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Guest Editorial

COMMUNICATION SYSTEMS AND IMAGE PROCESSING TECHNOLOGY

Communication Systems Technology

Communication has become the implicit part of our daily lives. Telephones in our hand, radios and televisions in our living rooms, computer terminals with access to the internet in our offices and homes have become essential accessories for normal living. Communication provides the senses for ships/ submarines in the deep seas, aircraft in the flight and rockets/ satellite in space. Communication has become the back bone of modern warfare. The basic requirement in the Tactical Battle Area is to establish a flexible, robust, reliable and secure info structure. Major challenges for information warriors are to enhance communication ranges due to the wide dispersal of forces necessitated by the nuclear back drop and increased reach of weapon system and sensors, non-linear conduct of operations, non-availability of LOS communication, dense electromagnetic and hostile environment conditions. Another challenge is the management of the electromagnetic battle space where complexity is increasing exponentially due to development of more and more wireless devices. These challenges are further complicated by the fact that the tactical info-structure cannot be static.

At present, the wireless communications research communities are continuously working towards the activities for the fourth generation (4G) of communication systems. The community has generated a number of promising solutions for significant improvements in system performance. Adaptive coding and modulation, iterative (turbo) decoding algorithms, space–time coding, multiple antennas and MIMO channels, multicarrier modulation, multiuser detection and ultra wideband radio are examples of enabling technologies for 4G. Antenna arrays and MIMO technology is useful in urban warfare, where traditional communication platforms are unable to operate. It provides high bandwidth and adaptable communication allowing the message to get through regardless of the surrounding environment. MIMO technology harnesses the surrounding landscape to provide a highly reliable, adaptable and morphable communication link. Significant new results have also been reported in the field of channel modeling and measurements for these applications, including new frequency bands. It is now up to the industry to implement these solutions and make appropriate selections from the variety of possible options. In order to really benefit from this opportunity, the implementer/industry will have to accept higher complexity and perfection in the implementation; otherwise the accumulated implementation losses may degrade significantly the system performance.

Researchers have also started working towards the communication system using nanotechnology. The two alternative means of communication at the nanoscale are nano-electromagnetic communication and molecular communication. While the first is based on electromagnetic radiation from components based on nanomaterials, the latter communicates through information coded in molecules. In practice the nanoscale systems has the ability to participate in a mobile information network, light-weight smart battle-field suits, wearable intelligence such as sensors and displays for situational awareness and health monitoring.

The communication system has got very wide range in terms of frequency, range, throughput, size and application. It starts from the ELF communication where throughput is few bits per minute and antenna can be as big as the hemisphere of the earth, but the communication range is throughout the world till the Hiding point of submarine at the bottom of the deep sea, where no other communication is possible. At the other end, communication device may be as small as the molecule (nanoscale), which can have throughput in Terabits per second and can be injected in the blood of a human being for health caring/monitoring.

In the present special issue, some of these communication technologies have been presented in six research papers. Brief outlines of all the papers are given here.

In the paper 'Implementation of physical layer key distribution using software defined radios', by Kambala and co-authors from IIT Madras have analyzed the beneficial effects of combining channel coding with security protocols. They have presented a brief tutorial introduction to the Wiretap channel, followed by an application of the physical layer model to a class of key distribution protocols along with results from an implementation of key distribution protocols using software defined radio tools along with physical RF hardware peripherals.

Sekhar and co-authors in the paper 'Optimal 4G OFDMA dynamic subcarrier and power auction-based allocation towards H.264 scalable video transmission' have presented a price maximization scheme for optimal OFDMA subcarrier allocation for wireless video unicast/multicast scenarios. The proposed scheme is cognizant of the user modulation and code rate, and is hence amenable to adaptive modulation and coding (AMC) feature of 4G wireless networks. Further, a framework for optimal power allocation is also considered based on a novel revenue maximization scheme in orthogonal frequency division for multiple access (OFDMA) based wireless broadband 4G systems employing auction bidding models.

VLF communication is used for long range shore-to-ship broadcasting applications. In the paper 'An architecture for high data rate VLF communication', by Kumar and Bahl from CARE-IITD, an architecture for high data rate VLF communication using GMSK modulation and LDPC channel coding is proposed. It encompasses Non-data aided techniques for carrier phase synchronization, symbol timing recovery, and

LDPC code frame synchronization. They have described the modeling of atmospheric radio noise (ARN) which is a typical characteristic of VLF communication along with technique for signal enhancement in the presence of ARN. Under limited bandwidth conditions of 200 Hz, they have quantified the BER results for data rates of 400, 600 and 800 bps.

Kalamkar and Banerjee in their paper 'Improved double threshold energy detection for cooperative spectrum sensing in cognitive radio' have focused on cooperative spectrum sensing (CSS) in Cognitive Radio for double threshold improved energy detector. Using two-step optimization, the optimum fusion rule is found at fusion center along with optimum power corresponding to the lowest value of the minimized total error rate. They have also analyzed the effect of errors introduced in reported decisions due to imperfect reporting channel.

The Nyquist–Shannon sampling theorem is a fundamental result in the field of information theory, in particular telecommunications and signal processing. It has been almost thirty years since Shannon introduced the sampling theorem to communications theory. In a review paper titled 'Advances in Shannon sampling theory', by Sharma and co-authors, recent advances in the Shannon sampling theory are discussed. They have also talked about the work related to 1-D signal reconstruction involving the samples taken below the Nyquist rate using nonlinear/time-variant systems. Apart from this, the extensions of the sampling theorems to the fractional Fourier and Linear canonical transform domains are also discussed.

Agarwal and co-authors in their paper 'Strengthening the growth of Indian defence by harnessing nanotechnology - A prospective', have discussed the developing research area of nanotechnology with respect to strengthening the defence forces. Along with a brief overview of nanotechnology applications in defence sector, the challenges towards realization of protocols and network architectures for nanocommunication are studied. Nanotechnology research is fast moving forward and one can expect better protection for defence in the 'nanoage'.

Image Processing Technology

Over the years, image processing has become an integral part of various systems for applications in the area of medical diagnostics using computerized tomography, ultrasound, MRI; remote sensing for natural resource management, agriculture, weather forecasting, and damage assessment due to natural calamities and war. Image processing plays a very important role in satellite based surveillance for military applications.

The key issues in designing a satellite based surveillance system are the design of sensors for image acquisition and technology to process these images. The sensors should have high spatial resolution, high spectral resolution, day, night, and all weather capability and high revisit frequency. Advancement in sensor technology has achieved these requirements. High resolution panchromatic imageries are available with sub-meter spatial resolution. Multi-spectral and hyper-spectral data fulfils the need of high spectral resolution for resolving the targets at spectral level. Synthetic aperture radar technology is the solution to all weather and night time imaging. Advanced techniques are required to analyze and extract information from this varied type of data. Moreover, each type of imagery has specific characteristics and way of interpretation. Research has been carried out in this area for quite some time and is still continuing at full pace.

This issue of *Defence Science Journal* comprises of contribution from researchers in the field of technology development to process various types of imageries. Hyperspectral imaging captures the data in hundreds of narrow and contiguous spectral bands. This makes them possible to discriminate among various targets on earth surface at spectral level. Target detection is of particular interest in hyperspectral image analysis as many unknown and subtle signals (spectral response) unresolved by multispectral sensors can be discovered in hyperspectral images. The detection of signals in the form of small objects and targets from hyperspectral sensors has a wide range of applications both civilian and military. The paper titled 'Comparative assessment of some target detection algorithms for hyperspectral images', by Arora and co-authors is an excellent review in which the authors presented a detailed comparative study of three prominent target detection techniques applied to hyperspectral images. The most challenging problem in case of hyper spectral data analysis is the problem of spectral unmixing. The phenomena of spectral mixing occurs because the spectral resolution is much higher as compared to the spatial resolution and multiple materials are mapped in a single pixel. The paper titled 'Sub pixel target enhancement in hyperspectral images', by Arora and Tiwari addresses this problem. Spectral unmixing outputs both the end member spectrum and their corresponding abundance fractions inside the pixel. It, however, does not provide spatial distribution of these abundance fractions within a pixel. This limits the applicability of hyperspectral data for subpixel target detection. In this paper, a new inverse Euclidean distance based super-resolution mapping method has been presented.

Another important area is the synthetic aperture radar (SAR) data processing. Electro-optic sensors cannot monitor those areas on earth which are constantly under cloud coverage or where the changes are very minute. Being an active sensor, the SAR has the ability to overcome these difficulties. The paper titled 'Coherent change detection with COSMO SkyMed data – experimental results', by Mishra and co-authors presents the coherent change detection experimental studies using COSMO SkyMed space borne data. It has been demonstrated that subtle changes caused by the vehicle movement can be detected using phase characteristic of the SAR data.

An important task in automated image analysis is the discrimination of objects based on their appearance. Any object in the image can be described by its properties of appearance such as texture, color and shape. A large number of research papers are available in the literature in this area. In the review paper titled 'Global contour and region based shape analysis and similarity measures', by Chaudhuri treats various aspects of shape analysis and matching problems. This includes computation of various global contour and region based shape attributes, analysis of different similarity measures and selection of specific similarity measures to compute the similarity.

Three-dimensional visualization of the geographic data using a digital globe model has been an integral part of

a modern GIS system. The visualization of the digital globe model presents many challenges not found in traditional terrain visualization system. The representation of the digital earth (globe) model is important to efficiently render the geographical data without any distortion either at equator or polar regions. The paper titled 'Quad tree-based level-of-details representation of digital globe', by Porwal presents a uniform scheme for efficient quad tree-based level-of-details representation of the digital globe to minimize the distortion at polar regions and meets the requirement of fast frame rate rendering. These advancements in the area of image processing and GIS technology are going to change the dimension of the future warfare.

We are thankful to Editorial team of *Defence Science Journal* for devoting this special issue on Communication Systems and Image Processing Technology. We are thankful to all the contributors for submitting their research work for this special issue. We are indeed grateful to the reviewers for sparing their valuable time and providing expert comments on the papers. Finally we would like to thank Director DESIDOC and his team for their continuous and untiring effort in bringing out this special issue.

Mr Shanker Mahto
Scientist 'G'
Communication Signal Processing Group
Defence Electronics Applications Laboratory
Dehradun- 248 001, India
&
Dr Sangeeta Khare
Scientist 'G'
Image Analysis Center
Defence Electronics Applications Laboratory
Dehradun- 248 001, India