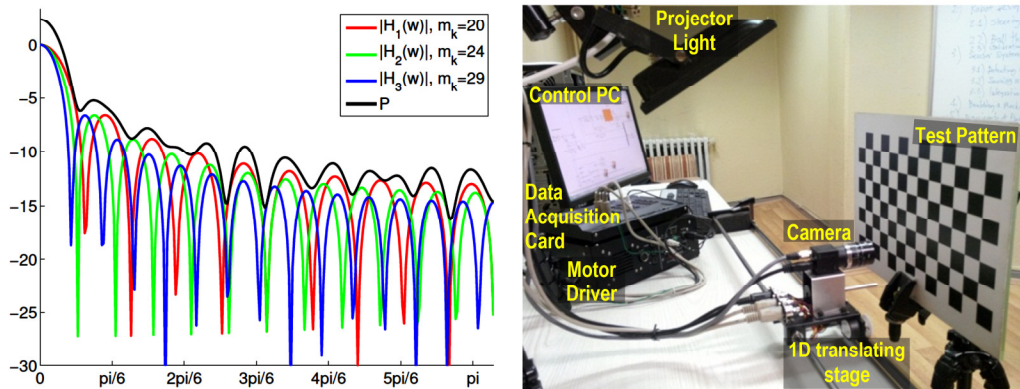


Figure 1. (Left) PSFs having different zeros in different frequencies ($|H_i(w)|$) and the combined jointly invertible operator P [1]. (Right) The speed controlled one dimensional translating stage with a Pointgrey Flea2 camera mounted on top that is used to generate controllable motion blur.

In the second part of the study, we consider a more controlled experimental setup where this idea from the literature is explored in detail. Figure 1 shows the speed controlled one dimensional translating stage with a Pointgrey Flea2 camera mounted on top. This stage is used to demonstrate controllable camera speed resulting in controllable motion blur (PSF). We attempt simple/ad-hoc methods of multi-frame reconstruction from known/controlled PSF multi-frame image data that is obtained through the speed controlled camera-motion setup. Then we try to make the method applicable for frames captured from the robot platform. We analyze a sequence of video frames to find a good set of successive image frames (jointly invertible PSFs) for multi-frame deblurring.

DESIGN AND IMPLEMENTATION OF AN ECG FRONT END CIRCUIT

Mohammadreza Robaei

Since the first electrocardiogram (ECG) was recorded by Eindhoven in 1903, examination of the electrical activity of the heart using surface electrodes obtained great clinical significance over the years. According to annual report of World Health Organization in 2013, cardiovascular diseases are counted as one of the four major reasons of 80% of deaths in the world. Therefore, the ability to acquire high quality recordings of electrical activity of the heart from surface of the body would be highly beneficial for the diagnosis of these diseases. For this purpose, invasive and noninvasive methods are used. Standard 12-lead ECG as one of the noninvasive methods is commonly used in the world at hospitals and clinics. In addition, more sophisticated methods are developed to measure the electrical activity of the heart from the surface of the body, using larger numbers of electrodes known as Body Surface Potential Measurement (BSPM). Invasive methods are also used in special cases to make in vivo measurements. In comparison to non-invasive methods, such as conventional 12-lead system and BSPM, invasive methods required surgical operation to implement the proper electrode network in the desired location. Standard 12-lead system is commonly used in clinical applications for diagnosing and monitoring because of its simplicity in use but it suffers from low spatial resolution of the acquired data. In contrast, BSPM as non-invasive technique, acquire data using large number of electrodes attached to the surface of the body. As a result, the acquired data has better spatial resolution than the 12-lead system. Data obtained from BSPM have significant importance in applications such as localization of the electrical sources in the heart.

In this study, we aim to build an analog front-end unit to detect the electrical activity of the heart using 10 electrodes connected to the surface of the body. These ten electrodes are recording measurements from the right arm (RA), left arm (LA), and left leg (LL) electrodes, six chest electrodes (V1~V6), and one RLD electrode. Unipolar measurements are used for chest channels (V1~V6). Also, lead I and lead II are constructed via bipolar measurements between (LA, RA) and (LL, RA) pairs, respectively.

The analog front-end proposed in this thesis is designed to be compatible with 24-bit Sigma Delta analog to digital converter (ADC), so we kept the channels as simple as possible to use the features recommended by the ADC. This unit can be used as the front-end of any ECG recording device; it can be the first stage for a 12-lead ECG system, as well as for a BSPM system. Depending on the application requirements, either bipolar or unipolar measurements can be recorded.

A Hybrid Energy Scavenging Structure Utilizing RF and Vibration Based Electromagnetic Harvesters

Hasan Uluşan

Energy harvesters use environmental energy sources such as solar, vibration and RF energy and convert them to electrical energy. The development of micro-scale energy harvesters together with decreasing power demand of the new generation integrated circuits, allow the use of these harvesters as energy source in microsystems as an alternative to batteries. However, environmental sources, by themselves are not always sufficient to generate enough power. This study presents a novel hybrid structure that combines the power generated by an Electromagnetic (EM) vibration-based and UHF band RF harvester. The hybrid structure uses only one power management circuit to step-up and to regulate the combined output.

Fig. 1 (a) presents the block diagram of the proposed hybrid structure where the utilized EM energy harvester is optimized to obtain best performance at $2 \times 2 \times 2 \text{ cm}^3$ of volume and for low frequency vibrations ($< 20 \text{ Hz}$). At the first stage of the system, the RF part generates positive DC output ($V_{\text{RECT}+}$) and the EM part generates negative DC output ($V_{\text{RECT}-}$) and at the 2nd stage, the generated voltages are serially added, stepped-up, and regulated. Both of the circuits use ground as the reference point and can generate continuous current from positive to negative. At the positive side, a threshold compensated 7-stage RF rectifier is utilized, while at negative side a self-powered AC/DC negative doubler circuit designed for low frequency operation at rectification. The harvested voltages from the EM and RF harvesters are at low levels; thus the rectified voltage is not high enough to be used as a power source. Therefore, the rectified dual rail output is fed to a DC/DC converter circuit, which steps-up the voltage and stabilize it at 3 V output voltage as of a typical battery. As the DC/DC converter an on-chip charge pump circuit which is suitable for low voltage application is used for step-up and the step-up ratio of the circuit is tuned with the help of the voltage regulator to set the output to 3 V. The proposed interface circuit designed and implemented at UMC 180 nm CMOS technology. Test results indicate that the hybrid operation enables generation of $9 \mu\text{W}$ at 3 V output for a wide range of input stimulations, which could not be attained with either harvesting mode by itself. Fig. 1 (b) presents the obtained test results while the EM harvester is excited by 10 to 11.5 Hz vibration frequency and 1 g peak-to-peak acceleration, and the input RF power is swept between -20 dBm and -5 dBm at 900 MHz. By combining the harvester outputs, the system generates regulated 3 V output for smaller harvester input power values when compared to the case where only one of the rectifiers (either EM or RF) are available in the system. Fig. 1 (c) presents the input and output voltage waveforms when the EM harvester is excited with 10 Hz and 1g vibration and RF harvester input is -5 dBm at 900 MHz.

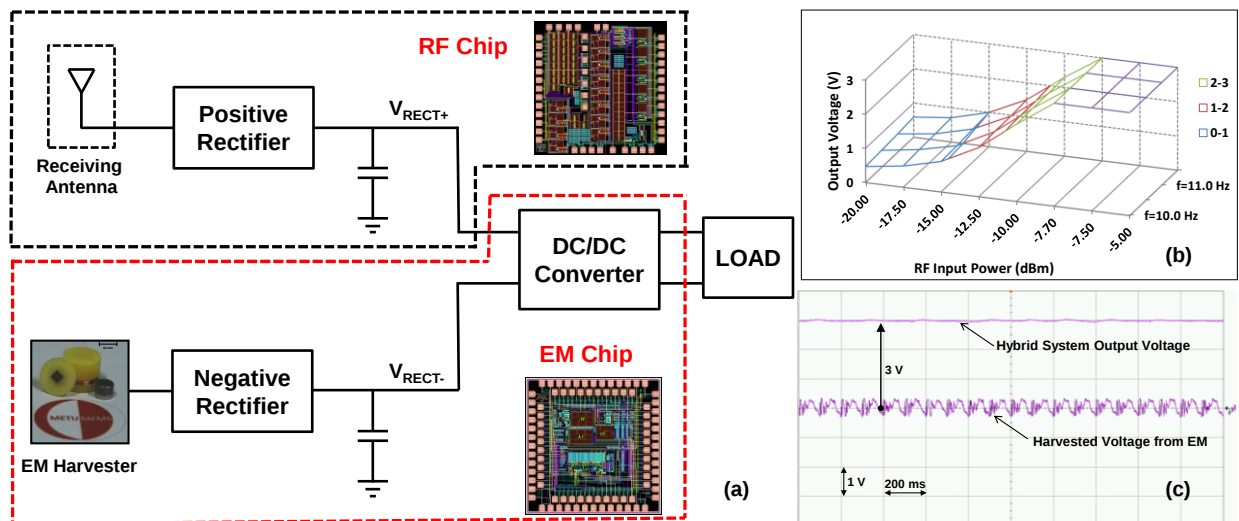


Fig. 1. (a) Proposed hybrid structure utilizing RF and vibration based EM harvesters (b) obtained test results of the system with $1 \text{ M}\Omega$ load resistance (c) input and output voltage waveforms of the hybrid system.

The Navigation and System Identification of an Unmanned Underwater Survey Vehicle, SAGA (Su Altı Gözlem Aracı)

Seda Karadeniz Kartal

In this study, the system identification and navigation of an unmanned underwater vehicle, SAGA (Su Altı Gözlem Aracı) designed by Desistek company are performed. A real pool test will be done in order to collect data for the system identification study of the vehicle. Firstly, a nonlinear parametric mathematical model is obtained. This mathematical model contains some unknown parameters such as added mass and drag coefficients. Then, the navigation problem is studied for SAGA. The integrated navigation system includes inertial measurement unit (IMU), acoustic sensors such as pinger, hydrophones and the others (i.e., depth sensor, magnetic compass and Pitot tube). The position of the vehicle is taken from IMU and the acoustic system. The attitude of the vehicle is taken from the magnetic compass and IMU. The velocity information is taken from IMU and Pitot tube. The hydrophones are located at known positions in the pool and pinger is on the vehicle. The vehicle moves around the pool, the distance between vehicle and hydrophones are determined according to transmission times (The overall system is time-synchronized). As a result, position information of the vehicle is obtained 5 to 10 times per second by this simultaneous localization technique. The IMU measures the acceleration and angular rate of the vehicle. The velocity information is obtained by integrating the measured acceleration data. The position information is obtained integrating the measured acceleration data twice. Also, the attitude information is generated by integrating the measured angular rates. The accuracy of position, velocity, and attitude information coming from the inertial navigation system is improved by fusing the information coming from the acoustic system, magnetic compass and Pitot tube. All the measurement data is noisy. The fusion is performed using the Extended Kalman Filter algorithm. Finally, system identification study where the particular target is the determination of added mass and drag parameters is performed for SAGA based on the filtered navigation data. During the system identification study, classical optimization algorithms in MATLAB (fminsearch algorithm) as well as evolutionary optimization techniques such as differential evolution, particle swarm optimization and genetic algorithms will be used.

Design and Implementation of a Communication System for Implantable Medical Devices

Yiğit Ürkmeztürk

The developments in the biomedical electronics field have increased the functionality of the implantable medical devices (IMD). Neuromodulation devices such as spinal cord stimulators (SCS), deep brain stimulators (DBS) and cardiac pacemakers are implantable medical devices that need communication functionality. The ability to communicate from inside the human body with other devices outside the body is critical for these devices, due to the need of therapy adjustment by the clinician. Radio frequency (RF) communication is the most widely used method for communicating with the implantable medical devices. Review of the scientific literature shows that frequency bands such as Medical Implant Communication Systems (MICS), which is located at 402-405 MHz and 2.4 GHz ISM band are preferred; the former due to being exclusive to the implantable medical device use, and the latter for low power consumption by the RF transceiver. Antenna design is another important aspect of the system; designing an electrically small multiband antenna to be used inside the human body is a challenging task. The implantable medical devices that are available on the market have communication systems that are very limited in range, bandwidth and reliability required for such as a system. In this study, a communication system that is suitable for implantable medical devices is proposed, which improves these properties. The theory for the RF far-field communication for the implantable medical devices is laid out for the purpose of determining the design criteria, such as link budget, transceiver selection, antenna requirements and the effects of the human body on the communication system. A system is planned using a transceiver and an antenna in the implantable medical device inside the human body, which are paired with another transceiver and antenna outside the body. Microsemi ZL70102 is selected as the transceiver. 3D full wave electromagnetic simulations using HFSS are used to design and investigate the impedance and far-field behavior of the designed antennas. The setup is to be tested with phantoms that are electrically similar to the human body at the used frequency bands, in order to evaluate system performance and the effects of the human body on the communication system. Results are analyzed according to the system criteria. The study indicates that communication from a device implanted into 1.5 cm depth is possible and 1 m range is achieved with a data rate of 200 Kbps and bit error rate (BER) of 10^{-6} .

Mechanically Tunable Metamaterials Operating Around 8 GHz

Kadir Üstün

Metamaterials are periodic metallo-dielectric structures which are engineered to obtain extraordinary electromagnetic response [1]. These structures show several intriguing properties that gives hope for solutions of real world problems. One of these properties is the negative refractive index, attained by double negative metamaterials, namely that exhibits both negative permittivity and negative permeability. Another property of on-purpose metamaterial designs are high permeability which is not observed in nature in the microwave frequency (and higher) part of the spectrum. These properties can serve for constructing cloak structures that provides invisibility and superlensing in the operating frequency region.

In this paper, we focus on a different application of metamaterials. Metamaterial devices rely on charge resonance between ends of the metallic pattern. Hence metamaterial behavior is very limited in bandwidth resembling optical cavities. Additionally, these high-Q resonances are hypersensitive to the small structural changes in both metal and dielectric portions. These aspects of metamaterials can bring us high performance sensors [2]. These changes can be in various physical forms such as structural changes, temperature, or material content of the design. Accordingly, metamaterials can be used for sensing displacement, temperature or material (such as gas or protein). These aspects can be used in reverse order, we can tune the metamaterial resonance with intentional changes in the environment, which is the motivation of our current studies.

Our study is development of a metamaterial structure initiated by Ekmekci and Turhan-Sayan in 2011 [3], which is called 'V' shaped resonator. We increase the length of the arms of the 'V' shape and increase the thickness of the dielectric to facilitate tuning. We also include a tuner metal bar in the middle of the dielectric layer, where the aimed tuning is dependent on location of the bar. The transmission data of the metamaterial is given in Fig.1, where incident electric field is oriented in the direction of the gap between two arms. In this configuration we obtain a tunability of 0.5 GHz around 8.05 GHz with a maximum change of 1.2 mm in the position of the metal bar.

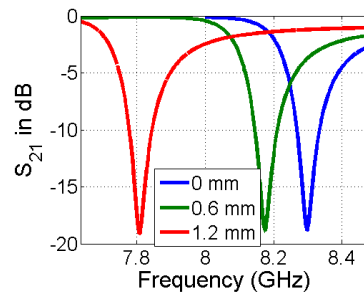


Fig. 1. The change in the S parameter with respect to the change of the position of the tuner metal.

In this paper, we show that a positional change in a small aspect of the metamaterial can highly shift its operation frequency. This change can be sensed by various antenna structures and can give birth to a displacement sensor operating in microwave frequencies. This structure can be also used as a tunable metamaterial as the property of adaptation of the resonance frequency is enabled.

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A Distributed, Time-Slotted Paging and Connection Scheduling Algorithm for Wireless Ad-Hoc Networks

Yunus Can Gültekin

Future wireless networks are expected to support variety of applications, very high data rates, and very low end-to-end delays. Due to this heavy traffic and strict higher layer constraints, in future cellular networks, device-to-device communication (D2D) strategies will be essential. D2D communication is basically the direct data transmission between peers without any help from a superior network control node (i.e. Base station, BS). In such a scheme; peer discovery, connection establishment, and connection scheduling problems should be solved by nodes (i.e. User equipment, UE) themselves in a distributed/decentralized manner.

To overcome those issues; a distributed, time-slotted, and hybrid paging and connection scheduling algorithm for wireless ad hoc networks is studied in conjunction with a peer discovery method. We propose an averaged signal-to-interference-plus-noise ratio (SINR) based scheduling scheme with multi-stage control signalling where not only the user identity information but also the average SINR and time slot information are sent for the purpose of link scheduling. By adding the extra flexibility of selecting the time slot where the data transmission will occur, the network exploits spatial re-use for every time slot separately. Scheduling decisions depend on the SINR information broadcast by receivers and received power levels which are averaged in the peer discovery phase of the control signalling. Peer discovery phase is over a larger period than the paging and link scheduling phase. To increase the reliability of the received power information, peer discovery messages of UEs are scattered over the time-frequency grid purposefully. In a shorter time duration, 3-stage hybrid paging and link scheduling signalling is performed. Every stage includes transmitters' broadcast of page messages and receivers' transmission of scheduling answers which are called TX and RX page blocks. In a randomized fashion, every link gets a priority to ensure fairness. According to this priority assignment, transmitters and receivers run their scheduling algorithms and decide to transmit or not by considering the favour of higher priority links. The ultimate aim is to schedule maximum number of links constrained by a priority assignment and minimum level of received SINR to ensure network's optimum spectral use.

In simulations, data transmissions are implemented in a Rayleigh fading, COST-207 Hilly Terrain multipath channel with AWGN. QPSK and a rate 1/2 convolutional code are employed. 1 MHz of bandwidth at 50 MHz carrier frequency is utilized with an OFDM-A structure of 300 subcarriers. Every user has 10 subcarriers from which 6 of them are used for data transmission and the remaining are left empty. Every 2 of 6 data carrying subcarriers are filled with pilots. Each RF hop is of duration 500 μ s and includes cyclic prefix of length 180 μ s. Path loss values between each node are calculated by SPLAT! software. To construct the network, 930 users are deployed randomly and uniformly in a 30 km X 30 km area. 30 dB of SNR between peers are required for paging, and scheduled links are planned to have at least 15 dB of SINR. Planning is done for 16 time-slot data transmission phase. Each time slot is of duration 3 ms and includes 6 RF hops with independent fading due to frequency hopping.

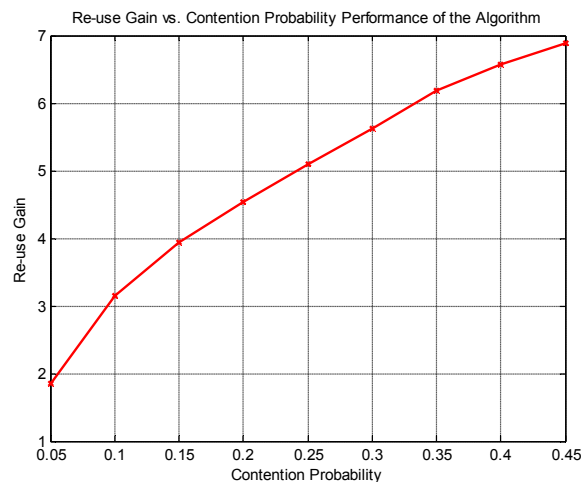


Figure 1. Re-use Gain vs. Contention Probability Performance of the Algorithm

Implantable Antenna Design for Implantable Neurostimulators

Damla Alptekin

Implantable neurostimulators deliver electrical signals to modulate neural signals at different parts of the human body (spinal cord, human brain, heart, etc.). To control the stimulation parameters and device status a wireless communication system must be established between the implanted device and the external control system. An important part of this communication system is the antenna inside the neurostimulator. It is crucial to design an antenna that is electrically small, energy efficient and that has a good radiation efficiency. In addition, due to power consumption considerations, a low power transceiver must be used. Since transceivers use 2.45 GHz ISM Band (Industrial, Scientific and Medical Radio Band) wake-up receiver option and MICS band (Medical Implant Communication Service; 402-405 MHz) for transmit and receive options, a dual-band antenna must be designed. In this thesis study, microstrip antennas are preferred to meet the design specifications. Microstrip designs were chosen because of their huge flexibility in design, conformability, and shape. To fit in a volume of 40x10x10 mm³, it is aimed to apply miniaturization techniques like introducing shorting pin and inserting superstrate layer. At least -30 dBi gain, which is directed outside of the body, is required in the MICS band to establish a link between the implanted antenna and the external control device. Numerical simulation studies are conducted using the commercial HFSS (High Frequency Structural Simulator) software with the antenna placed at different depths inside a dispersive skin tissue model. The electrical properties of skin are taken as $\epsilon_r = 46.741, \sigma = 0.68892 \text{ S/m}$ for 402 MHz and $\epsilon_r = 38.063, \sigma = 1.4407 \text{ S/m}$ for 2.4 GHz. Multi-layer tissue model (skin, fat, muscle, etc.) and realistic body models will be developed to assess the performance of the designed antenna. Based on the simulation studies, the antenna will be realized and experimental studies will be conducted to test the communication performance when the antenna is placed inside tissue mimicking phantoms.

On The Optimality and Design of Maisel Sidelobe Blanking System

Osman COŞKUN

Sidelobe blanking (SLB) systems are used to mitigate the adverse effects of signals intercepted from radar sidelobes. In the classical SLB system proposed by Maisel in 1968, two receiving channels are used. The first one is the main channel whose antenna has high gain in main beam and low gain in the sidelobes. The second channel is called the auxiliary channel which has an omnidirectional pattern and has flat gain slightly greater than the sidelobe gain of the main antenna. The ratio of squared magnitudes of auxiliary to main channel outputs is used whether to blank the main channel or not. This structure is not optimal in the sense of Neyman-Pearson type detectors, but it has many applications in practical systems due to its effective implementation in real time.

In this work, we study the optimum Neyman-Pearson type sidelobe blanking detectors for Swerling-0, Swerling-1 and Swerling-3 target models. The statistics for the optimum SLB detector for Swerling-1 targets are derived analytically. For other Swerling target models, the performance analyses are obtained with the aid of Monte Carlo simulations. For all three cases, the optimal detectors require the knowledge of SNR and JNR values which is typically not known at the radar site; hence the optimal detector is not realizable, in general. The optimal detectors are not implementable in practice; but provide a performance upper bound that can be useful in comparisons. The goal of the study is two folds, to examine the performance gap between the optimal detector and Maisel structure in spite of the non-availability of the additional information for the optimal detector and present a guideline to the designers of Maisel structure to achieve an almost optimal performance.

Wing in Ground Effect Vehicles: Minimum Energy Expenditure and Obstacle Avoidance

Raha Shabani

Wing-in-Ground-Effect Vehicles (WIG's) are actually very similar to aircrafts, but they are supposed to stay in close proximity to the sea level to utilize the "ground" effect. Fundamentally, ground effect is a nonlinear phenomenon which occurs when air is squeezed between the ground (sea) and the aircraft. It is important to mention that the ground effect makes aircraft payload to increase to 3- 4 times that of a similar aircraft not utilizing it. Among the other advantages of sea vehicles utilizing the ground effect are that they do not need a landing area, the passengers are not in much danger if a machine malfunction occurs. They can be built in a variety of ways and have been used for both military and civil purposes.

The first step of this article is to obtain a mathematical model of aircrafts involving the ground effect. The second step is to design a minimum energy optimal controller which will also be responsible for the guidance and obstacle avoidance. Simulation studies will be done in order to investigate the performance of WIG's under different conditions and with different autopilots and getting the maximum efficiency in minimum energy expenditure.

Wing in Ground Effect Vehicles: Modelling and Optimal Controller Design for getting maximum efficiency in minimum path time and at minimum Cost

Abdul Ghafoor

Wing-in-Ground-Effect Vehicles (WIG's) are kind of partially sea nor and partially air vehicles, unique in behavior and much more efficient than normal air or sea vehicle. They are actually very similar to aircrafts but they are supposed to stay in close proximity to the earth surface to "utilize the "ground" effect. Basically, ground effect is a nonlinear phenomenon which occurs when air is squeezed between the ground (sea) and the aircraft. It is important to mention that the ground effect makes aircraft payload to increase to 3-4 times of a similar aircraft not utilizing it. Among the other advantages of sea vehicles utilizing the ground effect are that they do not need a landing area, the passengers are not in much danger if a machine malfunction occurs. They can be built in a variety of ways and have been used for both military and civil purposes.



Şekil 1 Current Korean SWH-500

The first purpose of this project is to obtain mathematical models of aircrafts involving the ground effect. Next is the phase of designing of a robust controller which will be responsible for getting maximum efficiency in minimum time and at minimum cost. Different techniques for the design of controller will be used like PID, LQR, sliding mode or Modern Control theory and compare the results. Simulations studies will be done to investigate the performance of WIG's under different conditions and with different autopilots. If there is sufficient time and the financial conditions allow, a simple WIG type vehicle will be constructed and simulations will be verified by tests on the real physical system.

Studies on Traffic Behaviour and Traffic Signal Control Algorithms

Caner İpek

The improvements in the technology and economy, together with the rapid increase in the population causes that more and more vehicles are used in the roads. This results in more traffic congestion, long queues at the intersections, loss of time for the drivers, increase in the fuel consumption. This congestion problem can be solved by constructing wider roads and crossover roads but this solution takes lots of time and it is also very expensive.

The intersections which are the junction point of many lanes are the main cause of the urban traffic congestion. These intersection regions are controlled with traffic signals such that they make vehicles pass to other side of the road in a safety way. In general, timing schedule of these traffic signals are preset and they work according to this schedule all the time. Hence, by producing some intelligent solutions on these traffic signals, the congestion problem can be decreased or minimized.

In this study, it is aimed to arrange the timings of the traffic signals adaptively according to the current traffic situation. By doing so, the performance of an intersection will increase. Before developing adaptive traffic signal control algorithms, some observations are performed on the behaviour of traffic and traffic flow at an intersection. Without these observations, it is meaningless to develop adaptive traffic signal control algorithms. These studies are performed on a traffic simulator program called SUMO. Also, there is an interface of this simulator with MATLAB. With this interface, it is possible to get some desired data from the simulator or control the traffic signals in real time according to developed algorithms, which is very beneficial in this study.

Analysis and Elimination of Feedthrough Current in Resonator Based Gravimetric Cell Sensors and New Resonator Designs Considering the New Method

Eren Aydin

This paper presents a novel feedthrough cancellation method to be used in resonance-based gravimetric cell sensors, and design and simulation of gravimetric cell sensors based on the new method. The resonators are designed with a small proof mass which is compatible with mass of a single cancer cell to achieve enough sensitivity in liquid environment. Therefore feedthrough current becomes significant, as the output current is very small. The proposed method utilizes two resonators, one of which is passive, sharing common sense electrode while driven by out of phase signals. The analysis and experiments verify that peak voltage of drive signals and feedthrough capacitance multiplication matching and phase deviation from 180° is required for perfect elimination of feedthrough current. Moreover phase deviation from 180° is more important than amplitude matching to eliminate feedthrough current. In fact 15% deviation in phase matching of drive signals causes feedthrough current of almost three times that in the same signal magnitudes mismatching. The new resonators are designed considering these analyses.

The reason of feedthrough current is crosstalk between drive and sense electrodes. One of the main limiting factors in MEMS resonators [1]. This effect is much more crucial if the resonator is used to detect mass of single cell since it operates at relatively high frequencies and small. Therefore feedthrough current is needed to be eliminated. Differential drive method [2] is a useful method for elimination of feedthrough current but detailed analysis of differential drive is needed to understand effect of phase deviation and amplitude mismatch.

The proposed read-out electronic and feedthrough current elimination method reduces the feedthrough current gain at 220 KHz from -15 dB to -22dB, and enables close-loop operation for the detection of biological particles in liquid environment. To be able to drive resonator differentially, differential resonators are designed. The designed resonator has two separate drive and sense electrodes. Drive electrodes are driven with out of phase signals and this eliminates feedthrough current. Remaining feedthrough current is eliminated subtracting the currents at sense electrodes.

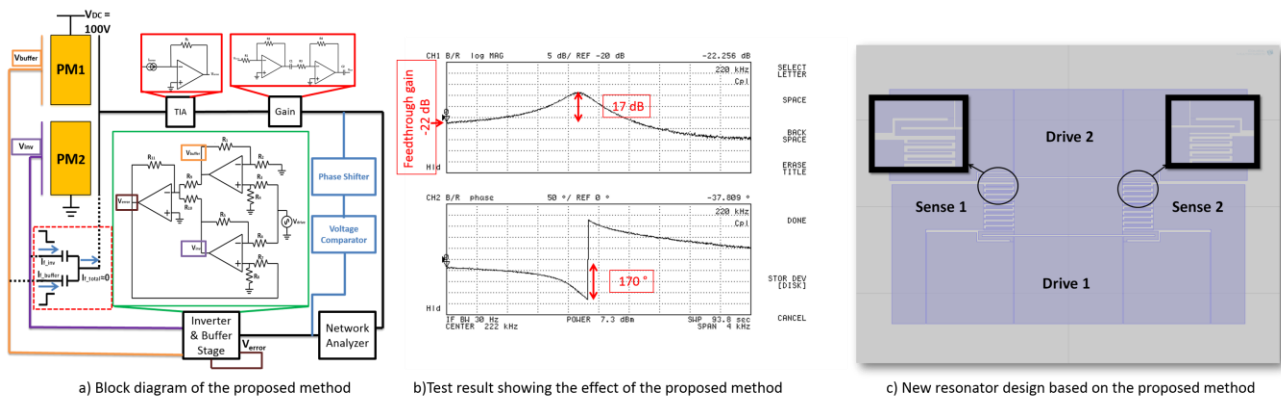


Figure 1. Illustration of the proposed system, test results and the new design

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- [2] J.E.Y. Lee, et al, *Sensors & Actuators A* 156, 2009

Realization of Harmonic Motion Microwave Doppler Imaging Method

Azadeh Kamali Tafreshi

Breast cancer is one of the most common types of cancer among women. Due to this fact, providing methods to assess the early-stage diagnosis and treatment of the breast cancer is of a great interest for researchers in the last decades. Mammography is being utilized as the primary imaging technique for breast cancer detection. However, this technique has been reported to suffer from missed detection, false alarms, employment of ionizing radiation, and patient discomfort. Microwave imaging, has been proposed as a safe and efficient tool for breast tumor detection. However, several studies show the limitation of microwave imaging in distinguishing the fibro-glandular and the malign tissues due to their similar dielectric properties. Some other techniques such as contrast agents or other imaging modalities can support this imaging method. Recently, the Harmonic Motion Microwave Doppler Imaging (HMMDI) method was proposed as a hybrid method to detect breast tumor. In this method, microwave signal is transmitted to the tissue meanwhile the tissue is vibrated locally using a focused ultrasound. The ultrasound transducer generates local harmonic motion inside the tissue. A microwave transceiver system is used for detecting the Doppler signal component of the ultrasonically vibrated region. The signal level at the Doppler frequency on the received microwave signal is a feature to distinguish the tumor. This feature depends on both elastic and electrical properties of the tissue.

In this thesis study, the performance of a data acquisition system for HMMDI method is evaluated on breast phantom materials. A breast fat phantom including fibro-glandular and tumor phantom regions is produced. The phantom is excited using focused ultrasound (FUS) probe and a microwave transmitter. The FUS transducer is used in the third harmonic frequency (3.32 MHz). A 2-cycle 10 Hz sinusoidal burst signal is generated from a waveform generator and used to amplitude modulate the 3.32 MHz signal generated by the second waveform generator. The AM signal is amplified with a high power RF amplifier (150A100B, Amplifier Research, WA, USA). The transmitting microwave antenna is fed by the Agilent E8257C Signal Generator with an output power of +15 dBm at 3.7 GHz frequency. The received microwave signal level is measured on three different points inside the phantom (fat, fibro-glandular, and tumor regions). The experimental results using the designed homodyne receiver proved the effectiveness of the proposed setup. In tumor phantom region, the signal level decreased about 3 dB compared to the signal level obtained from the fibro-glandular phantom area, whereas this signal was about 4 dB higher than the received signal from the fat phantom.

RADAR TRANSMITTER AND FAST TIME RECEIVER DESIGN UNDER RANGE SIDELobe MINIMIZATION CONSTRAINT IN PRESENCE OF CLUTTER

Seçil Özdemir

The conventional methods, such as the matched filter receiver, as the fast time processor in radar systems result in the targets with high radar cross section masking the low radar cross section targets at neighboring range cells; since sidelobes of matched filter is determined by autocorrelation of the spreading code and it is linearly proportional to the target signal power. An unbiased estimator, like the maximum likelihood receiver proposed in this study does not suffer from such issues. In addition to that, to suppress the signal dependent interference, namely the clutter, at the output of fast time processor, previous observations that do not contain any target are collected and utilized to predict (or estimate) the clutter signal for next time instant and this prediction can be used in the receiver; while for most of the radar systems, the clutter suppression part is implemented in the slow time processing. The approach followed can manage to have an unbiased estimation of the target range profile and the clutter suppression advantage in the fast time. In this study, the performance of the receiver using such approaches is developed and its performance is evaluated, and it is compared with the conventional methods. The proposed method is shown to outperform the conventional matched filter approach in terms of the target masking issue. Moreover, it is observed that, the receiver is able to suppress the clutter in the fast time, even in the presence of phase noise in the receiver. Afterwards, as a future work, the transmitter stage is to be optimized for the receiver developed.

Application of Image Enhancement Algorithms to Improve the Visibility and Classification of Microcalcification Clusters in Mammograms

Cansu AKBAY

Breast cancer is the second leading cause of cancer deaths for women. Mammography is the most effective technology presently available for breast cancer screening, despite the fact that there are still some limitations of the imaging technique, such as insufficient resolution, low local contrast and noise combined with the subtle nature of the usual radiographic findings. One of the most important radiographic findings associated to the existence of breast cancer is the clustered microcalcifications. Especially, it has been shown that some characteristics concerning the clustering parameters of microcalcifications are of great diagnostic value. However, the mentioned limitations of mammography make the detection and interpretation of microcalcifications a complicated task.

The main goal of this study is to develop a Computer Aided Diagnosis (CAD) software to make microcalcification clusters more identifiable on mammogram images and to generate features used to classify benign and suspicious cluster of microcalcifications. As a consequence, the efficiency of the mammographic screening process can be increased. The system may provide automated detection of microcalcification clusters leading a considerable decrease in misdiagnosis rates.

For this purpose, several image enhancement algorithms on both spatial domain (histogram modeling, morphological operators) and frequency domain (detail enhancement based on frequency, multiresolution analysis etc.) are implemented on region of interest (ROI) of real mammogram images which include microcalcification clusters. To evaluate the performance of enhancement algorithms, quantitative measures are implemented and assessment of radiologists is considered. According to these measures, enhancement by using nonsubsampling contourlet transform is chosen for detection of microcalcification clusters. Feature extraction is applied to depict properties of microcalcification clusters for classification. In this study, features are extracted from texture. Following feature extraction, classification algorithm (Support Vector Machine, SVM) is employed and performance of classification is evaluated. To decide which features best describe microcalcifications as benign or malignant, Random Forest Algorithm is applied. As a result, using Gabor filter banks as features outperforms to classification with other types of features. By using Gabor Filter banks, microcalcification clusters are classified with SVM by %91 truth rate (the area under the ROC curve is 0.97) .

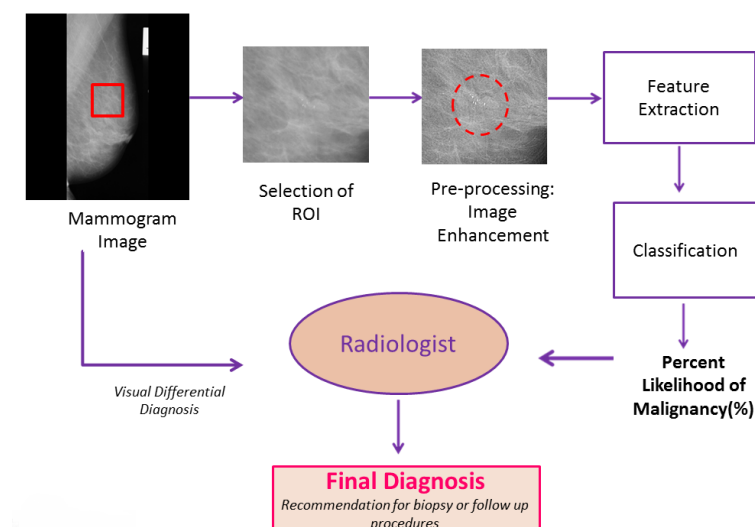


Figure 1. Desired CAD for Detection and Classification of Microcalcification Clusters

One Way Active Delay Measurement with Error Bounds

Tayfun EYLEN

This paper deals with the problem of measuring the delay of a packet in a network with an associated error bound but without having a need for clock synchronization and for any form of bidirectional messaging between the sender and receiver. A novel lightweight technique is proposed that aims to keep the actual error made in the delay estimation very low while providing also a good error bound for each individual estimated packet delay simultaneously. One way delay measurement without clock synchronization and messaging cannot guarantee an error bound on delay estimations in general, however we show that this is possible by using periodic probe packets and appropriate assumptions that are compliant with the physical conditions of the environments within which the sender and receiver operates. Although we calculate an error bound for all our delay estimates, the main purpose is to have a much smaller actual error in these delay estimates in comparison to the computed error bound and to existing works in the literature. The proposed method is evaluated against a recently reported technique of the same category and is shown to be much superior overall.

Nonlinear Apodization Using Windows of Different Length

Erdal Epçaçan

Existence of side lobes in spectral analysis and array systems is a common problem in many signal processing applications. The main objective is to obtain narrowest main lobe possible and no side lobe at all if possible. In conventional operations weighing/apodization is used to reduce the side lobe level at the expense of widening the main lobe. Nonlinear apodization has been used to suppress side lobes without widening the main lobe. In this work a new approach in which the side lobe levels are reduced without broadening main lobe will be provided. The main idea here is to use windows of different lengths. The aim is to coincide the nulls of windows with larger main lobes with the side lobes of the windows that have narrower side lobes. Taking the minimum of the normalized responses in frequency domain, the side lobes will be suppressed without widening the main lobe. Remembering that the highest side lobe of a rectangular window is about 13dB below the main lobe, a gain of about 12 dB can be obtained by this nonlinear approach by using only 5 different windows. The improvement increases as the number of windows used increases, since the nulls of each new window will be located at different points therefore suppressing more points in the side lobe region.

A Series, Capacitive RF MEMS Switch

Çağrı ÇETİNTEPE

This work describes the design, fabrication and measurements of a novel capacitive RF MEMS switch in series configuration. The proposed switch can be described as a reconfigurable high-pass transmission line section. In its up-state, the switch presents a low series capacitance and sets the high-pass line section below its cut-off for high isolation; whereas the increased capacitance in down-state sets a bandpass window centered on a given operating frequency. As Figure 1(a) illustrates, the switch employs a CPW topology as the transmission medium, a MEM bridge across the broken signal conductors for the series capacitance, short circuited line sections for the shunt inductors, and metal-insulator-metal (MIM) capacitors for DC biasing purposes.

Millimeter-wave performance of the switch is tuned using full-wave simulations, and the circuit model presented in Figure 1(b) is employed to facilitate the procedure. According to those simulations, the designed switch shows an isolation greater than 23.4 dB across 1-40 GHz band in the up-state, while it presents a tuned response at 35 GHz with 1.4 dB insertion loss and 17.7 dB return loss in the down-state.

The switches are fabricated at the cleanroom facilities of METU-MEMS Research and Application Center. Fabricated samples are characterized in DC-40 GHz frequency range using an open-environment probe station, Agilent E8361A PNA and a custom bias waveform generator. Fabricated samples exhibit a similar millimeter-wave performance to the ones predicted by full-wave simulations: In the up-state, isolation is better than 22 dB across the DC-40 GHz band; while the insertion and return losses are 2.4 dB and 13.0 dB respectively at 35 GHz using 35 V actuation voltage. Noted discrepancy in the down-state performance stems from bridge height variations in the fabrication process.

The results presented in this work validate the operating concept of the novel RF MEMS switch and suggest an alternative implementation means for a single switch component featuring high isolation and low loss simultaneously.

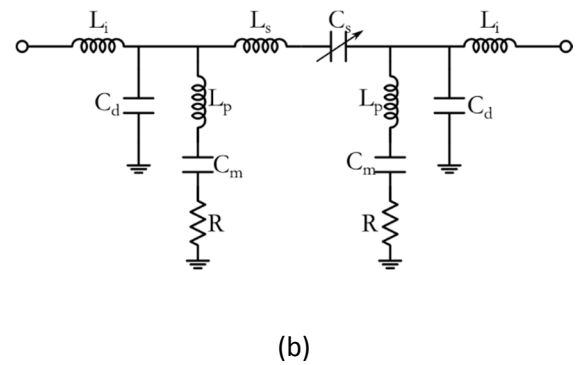
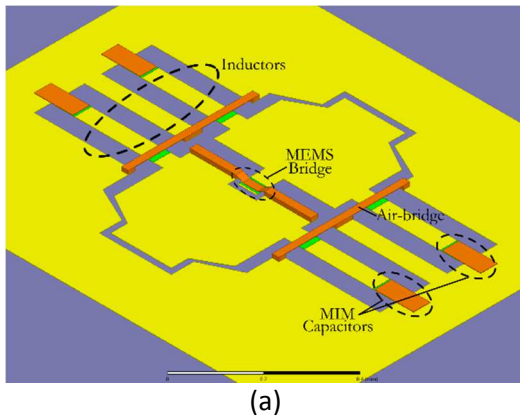


Figure 1. Proposed series, capacitive RF MEMS switch: (a) Physical layout, (b) circuit model.

A Fast Elimination Method for Incremental Pruning for POMDPs

Selim Özgen

A partially observable Markov decision process (POMDP) models an agent acting in an uncertain environment, equipped with imperfect actuators and noisy sensors. It provides an elegant and expressive framework for modeling a wide range of problems in decision making under uncertainty. However, this expressiveness in modeling comes with a prohibitive computational cost when it comes to solving a POMDP and obtaining an optimal policy. Improving the scalability of solution methods for POMDPs is thus a critical research topic and have received a lot of attentions.

We present a major improvement to the incremental pruning algorithm for solving partially observable Markov decision processes. The main idea is to revise the cross-sum step of the dynamic programming update, where the number of possible linear action value vectors increases exponentially with the cardinality of the observation set. Applying the pruning algorithm in an incremental manner proved really efficient and is still the most effective method for finding exact solutions.¹

Yet, many improvements to incremental pruning algorithm can be offered. Instead of applying the pruning algorithm in a monotone manner, our algorithm tries to find the subset(s) of linear action value vectors with highest number of dominated vectors to decrease the number of operations for the cross-sum operation in the incremental steps. Many algorithms can be proposed for finding the optimal solution to this subset problem; but we also want to avoid computational complexity. Therefore, a sub-optimal method with low-computational complexity is proposed and the results are compared to the incremental pruning algorithm.

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Controller Design For Agile Maneuvering Fixed-Wing UAV

Ferit ÇAKICI

In this thesis, design and development of a vertical takeoff-landing Tailsitter UAV with level flight capability is considered. Also, the challenging problem of designing and implementing a controller that makes the aircraft perform vertical takeoff and landing, hover, level flight, transitions between hover and level flight and agile maneuvers like dive and loop is investigated. A graphical user interface is designed in MATLAB GUI, in order to integrate all functionalities as design, analysis and simulation. Theoretical background for modeling the UAV and its components is established by determining the variables to be measured and calculated. Simulation-based modeling is completed by obtaining dynamical models of the system component for simulations. Thus, a dynamical model of Tailsitter UAV is established in MATLAB. Together with Tailsitter UAV, a Multirotor UAV is designed for comparison purposes. Linear analysis around trim points showed that both aircrafts are unstable and controllable, which made design of a controller possible. Proportional integral derivative and linear quadratic regulator controllers are designed for different trim points and evaluated for different mission scenarios. Flight simulations on the same waypoint scenarios show the differences in resultant flight path and performance criteria, caused by controllers. This reveals the requirement of controller switching in-flight in order to obtain better performance and reaching whole flight envelope. Flight simulation results proved the applicability of controller switching for mode transitions, when the closed loop stabilities are ensured. Finally, a method for controller switching is required to be design. After evaluating the performance of controller switching, the designed controllers are planned to be implemented in real Tailsitter UAV platform with flight tests.

Quad-Rotor helicopter modelling and control

Mehran E.Noudeh

This study investigated on the modelling and control of a quad-rotor helicopter and forms part of a research involving the development of an unmanned aerial vehicle (UAV) to be used in search and rescue applications. Quad-rotor helicopters consist of two pairs of counter rotating rotors situated at the ends of a cross, symmetric about the center of gravity, which coincides with the origin of the reference system used. These two rotors provide the predominant aerodynamic forces which act on the rotorcraft, and are modelled using momentum theory as well as blade element theory. From this, we can determine the expected payload capacity and lift performance of the rotorcraft. The Euler-Lagrange method has been used to derive the defining equations of motion of the six degree-of-freedom system. The Lagrangian was obtained by modelling the kinetic and potential energy of the system and the external forces obtained from the aerodynamic analysis.

Based on this model, a control strategy was developed using linear PD controllers. A numerical simulation conducted using MATLAB Simulink. First, the derived model will simulated to investigate the behavior of the rotorcraft, and then a second investigation will conducted to determine the effectiveness of the implemented control system.

Optimization Analysis of Hybrid Integral Equations for Perfectly Conducting Bodies

Barışcan Karaosmanoğlu

The choice of the surface formulation for an electromagnetic simulation directly affects the accuracy and efficiency of the solution. It is well known that the electric-field integral equation (EFIE) has high accuracy but it provides ill-conditioned matrix equations, corresponding to long computation times in iterative solutions. On the other hand, iterative solutions of the magnetic-field integral equation (MFIE) converge considerably faster than those of EFIE, but MFIE is less accurate. One of the well-known solutions to this dilemma is linearly combining EFIE and MFIE and obtaining the combined-field integral equation (CFIE). The accuracy of CFIE is better than the accuracy of MFIE, while its computation time (number of iterations) is less than the computation time of EFIE.

A sophisticated type of formulations, namely, hybrid-field integral equations (HFIEs), is obtained by applying EFIE and CFIE on different portions of the given three-dimensional geometry. In a HFIE formulation, EFIE is applied on open surfaces and/or thin closed surfaces, while CFIE/MFIE is applied on large and smooth closed surfaces. This type of a hybrid formulation can give better accuracy and efficiency than CFIE can achieve. In this work, we optimize the portions of three-dimensional geometries, where EFIE and CFIE should be applied. Genetic algorithms are used for the optimization in order to obtain more accurate results with less number of iterations.

Initial optimizations for verifying the validness of the proposed approach are carried out on small but challenging scattering problems. A perfectly conducting fishnet structure with 9 holes is illuminated by a plane wave with normal incidence. As a reference solution, a refined discretization is solved with EFIE. Hence, scattering results provided by the reference solution is used to obtain the relative errors of different HFIE configurations. The relative errors of HFIEs and the corresponding numbers of iterations are used to construct alternative cost functions. Various cost functions and their minimizations are used to develop optimal HFIEs in terms of accuracy and efficiency.

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