Sensors &
Actuators
Mirrorless Miniature Fourier Transform Spectrometer with Algorithmic enhancement of Spectral Resolution

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A mirrorless miniature Fourier Transform spectrometer was prepared using a LiNbO$_3$ waveguide electrooptic modulator (EOM), and its spectral resolution was enhanced by the interferogram extension with the forward–backward linear prediction algorithm.

Abstract

Compared with the existing table-top Fourier transform spectrometers (FTS) that are mainly used in laboratory, a miniature FTS with light weight, low power and strong vibration immunity is applicable for rapid on-site detection of chemical and biological substances, and is also suitable for remote monitoring using small unmanned aerial vehicle (UAV) as a carrying tool. These potential important applications combined with the increasingly established MOEMS technology result in rapid development of miniature FTS. According to the literature, miniature FTS devices have been widely implemented by miniaturization of the moving-mirror Michelson interferometer, which is therefore similar in structure to the table-top FTS. The driving force for the movable MEMS mirror includes electrostatic force or electromagnetic force or electrothermal force. The scanning distance for the MEMS mirror is very limited, leading to insufficient spectral resolution. Moreover, the MEMS mirror easily tilts during its scanning, which would impair the accuracy of the retrieved power spectrum. To overcome these shortcomings, we recently developed a mirrorless miniature FTS based on a LiNbO$_3$ waveguide electrooptic modulator (EOM) [1–4]. The dispersion equation for the half-wave voltage of the EOM was experimentally determined, which was used for simple accurate reconstruction of the input power spectrum from the measured intensity-against-voltage interferogram without consideration of the structural and optical parameters of the device. The at least 3-fold resolution enhancement of the EOM-based miniature FTS was realized by extension of the interferogram with the forward–backward linear prediction algorithm. Both the laser wavelength and the near infrared absorption spectra of liquid and solid samples have been measured using a prototype of the FTS. The work indicates the bright prospect of the EOM-based miniature FTS for rapid on-site spectroscopic analysis.

Keywords: Miniature Fourier Transform spectrometer; Resolution enhancement; Intensity-against-voltage interferogram; LiNbO$_3$ waveguide electrooptic modulator

Acknowledgements

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References

A Novel Identification Algorithm for Physiological Signal Sensing

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Abstract

Physiological signals have been collected and used to detect the state of human beings, such as ECG/EKG, EMG, EEG, and EOG signals. A challenge of using these signals for human behaviour identification is that they have significant uncertainties and contain large amount of environmental noise. Many algorithms have been explored and developed to identify physiological signatures that are associated with various states of human beings. The sliding window root mean square algorithm, Fourier and wavelet transforms have also been employed to extract transformation coefficients for use as features. Various types of classifiers, including neural networks, fuzzy logic, and supporting vector machine, are designed to quantitatively detect the human behaviour changes. However, all the existing identification techniques use arbitrarily chosen features to train classifiers that are not robust enough against changes in measurement method, noise level of signal, and individual subject variability. A novel system dynamics-based approach is proposed by the authors. In our research, the human being is considered as a dynamic system. The physiological signal is treated as a neurophysiological response of human being under a series of neuron firing impulses. A system transfer function is then obtained based on the input to output relation or the impulse response. From this transfer function, poles are computed and used to characterize the state of a human subject. It is found that the locations of system poles in the frequency domain/S-domain are distinctly different and associated with different states of human beings. This finding can be used in sensing and actuation applications for a human-centered detection system. An experiment was conducted to prove the utility of the proposed method. During this experiment, EOG signals were collected and used to generate a transfer function of an oculomotor system. From the transfer function, the system poles were plotted in the S-domain. It was found that the complex poles are associated with the alert state of a human subject, and real poles are associated with drowsy states of the human subject. Despite that the collected physiological signal exhibits significant different behaviour in the time domain, the
pole location based identification in the S-domain is capable of classifying the human state or condition with much relaxed and robust criteria. In summary, the proposed method takes a systematic approach to analyse physiological signals, which does not need extensive classifier training. It is robust against variations in the subject condition, sensor placement, and noise level.

**Keywords:** physiological signal sensing; system identification; robustness.

**Reference**

Microwave Humidity Sensor with TEMPO Oxidized Cellulose Nanofibers Based Materials as Sensitive Dielectrics

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CPWG structure and EM field distribution (a) out of the resonance; (b) at the resonance

Humidity response of the CPWG resonator with TOCN

Humidity response of the CPWG resonator with TOCN/PVOH composite

Abstract

Humidity measurement is one of the most important assessment in many applications including industrial safety, public health and agriculture. On the first hand, the investigation on sensing materials to improve humidity sensing
has become a major field to rise the competitiveness of humidity sensors. On the other hand, the preservation of the environment has become a major concern worldwide. Therefore, it is essential to find environmentally-friendly materials to address this issue. In the range of microwave frequencies, this research will allow taking advantage of passive operation and wireless communication.

This paper presents a coplanar waveguide grounded (CPWG)-based humidity sensor with TEMPO oxidized cellulose nanofibers (TOCN) based materials as sensitive dielectrics. Cellulose is the most abundant organic polymer on earth. The main advantages of cellulose include widespread availability, biodegradability and renewability. Scaling down cellulose to nanoscale fibres help to improve its mechanical properties such as high tensile stress. The TEMPO oxidation process rises the carboxyl rate of cellulose nanofibers, thereby improving their affinity to humidity and making them suitable candidate for humidity sensing. Here, a gel of 1.7 %wt so-called TEMPO oxidized cellulose nanofibers (TOCN) with approximately 1440 mmol/kg carboxyl rate was synthetized. The dielectric characterization of the TOCN material as a function of humidity was performed, then validating its humidity sensing capability. Furthermore, a composite material formed by adding 10%wt of PVOH to TOCN was prepared to study the influence of PVOH on sensing performances. The sensing performances were investigated through a microwave resonator in CPWG transmission line technology. The CPWG configuration was chosen for its relatively easy integration with other planar devices and its low losses compared to other transmission line counterparts. The resonator is formed by milling slot lines that delineate a rectangle within the CPWG line central track. The resonant frequency depends on the length of this rectangle. The electromagnetic (EM) analysis of the microwave structure was performed. It appears that the gaps delineated by the slots formed superficial capacitors that help to canalize the propagation of the electromagnetic (EM) energy as a function of the frequency. The TOCN based materials were simply dropped in the region where the EM analysis shown the EM field to be maximum at the resonance. The circuit was then submitted to various humidity conditions using saturated salts solutions. The results show successful humidity dynamic range with good linearity. The best sensitivity regarding TOCN is 2.67 MHz/%RH from 22%RH to 80 %RH with resonance shift, and 0.523°/%RH with S21 phase shift. The effects of PVOH insertion are visible from 55%RH. The sensitivity rises to 6.00 MHz/%RH in the range 55-89 %RH with resonance frequency shift, and 0.785 °/%RH with S21 phase shift. All these results are discussed.

**Keywords:** Humidity sensing ; Cellulose ; Coplanar waveguide ; TEMPO oxidation, PVOH

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**Reference**

Electromagnetic Sensor for the detection of alpha-Cypermethrin on walls

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Abstract

The control of insect vectors that transmit diseases including malaria, visceral leishmaniasis and Zika rely on the use of insecticide. These disease effect millions, malaria alone accounted for 214 cases of resulting in 438,000 deaths in 2015. One of the key methods used in controlling the vectors is through indoor residual spraying, applying insecticide to the surface inside houses. Alpha-Cypermethrin is one of the insecticides that is currently sprayed onto the internal walls of houses in several countries to control. Spraying the internal walls of houses is effective because the vector rest on the walls where they pick up a lethal dose of the insecticide reducing disease transmission. Quality assurance and monitoring of the control activities has always been a challenge relying historically on the use of laboratory-reared insects to see if homes were sprayed adequately. This was improved with the development of a chemical based Insecticide Quantification Kit at LSTM. While this was a significant improvement these assays have been challenging to operationalise. Building on this a patch array sensor is being developed to investigate the potential of electromagnetic waves to detect alpha-cypermethrin, one of the insecticides used for control. Preliminary experiments were carried out to differentiate tiles sprayed with H2O, Technical Grade α-Cypermethrin and wettable powder containing 5% α-Cypermethrin, using the array sensor. The measurements were provided by S parameter, i.e. reflected power from the EM sensor at a frequency range between 1GHz to 6GHz. The experimental results indicated the potential use of electromagnetic waves to determine α-cypermethrin in a non-destructive manner. Obtained data showed that each measured chemical has its unique signature, which could be distinguished by analysing frequency shift as well as amplitude change. The frequency range where the most significant changes are observed can be selected to develop a portable sensor to determine alpha-cypermethrin insecticide on the internal wall of the houses.

Keywords: Alpha-cypermethrin; Electromagnetic Waves; Malaria; Visceral Lieshmaniasis, Sensor.

Acknowledgements

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Multi-Source Energy Based Routing Protocol in Sensor Networks

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Abstract

One of the major characteristics of Sensors is Routing. Different routing protocols were proposed to efficiently send the sensed data from source to destination. Directional Source Aware Routing Protocol (DSAP) takes into consideration the shortest path from source to destination and this can lead to inefficient use of the sensors power (frequently used sensors will lose quickly their power). DSAP-power aware protocol was proposed to remedy this situation. It also incorporates the Power metric of each sensor node present in the network. This is achieved by considering the maximum available power and minimal directional value in the node route selection. Instead of simply picking the node with the lowest directional value, the directional value is divided by the power available at that node. The smallest value of this power-constrained directional value is the chosen path. This allows a least transmission path that is also cognizant of power resources, although in some cases a longer path may be chosen if the available power dictates that choice. This can lead to an unacceptable situation because some nodes will lose their power faster than other nodes.

Maximum Power DSAP (MDSAP) was proposed in which the messages exchanged between the different sensor network nodes were divided into three categories: Low priority, High priority (urgent messages) and Medium priority messages giving that the priority is going to be decided based on the application to be monitored. Simulation will show that the network will survive longer than with DSAP and DSAP-power aware. The most important limitation of the regular DSAP and the MDSAP are the barrier nodes at the destination proximity. Whatever techniques used to send the information from the source to the destination (using the shortest path, selecting message priorities, load balancing between available powers …etc), the main problem still exist because the message will not be able to reach the destination when all its neighbors are down. So, a new power distribution technique should be added to the existing MDSAP to overcome this dilemma that will radically increase the network lifetime.

The Energy Based Protocol (EBP) was proposed to remedy this limitation. The main objective of EBP is to maximize the wireless sensor network lifetime. To achieve this, we considered the fact of using, to the maximum, the power available at each sensor of the network. In our improved EBP algorithm and after selecting all different paths, the simulation showed a drop down on all the nodes without leaving any missed energy. The network lifetime is maximized where each sensor’s power is fully used. On the other hand, we overcome the limitation of same type of priority and the barrier across the destination. In addition, all nodes and paths will be taken making the destination always reachable. Based on a simulation using TinyOS, A detailed comparison between DSAP, MDSAP and EBP shows the efficiency of EBP. As stated above, the Clustering Energy Based protocol (CEB-P) aims to physically distribute the number of sensors in one area called cluster to get the total power of the assigned value in EBP, having a fixed battery level for each node. To have the flexibility to detect information from multiple sources in a grid, Multi-Source energy Based Protocol (MSEB-P) amends EBP by allowing every sensor node to sense data and
send it to the destination where it overcomes the fixed source detection limitation of EBP. MSEB-P was proposed to be used in a Hospital application model.

**Keywords:** Energy, Lifetime, Power, Routing, Sensor Networks, Source, TinyOS.

**Acknowledgements**
Thank you for the university of Balamand for its support to apply to this valuable conference.

**Reference**


Ground-Condition Detection with Pressure Sensor to Drive Two-Leg Robot

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Fig. (a) Robot system consists of two legs that can sense the dynamic pressure change induced by ground-surface condition. Fig. (b) illustrates a schematic picture of transient pressure characteristics of two legs on smooth ground surface. An equivalent mechanical component of the developed robot-system is shown in Fig. (c), where m and k are the robot mass and elastic constant, respectively. Suffixes r, s, and g represent the robot body, pressure sensor, and ground respectively. Effect of contacting events such as soft ground, leg-contact height and depth are considered in terms of pressure delay, τn and kgs. Pressure sensing robot control system simulation is shown in Fig. (d). Corresponding left leg and right leg positions of robot are depicted in Fig. (e). Fig. (f) shows a zoomed view of Fig. (e) with clear delay effect on leg positions. Table 1 represents equations which we considered to implement the ground-contact effect.

Abstract

Pressure-sensing-based ground-condition detection is an important aspect for robot actuators, particularly for walking robots [1]. The detection characterises the ground surface, with which robot is in contact, is investigated. Especially, for non-smooth muddy ground surfaces, robot observes dynamically varying pressure on the two individual legs, which must be considered to manipulate the robot’s smooth movement [2]. In this work, we focus on the detection of ground surface with pressure-sensor-embedded two-leg robot [see Figs. (a)-(b)]. A simulation tool has been developed for a walking robot, to model pressure changes provided by sensors, according to the ground-surface condition change. The contact effect of the robot with the ground surface is
modeled through the equivalent properties of the ground surface, which include compressive normal forces and tangential friction forces transmitted to ground by robot legs, where the connections to the sensors and further to the robot-body are included [see Fig. (c)]. First, we performed finite-element-method-based numerical simulations of contact events for smooth-hard, smooth-soft, non-smooth-hard, and non-smooth-soft ground surfaces to extract ground pressure information [3]. The detected pressure dynamics due to the surface conditions are translated into time delay, \( \tau_n \) together with elasticity coefficient, \( k_g \). Obtained \( \tau_n \) and \( k_g \) are further applied to manipulate the robot motor control. We propose contact-event effects such as contact timing (leg contact on ground at different positions and heights), direction of contact force, friction information, flexible properties of ground surface using the concepts of transit-pressure delay, \( \tau_n \) and elasticity, \( k_g \) [see Table 1]. Simulation results for various surface conditions are depicted in Fig. (d). Combination of different \( \tau_n \) and \( k_g \) provides real pressure-sensor detection with our developed pressure-sensor model [4]-[5]. The entire robot-system model with integrated contact events is utilized to manipulate the robot dynamics. The developed robot-system model is based on the equivalent-circuit-network concept, under the energy-conservation condition in terms of respective potential and flow quantities of each robot-system component, to incorporate the two-way interactions (robot ↔ ground) in the robot system [5]. The robot system employs two legs connected with pressure sensors, transducing mechanical force to electrical signals which are magnified by amplifiers. The time-domain trajectories of robot-legs positions for smooth-hard, smooth-soft, non-smooth-hard and non-smooth-soft ground surfaces are depicted in Fig. (e). A zoomed view of Fig. (e) is illustrated in Fig. (f), showing a clear dependence of leg position on contact-event conditions.

**Keywords:** pressure sensor; surface condition detection; electro-mechanical; walking robot.

**Reference**

On the coffee ring effect in pseudo-evaporative and non-evaporative diffusive systems

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Coffee ring effect deposition of an antigen onto a surface resulting from a convective solvent flow field (left) and purely diffusive delivery (right).

Abstract

Nucleic acid and protein microarrays are commonly used in lab-on-a-chip technologies. This approach enables the detection of a broad spectrum of biomarkers from a single sample. One of the major challenges in creating/using microarrays is the formation of so-called coffee ring patterns. These patterns are formed by the deposition of high levels of solute at the outer edge of a liquid droplet and can have a notable negative effect on the fabrication and application of these analytical systems.¹ As part of our interest in this area, we are examining the mechanistic underpinnings of this effect in order to mitigate the detrimental impact of these patterns on microarrays with a focus on immunoassays. We found that these patterns originate largely from two factors. The first results from the thermo-capillary mass convection of materials that occurs at the air-liquid interface of an evaporating sessile droplet. In other words, the evaporative temperature drop at this interface induces a convective liquid flow that causes solute molecules to concentrate at the edge of the droplet.² Second, we found that these ring patterns can also develop in purely diffusive systems. Specifically, we looked at how differences in the lipophilicity and other physiochemical properties of the solute, as well as the ambient environment, influenced pattern formation.³ Our data shows that often overlooked factors, such as the temperature and humidity of the surrounding environment, immediately after the application of a droplet, can have a significant impact on the distribution of a analyte across a micron-sized address. The data further demonstrates that when carrying out immunoassays in a non-evaporative, purely diffusive system (i.e., approaches designed to mitigate thermo-capillary convection), the concentration of the diffusing species and incubation time dictate the extent of ring formation. These experimental findings also qualitatively correlate with computational simulations of these systems using steady-state kinetics approximations. Drawing on these insights, we have been able to identify optimal conditions to avoid ring formation, which has resulted in the ability to fabricate more homogenous and reproducible distributions of solute accumulation across an array address, and, therefore, improve the accuracy and precision of the analysis of these systems. The potential extension of these findings to other microarray formats afflicted by ring formations is also briefly discussed.

Keywords: radial diffusion; microarray assay, analyte accumulation; coffee ring effect

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Reference


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Title: Amplification-free liquid biopsy by fluorescence microscopy

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Liquid biopsy is an exciting new paradigm of modern oncology (1). With next-generation sequencing approach, previously unachievable precision becomes reachable for point-of-care diagnostics and follow-up. The precision is crucial for reliable detection of single nucleotide polymorphism in cancer related circulating tumor DNA(ctDNA), due to their low abundance and low diversity. The present detection methods of ctDNA samples include hybridization with mutation specific probes after amplification, allele-specific polymerase-chain reaction and/or sequencing (1).

Regardless of the method employed, enzyme-assisted analysis of nucleic acid mutations poses multiple challenges. Among those are time-consuming processes that tend to be fairly expensive, low target abundance, rapid degradation and restrictions on identifying amplification primers (2). These cons have raised an interest in amplification-free detection methods. The use of modern fluorescence microscopy and fluorescently labeled mutation specific probes containing locked nucleic acids (LNA) show reliable detection of ctDNA is achievable. In this work, the aim was to develop a new amplification-free detection method for cancer associated mutation, *BRAF* V600E, *KRAS* G12D and *KRAS* G13D respectively. This is done by a split probe design with a capture probe and a mutation sensitive beacon along with hairpin free detection probes (Fig.1). In the presentation I will describe our new approach, present our data on *BRAF* and *KRAS* oncogene detection, and discuss how this new method paves the way for detection of other low abundance target such as DNA/RNA mutations including miRNA, circRNA, viruses and bacteria.

![Enzyme-free detection of mutations in human oncogenes: *BRAF* V600E and *KRAS* G12/13D.](image)

**Fig.1** Enzyme-free detection of mutations in human oncogenes: *BRAF* V600E and *KRAS* G12/13D.

Emotion recognition from physiological signals and videogames to detect personality traits

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Please make a brief schematic diagram as the ‘Table of Contents’. Insert those Graphics and Synopsis here. Please make sure that this can illustrate your work briefly but completely. Below is sample of schematic diagram.

Abstract

The purpose of this research is to build an emotion recognition system to identify personality traits using physiological signals (Electrocardiogram ECG, Galvanic Skin Response GSR, and Electromyogram EMG) and video games. “Personality is a psychological construct aimed at explaining the wide variety of human behaviours in terms of a few, stable and measurable individual characteristics, current personality models successfully predict patterns of thought, emotion, and behaviour” [1]. Based in this affirmation our hypothesis is that through emotions is possible to identify personality traits that define the behaviour of an individual. In this work we present the signal acquisition, processing and featuring extraction system for the three physiological signals (ECG, GSR, EMG) to detect the level of arousal or passiveness using as reference the Russell’s affect model to identify emotion based in the Arousal – Valence dimension [2]. We extract some metrics from the physiological signals related with the activation of the sympathetic and parasympathetic autonomous nervous system and the Arousal dimension of the affect model chosen. The system allows to capture the three signals while the test subject is playing a videogame as the emotional stimuli, in a time window defined by the researchers. Then the three raw signals are conditioned and filtered to extract metrics from the ECG, GSR and EMG signal as: beats per minute (bpm), heart rate variability (HRV) in the frequency domain, number of GSR peaks in the skin conductance response (SCR) and the forearm contraction time. The data is exported to a spreadsheet to further analysis with the personality data acquire from the EPI questionnaire to compare emotion with personality traits identified by using the Eysenck personality theory [3]. With this system we create an acquisition signal tool for personality computing researchers using ECG, GSR, EMG signals and Videogames, although these is a novel field in which capturing procedures and acquisition features as sample rates, values, tools, etc., has to be standardized to compare results with other.
research, the system allows obtain the physiological signals metrics from the user to compare the emotion experimented during a videogame play session with the results from the EPI questionnaire.

**Keywords:** Emotion recognition; physiological signals; personality traits; videogames.

**Reference.**


Signal enhancement using PVDF sensor arrays via blind source separation

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Abstract

This paper proposes a signal enhancement system using PVDF (polyvinylidene difluoride) [1] sensor arrays for monitoring heart rate via blind source separation. Due to sensor arrays, each signal of sensors is mixed including noises. We can separate the signals by using the independent component analysis algorithm [2]. Thus, we can get more approximated signals for calculating heart rate or diagnosis. Below is sample of schematic diagram.

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This paper lays emphasis on signal enhancement for monitoring heart rate. The polyvinylidene difluoride (PVDF) material is used as the sensor for signal acquisition. There is a crucial subject in this paper that shall be solved. The amplitude of signal is various while putting the sensor in different positions on chest wall. Generally speaking, it is difficult to find the right position of heart to acquire signal. Added to this, the signal acquisition makes noise, which influences the calculation of heartbeat. In order to increase the quality of heart signals, this paper proposes a method that using the PVDF sensor arrays which are put on chest wall. There are three signals simultaneously collected from heart. In additionally, this paper applies the independent component analysis algorithm to separate these signals. Thus, we get the more approximated signals.

Keywords: PVDF; sensor arrays; signal enhancement; blind source separation.

Acknowledgements

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Reference

Effect of Electrode Material on Piezoelectric Output of PVDF Sensor with electrospinning

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Abstract

The electrospun PVDF(Polyvinylidene Fluoride) nanofiber web is commonly agreed on a kind of new sensitive materials for the sensor testing the dynamic pressure and energy harvesting, and has the characteristics of fast response and high sensitivity of pressure. As a result of the nanofiber web, it must be packaged to collect piezoelectric charge and bear strong mechanical behavior before industrial practice. The packaging of PVDF nanofiber web is usually sandwiched by incorporating a pair of flexible electrode. However, the effects of the surface and mechanical properties of electrodes such as morphology, roughness and compressibility have not been well investigated yet. This work will introduce three common types of electrode materials (adhesive copper foil tape, indium tin oxide (ITO) thin plate, adhesive conductive fabric) in previously published literatures, compare the piezoelectric output of their sensor prototypes under a periodic force impact, and discuss the effect of surface morphology, electrical resistance, and compressibility.

To make the sensor prototype, a patch of electrospinning PVDF nanofiber web was firstly cut by a size of 3x3cm and a thickness of 47±10μm, and then its surface was attached by a pair of electrode materials with size of 2x2 cm. Three sensor prototypes for each type of electrode material are tested at the repeated impact of 15N and 1.0Hz, and their corresponding piezoelectric outputs are recorded. The results showed that it has higher output of PVDF piezoelectric sensor packaged by electrode materials with the smooth surface and low mechanical compressibility. This result provides a guideline for designing the textile electrode material packaging the PVDF nanofiber web.

Keywords: PVDF; electrospinning; Nano-fiber web; piezoelectric; Electrode Material

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Generalized Predictive Control for DEAP Flexible Bionic Actuator with Fuzzy Model

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Abstract

Bionic robot has been widely researched in recent years as an emerging branch in robotics. As conventional drive mechanism such as motor, pneumatic and hydraulic actuators usually have large mass, complex structure and low energy density, they are not suitable for driving bionic robots. Dielectric electro-active polymer (DEAP) is attractive as a smart material because of its low energy consumption, light mass and a large deformation capability and faster response than competing materials such as SMA and IPMC. The advantages of DEAP push its application in actuators, especially in the field of bionic robot. However, the bionic actuators based on DEAP material generally have strong hysteresis, creep property, uncertain and nonlinear characteristics, which lead to a poor application performance of many control strategies. This paper addresses the issue of model and control for a flexible bionic actuator with DEAP materials. According to the electromechanical characteristic of DEAP actuator, a generalized predictive control (GPC) strategy based on T-S model is presented. As a widely used fuzzy model, T-S model has potential ability to describe the dynamic of complex systems without actual physical model. As a branch of predictive control, GPC is an important control strategy for industrial process control with excellent control performance and robustness. In this paper, T-S fuzzy model was established and identified by using input output data collected with DEAP experiment platform. The premise parameters of T-S fuzzy model were identified by fuzzy c-means (FCM) clustering algorithm, and the consequent parameters were obtained by least square method. Then, GPC was employed to calculate the control variables for each rule in T-S model, and the total control variables for the DEAP flexible actuator are weighted mean of each one. The weight coefficient is the membership of the corresponding fuzzy rules. Finally, a position tracking experiment was conducted with the DEAP experiment platform. The Experimental results show that the control strategy applied in DEAP flexible actuator has high tracking accuracy and fast response speed. The proposed model and control method for EAP flexible actuator were verified.

Keywords: Flexible Actuator; Electro-Active Polymer; Generalized Predictive Control; T-S model.

Acknowledgements

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Reference

Development of ethylene gas sensor for evaluating fruit ripening

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SiC-FET gas sensor with iridium gate and sensor signal characteristics at different concentrations of ethylene at 200 °C.

Abstract

The quality of fruit is depending on preharvest environmental conditions and postharvest handling1. It is widely known that the ethylene treatment is one of the effective method of postharvest handling. Ethylene which is the smallest and colour less gaseous plant hormone is considered as a trigger of the ripening process of fruits. All fruits are divided into two types, climacteric or non-climacteric fruits. Non-climacteric fruits, such as grapefruit, grapes, orange, pineapple, and strawberry are not affected by ethylene gas and not ripen after harvest. On the other hand, climacteric fruits, such as apple, banana, kiwifruit, melon, and pumpkin are characterized by a ripening linked increase in respiration and in ethylene production2. Thus, it is necessary to monitoring the ethylene concentration and to evaluate the ripening state of fruits in the fruit ripening and storage facilities.

In this study, we developed the ethylene gas sensor for evaluating fruit ripening using the SiC based field effect transistor (SiC-FET) device. Various papers indicate that SiC-FET gas sensor can withstand harsh chemical and temperature environments and can change selectivity and sensitivity according to operating temperatures, gate material and material structure1. In addition, we measured and analyzed the bioelectric potential responses3 of fruits and tried to clarify the relationship between the fruit ripening state and the bioelectric potential of fruits. It is reported that the electrical impedance of several kind of fruits change depending on the ripening process5, however there are few papers about the relationship between bioelectric potential and fruit ripening.

At first, we studied the sensing characteristics of iridium gate FET sensor (left figure) with different ethylene concentrations (0.5-2.5 ppm) in 20% O2 mixed with N2 as the carrier gas at different operating temperatures ranging from 150 °C to 400 °C in steps of 50. The exposure to the sample gas was performed during 300 sec and recovery in carrier gas was allowed for 300 sec. The results showed that the iridium SiC-FET sensor detects all concentrations and the signal increase depends on increasing concentrations at 200 °C (right figure). Next, we measured bioelectrical potential of a pumpkin, which is a climacteric fruit, just after harvest in a closed vessel. In the vessel, the ethylene concentration increases by ethylene gas produced by pumpkin. The results suggest that the amplitude of the bioelectric potential of fruits are gradually decreasing with elapsed time. In future work, an algorithm to the sensor signal will be established, such that the sensor monitors ethylene in the real environment with fruit in the vessel. Furthermore, the relationship between the decreased bioelectric potential signal with elapsed time and ripening process will be clarified. Eventually, we aim to develop a fruits ripening control system by combined the developed SiC-FET sensor system and the plant bioelectrical potential response.

Keywords: Ethylene gas; SiC-FET gas sensor; postharvest ripening; plant bioelectric potential.
Acknowledgements
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Reference
Actuator device based on neodymium permanent magnets printed with 3d printer

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Abstract

According to World Health Organization data, about one billion of people worldwide are disabled people [1]. About one third of these people are people with mobility or movements impairments. First problem is that for that kind of people high precision prosthetic devices with neural control and feedback are very expensive. Second problem almost all average price prosthetic devices have visual feedback system which loads user vision as example bebionic[2]. To solve these two problems, decided to develop prosthetic devices with other kind of feedback systems thermal, electrical, pressure, vibration...etc. A haptic vibro-tactile test bench developed to evaluate vibration feedback systems. Vibro-tactile test bench works in wide range of frequencies and magnitudes. The main goal of the presented paper is to develop vibro-actuator device for this test bench using additive manufacturing method (3d printing) using PLA plastic neodymium permanent magnets and copper wire only. This kind of engines must reduce price of vibro-tactile devices manufacturing. In previous papers[3, 4] was tested industrial loudspeaker vibro-actuator with different drivers using different control methods[5]. The actuator used as test model which with compared 3d-printed actuators. Both device models compared using FEM software COMSOL metaphysics environment. Different parts of 3d-printed actuator tested: magnetic circuit, mechanical properties of PLA membrane. Electrical parameters of different coils. Produced force control measurements for control actuator device and for 3d-printed control device. Force tests of 3d-printed device are better than for control device. Frequency test are depended of mechanical properties of the printing material and form of the membrane. Produce vibration actuators using 3d-printing addition technology is possible and the can be more effective than produced using subtraction technology. For feature work testing of different membrane configuration and 3d-printing materials.

Keywords: Vibration control; Biomechanics; Biomedical transducers; biomedical electronics

Acknowledgements

Please acknowledge the funding authorities and other research supports.

Reference (Not more than 5, please follow the below reference style if any).

2. http://bebionic.com*
Analysis of disturbance forces in magnetic levitation system with complex force-current matrix

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Velocity

Back
electromotive force

\[ EMF = \oint_{\text{coil}} (E + v \times B) \cdot dl \]

Force-
current Matrix

Disturbance
current

Disturbance
forces

Analysis of disturbance forces with force-current matrix.

Abstract

Magnetic levitation system has been researched for many years due to its non-contact property. The non-contact property brings many advantages. The non-contact does not generate particles since there is no mechanical contact. It makes possible to maintain facility clean. Especially, the most advantageous merit is non-friction. Since the nonlinearity of the friction degrades preciseness, the magnetic levitation system can have precise resolution. Also, non-friction makes the control of the system becomes easier. In order for non-friction, the system has to be levitated. Due to the levitation, the system is vulnerable to disturbance forces. Therefore, the disturbance forces are important issue in terms of controlling the magnetic levitation system. The disturbance forces are analysed with force-current matrix describing relationship between force and current. The magnetic levitation system uses Lorentz force that is interaction force of coils and magnets. The magnetic levitation system uses many coils, the force-current matrix which expresses relationship between forces and current is complex. Since the magnetic levitation system moves long range with high velocity, the back electromotive forces are inevitably generated in the electric system in the coil. The back electromotive forces generate current disturbance which results disturbance forces in magnetic levitation system. Especially, if the force-current matrix in the system is complex, the resulting disturbance forces are also complex. In this paper, the resulting disturbance forces are derived by using mathematical models. Since the disturbance forces are generated from the disturbance currents and the disturbance currents are motivated by the back electromotive forces, the back electromotive forces are firstly derived. Then, the disturbance currents are derived from the back electromotive forces. Finally, using the complex force-current matrix, resulting disturbance forces are found. For future work, the modelled equation of the disturbance forces are to be utilized in order to compensate the disturbance forces with feedforward control technique.

Keywords: magnetic levitation; disturbance forces; force-current matrix.

Reference (Not more than 5, please follow the below reference style if any).

Fabrication of needle type pH sensor for quantitative caries detection

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Abstract

Since detection methods of dental caries are based on clinical skills of dental doctors such as inspection, palpation, and X-ray imaging, caries detection on approximal surfaces or in caries cavities using these methods is difficult. Therefore, quantitative and objective diagnostic technique having high spatial resolution is needed [1]. On one hand, it is already well studied that the progress of caries and the pH decreasing are correlated.

In this study, we fabricated and evaluated Iridium/Iridium Oxide (Ir/IrOx) pH sensor for quantitative diagnosis of dental caries. Thermal oxidation of Ir wire (φ 0.3 mm) was carried out at 870°C for 5 hours at air atmosphere in the electric furnace according to the prior study [2]. The thickness of the thermally grown IrOx layer was observed by SEM. The potentiometric response to pH showed -57.4 mV/pH in evaluated pH range from 4 to 8, which demonstrated that our electrode possesses the excellent proton sensitivity (Nernst slope; -59.2 mV/pH). Subsequently, we tried to measure the pH difference between carious lesion and sound enamel areas. Based on the evaluation results of dental caries, we confirmed the possibility for quantitative diagnosis of dental caries using Ir/IrOx electrode based on the pH as an index. This needle type pH sensor has some advantages with regard to miniaturization and mechanical strength, and might be a potential material for dental instruments.

Keywords: dental caries; pH sensor; Iridium/Iridium Oxide

Acknowledgements

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Reference

Towards airflow sensors with energy harvesting and wireless transmitting properties

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IV. AN ENERGY HARVESTING CONSTRUCTION
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Abstract

The rapidly growing demand for even more detailed low cost measurements of weather conditions, including wind flow, asks for self-sustained energy solutions that eliminate the need for external recharge or replacement of batteries. Today’s wind measurement market is limited to traditional anemometers, ultrasonic measurement or expensive LIDAR (Light Imaging, Detection and Ranging) systems. This paper presents the initial design considerations for a low cost combined air speed and wind direction sensor, which harvests energy to drive it and to power the wireless transmission of system configurations and measurements. An energy-budget for this transmission is included.

Keywords: Keyword 1; keyword 2; keyword 3. (Include 3-5 Keywords) airflow sensor; fluid mechanics; energy harvesting; smart materials; oscillations.

Acknowledgements

Internal innovative project.

References


Flexible micro gripper using novel IPMC fabrication scheme for medical application

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IPMC based flexible micro gripper schematics. And an AFM picture of Nafion surface prepared using oxygen plasma for adhesion improvement

Abstract

This paper describes a two-Finger micro gripper fabrication using ionic polymer metal composite (IPMC) actuators. Each finger is an IPMC actuator which is controlled separately by positive/negative bias voltage between 5V and 0.2V so each finger has exact inner and outer side deformation regarding to shape of target object. IPMC is an ionic type of electro active polymer known as low active voltage actuator which may also respond to deformation and humidity changes. The IPMC actuator has artificial muscle feature with large deflection and excellent flexibility, low power, low voltage and light weight. In addition, it is bio-compatible actuator so it is possible to use this gripper in medical application like surgery robots. It is common to use chemical deposition to fabricate IPMC electrodes. However, physical deposition method is more compatible with device fabrication technology. In addition, physical deposition methods like sputtering are more controllable with respect to thickness and the pattern. Furthermore, sputtering method with 700 nm Au thickness is more cost effective compared to 1-10 µm Pt electrode using Pt salt. Major problem in using sputtering is the film adhesion and the created strain in the nafion layer. IPMC needs mobile ions to move through nano-channels inside the Nafion with respect to the electrical field. This movement causes volume variation and then bending of IPMC. In common Pt electrode IPMC, Nafion is placed in a wet condition before and after fabrication process. So there is no change in environment condition and then no strain affect appears during the deposition step. But to deposit electrode by sputtering method, dry nafion layer must be used because of high vacuum process. After deposition, as dry nafion enters into the water or ion-exchange solution, polymer layer absorbs liquid and expands to more than 10% of its initial volume. Expansion of nafion layer leads to expansion of electrode layer. Electrode layer can’t support this large strain so bursts into small pieces or peels off rapidly. This problem was solved with two type approaches; using Ti layer before gold sputtering and creation of nano-metric roughness features. Wrinkling of electrodes in micrometric scale followed by sputtering the electrodes prevents the mentioned electrode failures. The IPMC actuation has been thoroughly characterized and the results have been explained in details.
Keywords: IPMC, EAP; Flexible micro gripper, Actuator.

Acknowledgements
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Reference
Fabrication of a nickel-coated optical fiber sensor and its applications

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Abstract

An optical fiber sensor (OFS) composed of silica (SiO₂) shows elastic behaviors when an external load is applied to the sensor. However, it is not valid anymore if an elastoplastic metal is coated on the sensor. An OFS with a metal coating has a memory effect due to elastoplastic properties of a metal. The “memory effect” indicates that the sensor can recall the impact event formerly experienced by the structure if the correlation between the residual strains and the impact information is given [1]. In this study, a type of an OFS, a nickel-coated fiber Bragg grating (FBG) sensor was fabricated using a two-step plating method [2]. An electroless plating was performed to construct a first layer of coating, i.e., a conductive layer for electroplating. An electroplating was consequently undertaken on the conductive layer in order to increase a thickness of a nickel coating. The surface of the coating fabricated by the two step plating method was compact. Then mechanical property tests, i.e., cyclic loading tests for nickel-coated FBG sensors were performed to examine their capability to yield residual strain. It was found that the residual strains induced by a nickel-coated FBG sensor increased with an increase of the maximum strains formerly experienced by the sensors. It means that a nickel-coated FBG sensor has a potential to recall the former impact information. The residual strains induced by elastoplastic properties of a nickel-coated FBG sensor play a role of a quantitative index. For examples, they can be used for evaluating barely visible impact damages (BVID) of composite structures such as delamination, matrix cracks and fiber breakage after a low-velocity impact occurred. In addition, a nickel-coated FBG can be also used as normal purpose, i.e., a typical strain monitoring in real-time while in service. Therefore, a nickel-coated optical fiber sensor has a feasibility to be used for damage detection and strain monitoring under operation as well as non-operation conditions.

Keywords: Nickel coating; plating; FBG sensor; memory effect; structural health monitoring.

Acknowledgements

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Reference


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Performance envelope of piezoelectric actuators at high temperature

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Abstract

Available standards for modelling the performance of piezoelectric devices are mostly oriented towards low electrical field, operation at ambient temperature and around resonance. Temperature dependency is often introduced as a linear parameter, which is contrary to observations. In addition, the standard piezoelectric equations are linear approximations based on small signal measurements, which provide a poor match with multilayer piezoelectric actuators operated at high electrical field. Instead of standard material parameters, it has become an industry standard to describe the behaviour of multilayer piezoelectric actuators using two parameters: free displacement and blocking force. In this research, the high field characteristics of two types of piezoelectric actuators, based on two different PZT materials (one soft-doped, NCE51, and one hard-doped, NCE46) have been measured at high electrical field and up to 200°C using readily available techniques. Both the electrical parameters (dielectric charge and losses) and the mechanical parameters (free displacement, stiffness and thermal expansion) have been measured. Looking more closely at the mechanical parameters, these measurements allow a mapping of the envelope of the actuator performance in terms of three dimensions: position, force and temperature. The usual force-displacement diagram can be expanded to include temperature, thereby defining two surfaces in three-dimensional space, one corresponding to the fully retracted state and the other to the fully extended state. The volume between the two surfaces defines the operating envelope of the actuator. Although a linear relationship is conserved for the force-displacement behaviour, the evolution of free displacement, stiffness and thermal expansion with temperature is non-linear. From this analysis, it is clear that models of higher complexity are required to match the experimental data.

Keywords: Piezoelectric; Actuator; Behaviour model; Temperature.

References

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