The Institute of Electronics Engineers of Korea

2013년도 대한전자공학회

하계종합학술대회 프로그램

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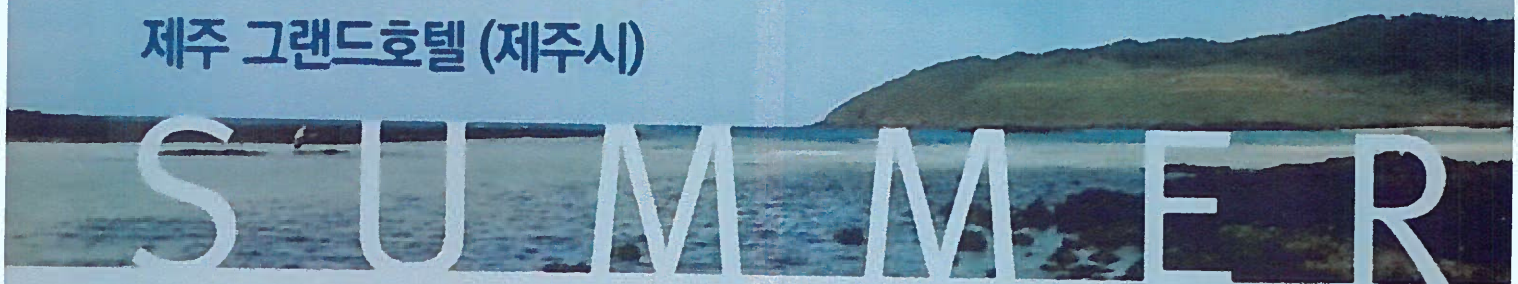
제주 그랜드호텔 (제주시)



주최 : 사단법인 대한전자공학회

후원 : 해동과학문화재단, 삼성전자(주), LG전자(주), SK하이닉스, KT, 전자부품연구원

협찬 : 현대자동차, 현대엠엔소프트, 현대모비스, 삼성디스플레이, (주)엠에이, AWR 코리아, 과학기술연합대학원대학교, 한빛미디어

사단법인 대한전자공학회
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09. Depth 및 Spectral정보를 이용한 객체검출 방법 ▶CFP-496
권 순, 정제교, 김현우, 하재욱(대구경북과학기술원), 김성호(영남대학교) 728

10. Speckle 분포에 기초한 후쿠시마 원자로 2호기 압력억제실Vent 배관의 감마선 세기해석 ▶CFP-004
조재완, 정경민(한국원자력연구원) 731

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송 혁, 신화선(전자부품연구원), 곽수영(한밭대학교), 유지상(광운대학교), 최병호(전자부품연구원) 735

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최진모, 정용무, 송 혁, 민수영(전자부품연구원) 738

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변주원, 홍윤표, 김재석(연세대학교) 741

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권혁주, 이성학, 이근영, 채석민, 송규익(경북대학교) 776

압축 센싱을 이용한 초음파 이미지의 신호 복원

Pavel Ni, 성진택, 장환철, 박상준, 류정민, 이흥노*
광주과학기술원 정보기전공학부

e-mail : {pni, jtseong, hcjang, sjpark1, jmryu, heungno}@gist.ac.kr

Signal Reconstruction of Ultrasound Images Using Compressive Sensing

Pavel Ni, Jin-Taek Seong, Hwanchol Jang, Sangjun Park, Jeong-Min Ryu, Heung-No Lee*

School of Information and Mechatronics
Gwangju Institute of Science and Technology (GIST)

Abstract

In this paper we present results of applying Compressive Sensing technique to medical ultrasound Radio Frequency signals (RF). Compressive Sensing allows decrease sampling rate by acquiring directly compressed signals. Those signals then reconstructed through optimization routine. In our research we reduced sampling rate 4 times of that stated by Nyquist-Shannon theorem. As a result we provide B-Mode image reconstructed without significant losses and have no visual difference comparing with image obtained with Nyquist-Shannon sampling rate.

I. 서론 (Introduction)

Ultrasound (US) medical imaging is widely used because it can operate in real time and relatively inexpensive comparing with MRI, PET systems. However among those systems US has purest spatial resolution and high speckle noise. Principle of ultrasound imaging modalities is based on propagation sound pulses from individual transducer elements into human body. Different time delays appling to elements on transducer array to make focused beam and to steer beam along region of interest (ROI). During propagation sound wave encounter certain anatomical structures where it is attenuates absorbed and reflects back to transducer. Reflected signal then recorded and processed to obtain B-mode images. Engineers focused on improving quality of ultrasound images and maintain real time imaging capabilities.

Conventional approach is to increase number of elements and use higher frequencies to achieve better resolution, it results in complexity of system and large amount of data to be generated. Recently developed technique known as Compressive Sensing (CS) allows acquire directly compressed signal. and this paper we show results of applying CS theory to medical ultrasound signals. Further, we provide short review of CS theory and description of our experimental setup.

II. 본론 (System Description)

In our research we used B-scan images obtained using commercial E-Cube 9 ultrasound machine. We used 128 element transducer (C1-6) with frequency range 1-6 Mhz. We examined multi purpose ultrasound phantom (CIRS 040 GSE). Phantom has series of gray scale targets. Hardware of E-Cube 9 was modified to allow directly access data from 64 channels. RF data was acquired in signal processing chain after analog digital converter (ADC). We resampled this data using 5 times lower sampling rate and used this data as an input to our compressive sensing approach of reconstructing original B-mode image.

III. 구현 (Implementation)

Compressive Sensing theory based on two ideas signal should have sparse representation in a given basis and sampling protocol should be incoherent to sparsifying basis. The idea of sparsity is states that if signal has sparse representation it can be compressed. In our research we used Fourier-domain for spars representation of signal because RF data is sufficiently sparse in this domain. Incoherence sampling is a requirement to sample basis to be not correlated with sparse basis. It simply can be done by making sampling protocol random. Mathematically we can write reconstruction of ultrasound images as $y=\Phi\Psi x$, where x is original signal of the length n, y - is random measurements of original signal of the length m, Φ - is a sensing basis. Ψ - is sparsifying basis. CS allows reconstruct signal x known only $m<n$ measurements y if x has sparse representation in certain domain.

Given m measurements of y and Φ,Ψ bases we reconstruct signal x of length n using Minimum L1 norm $\hat{x}=argmin \| x' \|_1$ such that $\Phi\Psi x'=y$.

Figure 1 shows an image obtained using L1 norm reconstruction of sparse signal using only 20% of original data.

IV. 결론 및 향후 연구 방향 (Conclusion)

Conventional ultrasound systems rely on Shanon-Nyquist sampling theorem. Compressive sensing has shown that sampling rate could be dropped and signal can be reconstructed with few measurements. We achieved 5 times drop in sampling rate and reconstructed B-mode imageonly with 20% of data needed for conventional approach. This advantage was achieved by solving underdetermined system of linear equations.

In our further work we would like to maximize efficiency of CS algorithm and, understand the limits of Compressive Sensing theory in medical ultrasound field. Future work also may include the study of taking RF signals in random unfocused wave manner instead of focused beam. This kind of approach may help robust acquisition time by avoiding scanning steps and simultaneously acquire reflected signals from all region of view.

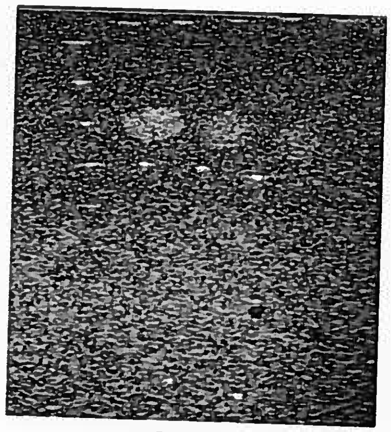

Figure 1. B-mode image achieved with only 20 % of original data

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