Final Report of CoE, Tezpur University

MHRD FAST SCHEME

1. Name of the Institute	Tezpur University
2. Name of the CoE	**Machine Learning Research and Big Data Analytics (MLRBDA)**
3. Name of the Centre Coordinator	Prof Dhruba Kr Bhattacharyya
4. Contact details (Email & Mobile No.)	Email : dkb@tezu.ernet.in Mobile : 09435381628 Telephone : 03712-273501, 275353 Fax : 03712-267006
5. Research Area	Machine Learning and Its Applications in • Network Security, • Bioinformatics, • NLP, • Rehabilitation Robotics, • Cognitive Radio Networks, and • Hyper-spectral Satellite Data Analysis
6. Date of Start	June, 2014
7. Total Fund allocated:	250.00 lakh
8. Total Fund received:	239.56 lakh
9. Expenditure as on 30 June 2017	**225,40,253**

10. Objectives of CoE

(i) Objectives/ Goals as stated in the proposal:

a) The development of intelligent tools, systems or approaches to support construction of large genome-wide co-expression and regulatory networks based on gene expression and PPI data for analysis, and identification of salient sub-graphs from those large networks can be of great help diagnosis of critical diseases.

b) The development of such intelligent approaches to support bio-signal processing and classification shall replicate the capability close to the anthropomorphic sensing system. The final goal is to customize the exiting indigenous robotic systems for rehabilitation of physically challenged people.

c) Development of a real time victim-end network anomaly detection system capable of identifying all classes of DDoS attacks with IP trace supported by a DDoS tolerant architecture can be of great use. In today's digital world such security mechanisms are essential for delivering the benefits of technology to the masses.
d) Creation of computational linguistic resources such as a TreeBank of some language of North-Eastern India.
e) Development some approach for domain specific information extraction from texts in the chosen Indian language
f) Development of some approach for generating natural language expressions in the chosen Indian language for domain specific information.
g) Development of Cognitive radio (CR) technology to enable growth in wireless applications and services for better communications for public safety community, which is in dire need of additional spectrum to enable broadband applications to their offices/officers such as police, fire and paramedic personnel.
h) Development of Cognitive radio (CR) technology that will provide a robust communications system and enable lower cost Internet access for underserved regions and tribal lands.

11. Progress made with respect to approved objectives/goals: *(not more than four pages)*

A. **Bioinformatics**

- *Several exhaustive surveys conducted and published in reputed (high Impact Factor) journals on*
  - Differential Co-expression Analysis over RNAseq Data,
  - Differential Expression Analysis over RNAseq Data,
  - Big data analytics in bioinformatics,
  - Discretization Techniques for Microarray Data,
  - Triclustering Techniques for Microarray Data,
  - Classification of Cancer Microarray Data, and
  - Biclustering Techniques in Biomarker Identification for Breast Cancer Patients
- *Developed a multiple tools to extract protein-protein interaction (PPI) complexes from PPI network using unsupervised graph-based approaches.*

We have introduced several clustering methods for protein-protein interaction complex finding using graph-density approach. It assumes that a protein complex in a PPI network is arranged as a relatively dense core region and additional proteins weakly connected to the core. We use two connectivity criterion functions to identify core and peripheral regions of the cluster. To support our complex finding methods, we also introduce unique measure called *DNQ (Degree based Neighborhood Qualification) index* that evaluates tendency of the node to be part of a cluster. Performance comparisons with its well-known counterparts establish the effectiveness of our methods.

- Developed a tool for PPI data analysis and ranking with an application to Alzheimer's disease.

We introduce a novel method called ComFiR to analyse PPI data to identify complexes and rank the diseased complexes. This method is evaluated in terms of positive predictive value, sensitivity and accuracy. The performance of the ranking approach has been established over Alzheimer patient data.

- Developed a parallel biclustering technique to identify key genes involved in ESCC.

We analyze gene expression data for esophageal squamous cell carcinoma (ESCC) using biclustering, gene–gene network topology and pathways to identify significant biomarkers. We introduce a parallel and robust biclustering algorithm to identify shifted, scaled and shifted-and-scaled biclusters of high biological relevance. Additionally, we introduce a mapping algorithm to establish the module–bicluster relationship across control and disease stages and a hub-gene identification method to support our analysis framework. The C-CUDA implementation of our biclustering algorithm makes the method attractive due to faster speed and higher accuracy of results. Biomarkers such as CCNB1, CDK4, and KRT5 have been found to be closely associated with ESCC.

- A robust triclustering technique called THD-Tricluster has been developed to analyse HIV-1 progression data.

It introduces a robust triclustering algorithm called THD-Tricluster to identify triclusters over the GST domain. In addition to applying over several benchmark datasets for its validation, the proposed THD-Tricluster algorithm was applied on HIV-1 progression data to identify disease-specific genes. THD-Tricluster could identify 38 most responsible genes for the deadly disease which includes GATA3, EGR1, JUN, ELF1, AGFG1, AGFG2, CX3CR1, CXCL12, CCR5, CCR2, and many others. The results are validated using GeneCard and other established results.

- Developing a robust method to identify disease biomarkers from gene networks for metastasized Breast Cancer.

A major concern in the area is the spread of cancerous cells, technically referred to as metastasis into other organs beyond the primary organ. Treatment in such a stage of cancer is extremely difficult and usually palliative only. In this study, we focus on finding gene-gene network modules which are functionally similar in nature in the case of breast cancer. These modules extracted during the disease progression stages are analyzed using p-value and their associated pathways. We also explore interesting patterns associated with the causal genes, viz., SCGB1D2, MET, CYP1B1 and MMP9 in terms of expression similarity and pathway contexts. We analyze the genes involved in both the stages– non metastasis and metastatsis and change in their expression values, their associated pathways and roles as the disease progresses from one stage to another. We discover three additional pathways viz., *Glycerophospholipid metablism*, *h-Efp pathway* and *CARM1* and *Regulation of Estrogen Receptor*, which can be related to the metastasis phase of breast cancer. These new pathways can be further explored to identify their relevance during the progression of the disease.

- Developed a robust network module extraction technique to support interesting gene identification for Alzheimer disease.

A method is introduced to construct co-expression network and to extract co-expressed modules having high biological significance. The proposed method has been validated on several well known microarray datasets extracted from a diverse set of species, using statistical measures, such as *p* and *q* values. The modules obtained in these studies are found to be biologically significant based on Gene Ontology enrichment analysis, pathway analysis, and KEGG enrichment analysis. Further, the method was applied on an Alzheimer's disease dataset and some interesting genes are found, which have high semantic similarity among them, but are not significantly correlated in terms of expression similarity. Some of these interesting genes, such as MAPT, CASP2, and PSEN2, are linked with important aspects of Alzheimer's disease, such as dementia, increase cell death, and deposition of amyloid-beta proteins in Alzheimer's disease brains. The biological pathways associated with Alzheimer's disease, such as, Wnt signaling, Apoptosis, p53 signaling, and Notch signaling, incorporate these interesting genes.

- A Fuzzy genome-wide network module extraction technique using integrated sources of gene expression information has been developed.

An effective genome-wide biologically relevant network module extraction technique based on fuzzy set theoretic approach has been introduced. The technique can handle both positive and negative correlations among genes. The constructed network for some benchmark gene expression datasets have been validated using topological internal and external measures. The effectiveness of network module extraction technique has been established in terms of well-known biological and topological statistics.

- A robust shifting-and-scaling correlation measure and a biclustering technique has been introduced to handle gene expression data.

The existence of various types of correlations among the expressions of a group of biologically significant genes poses challenges in developing effective methods of gene expression data analysis. The initial focus of computational biologists was to work with only absolute and shifting correlations. However, researchers have found that the ability to handle shifting-and-scaling correlation enables them to extract more biologically relevant and interesting patterns from gene microarray data. In this work, we introduce an effective shifting-and-scaling correlation measure named Shifting and Scaling Similarity (SSSim), which can detect highly correlated gene pairs in any gene expression data. We also introduce a technique named Intensive Correlation Search (ICS) biclustering algorithm, which uses SSSim to extract biologically significant biclusters from a gene expression data set. The technique performs satisfactorily with a number of benchmarked gene expression data sets when evaluated in terms of functional categories in Gene Ontology database.

B. **Network Security**

- Developed a complete detection and mitigation framework to protect a network from DDoS attacks.

In this paper we present a complete framework for detection and mitigation of different types of commonly seen deadly DDoS attacks. The system assumes bi-directional traffic information at an edge router to detect and mitigate the attacks. A router might not always see the outgoing traffic corresponding to the incoming traffic carried by the router and which has always been a problem for other approaches which assume bi-directionality of the traffic in the monitoring point. We introduce an agent-based technique which enables each edge router to validate the bi-directional nature of effectiveness of our detection and mitigation the incoming traffic passing through them. We present several experiments demonstrating the system. Also, we introduce a packet marking scheme called as XORID, which can be used to defend against spoofing based DDoS attacks.

- Developed a robust FPGA based victim-end DDoS defense solution for all types of DDoS attacks.

A real-time DDoS detection method is introduced that uses a novel correlation measure to identify DDoS attacks. Effectiveness of the method is evaluated with three network datasets, viz., CAIDA DDoS 2007, MIT DARPA, and TUIDS. Further, the proposed method is implemented on an FPGA to analyze its performance. The method yields high detection accuracy and the FPGA implementation requires less than one microsecond to identify an attack.

- Developed a dynamic DDoS defence system for DDoS attacks using Active Learning framework over ranked features.

This paper presents a parallel cumulative ranker algorithm to rank the attributes of a dataset for cost-effective classification of network traffic. We use MIT-DARPA, CAIDA, ISCX-IDS and TU-DDoS datasets to validate our method. Our feature ranking algorithm on large datasets (50,000-1,000,000 instances) finds best possible features from the above mentioned datasets and gives high accuracy (92%-97%) in a parallel environment, which takes significantly less time (71%-85% lower) than a sequential environment. We also discuss the importance of active learning to select appropriate instances by an expert module in an unsupervised way to train an SVM binary classifier for detection of DDoS attack traffic. Our approach selects small batches of training samples from a dataset to yield classification of network traffic with high accuracy. Our approach on large data provides better accuracy in classification with fewer training samples. A case study looks into the detection of intrusion in power systems.

- Developed a SQL Injection Attack detection method in authentication security.

To evaluate the existing practices of its detection, we consider two different security scenarios for the *web-application* authentication that generates dynamic SQL query with the user input data. Accordingly, we generate two different datasets by considering all possible vulnerabilities in the run-time queries. We present proposed approach based on *edit-distance* to classify a dynamic SQL query as *normal* or *malicious* using web-profile prepared with the dynamic SQL queries during training phase. We evaluate the dataset using proposed approach and some well-known supervised classification approaches. Our proposed method is found more effective in detecting SQL injection attack under both the scenarios of authentication security.

- Developed a Granger Causality based scheme to defend TCP Flooding Attacks

Malicious software events are usually stealthy and thus challenging to detect. A triggering relation can be assumed to be causal and to create a temporal relationship between the events. For example, in a spoofed TCP DDoS flooding attack, the attacker manipulates a threeway handshake procedure. During this attack, the number of spoofed IP addresses and the number of open ports used by the attacker follow a causal relationship. This paper demonstrates the effectiveness of Granger Causality in confirming TCP flooding attacks. We focus on discovering the presence of TCP-SYN flooding DDoS activity in network traffic by analyzing causal information in near real time.

- Developed an efficient feature selection method using information theoretic approach.

We introduce a greedy feature selection method using mutual information. This method combines both feature–feature mutual information and feature–class mutual information to find an optimal subset of features to minimize redundancy and to maximize relevance among features. The effectiveness of the selected feature subset is evaluated using multiple classifiers on multiple datasets. The performance of our method both in terms of classification accuracy and execution time performance, has been found significantly high for twelve real-life datasets of varied dimensionality and number of instances when compared with several competing feature selection techniques.

- Developed a multi-step outlier-based anomaly detection method.

In this paper, we present a multi-step outlier-based approach for detection of anomalies in network-wide traffic. We identify a subset of relevant traffic features and use it during clustering and anomaly detection. To support outlier-based network anomaly identification, we use the following modules: a mutual information and generalized entropy based feature selection technique to select a relevant non-redundant subset of features, a tree-based clustering technique to generate a set of reference points and an outlier score function to rank incoming network traffic to identify anomalies. We also design a fast distributed feature extraction and data preparation framework to extract features from raw network-wide traffic. We evaluate our approach in terms of detection rate, false positive rate, precision, recall and *F*-measure using several high dimensional synthetic and real-world datasets and find the performance superior in comparison to competing algorithms.

C. **Natural Language Processing**

1. A method has been developed to incorporate dialectal features in synthesised speech as a dimension of naturalness. Building systems that produces natural-sounding speech require considerable resources in the form of raw and annotated speech corpora. For less prominent dialects of languages such resources are generally scarce and hence, quality of synthesised speech is less than satisfactory. We have attempted to synthesise speech in a resource poor dialect by first producing speech in the more prominent variety of a language and then transforming that to the target dialect. For this the Assamese language as spoken in the news bulletins of All India Radio (AIR) is considered as the base variety and the Nalbaria variety as the target dialect. A Text-to-Speech (TTS) system for the AIR variety of Assamese is built using known methods and a speech corpus for training. Dialectal differences between the two varieties of the language are identified and attempts are made to apply the differences over the TTS output so as to obtain a speech in the target variety. Two approaches are tried for modification of the TTS output- first, Voice Conversion (VC) techniques are applied over the spectral as well as the prosodic features. In the second approach, Formant Transformation of the vowel formant space is performed. Both the approaches have produced encouraging results.

2. An HMM based Text To Speech System has been built using the HTS toolkit for synthesizing Assamese text.

3. Collected an un-annotated text corpus of Manipuri of about 18 million words. A portion of this corpus has been manually annotated.

4. Developed transliteration software for conversion of Manipuri texts into Unicode (UTF-8) format.

5. Studied the syntax structure of Manipuri text and identified issues related to ambiguity, word order, etc. We have developed a Context Free Grammar (CFG) for Manipuri and implemented techniques for parsing sentences of the language.

D. **Rehabilitation Robotics**

- Performed the classification of human emotions using EEG data via two classification tasks resulting in four-state classification of emotions.
- Proposed a collaborative control architecture for a robotic wheelchair with the aim of providing `assistance as required'. The architecture is based on cBDI - an extension to the Belief-Desire-Intention model to support human-machine collaboration.
- For a collaborative assistive device, human intent recognition (IR) is one of the first and foremost requirements. Formalizing the complex process of human IR in a compact yet expressive mathematical model holds promise. We put forward a Hierarchical Finite State Machine (H-FSM) for human IR within a generalized framework for collaborative assistive devices.
- We propose an efficient representation schema for extended objects together with a simple recursive algorithm to extract spatial information. We evaluate our approach and demonstrate that, for Human Activity Recognition, the spatial information thus extracted leads to better models for video understanding.
- Acquisition of EEG Motor Imagery Data with annotations of both mental fatigue and motor imagery.
- Selection of optimal features of EEG signal.
- Estimation of mental fatigue during EEG based Motor Imagery.
- Extraction of optimal spatio-temporal patterns of EEG signal.
- Minimizations of the size of EMG signal processing (8-bit) circuit board.
- Designing an embedded system for classification of two types of hand-grasp patterns using ON/OFF control in real time
- Designing an embedded system for classification of six types of hand-grasp patterns using SVM in real time.

E. **Cognitive Radio Networks**

- Developed a power allocation strategy for underlay Cognitive Radio Network.
- Developed a Cross-Layer based Location-Aware Forwarding using Distributed TDMA MAC protocol for Ad-hoc Cognitive Radio Network.
- Developed an Opportunity prediction at MAC layer sensing for Ad-hoc Cognitive Radio Network.
- Developed a Dynamic virtual backbone based routing scheme in Cognitive Radio Network.
- Developed a Constrain based Cooperative Spectrum Sensing scheme for Cognitive Radio Networks.
- Developed a Dynamic Threshold based Cooperative Spectrum Sensing using Coalitional Game for CRNs.
- Developed a capacity constraint distributed data dissemination protocol for Ad-hoc CRN.
- Developed a distributed solution for cooperative spectrum sensing scheduling for multiband cognitive radio networks
- Developed a DAMW: Double Auction Multi-Winner Framework for Spectrum Allocation in Cognitive Radio Networks
- Developed a Multi-Winner Heterogeneous Spectrum Auction Mechanism for Channel Allocation in Cognitive Radio Networks

F. **Hyper-spectral Satellite Data Analysis**

- Completed an exhaustive survey on hyper-spectral satellite data analysis using ensemble approaches.
- A method has been developed for hyper-spectral satellite data analysis using ensemble learning approach.
- An efficient hyper-spectral satellite data classification method has been developed using SVM approach.
- An efficient multi-spectral satellite data classification method has been developed using soft computing approach.

12. Work which remains to be done: *(not more than one page)*

A. Bioinformatics:

All the objectives have been achieved. Only testing works are remaining for some developed methods. Now, focusing on Single Cell RNAseq data analysis using Machine Learning approach.

B. Network Security:

All the objectives have been achieved. Only testing works are remaining for some developed methods. Now focusing on Malware and Malware-based attacks detection and mitigation.

C. Natural Language Processing:

Almost all the objectives have been achieved. Now-

1. We are identifying the tools and techniques required for processing natural language data available in different formats, viz., speech, scanned images of handwritten and printed texts, and digitized texts encoded in different coding schemes. Towards this end we are building a heterogeneous Assamese corpus.
2. Implement information extraction method for Assamese and Manipuri.
3. Implement natural language output expressions for information from databases.

D. Cognitive Radio Networks:

All the objectives have been achieved. Following minor works are remaining.

1. Implementation of an energy efficient prediction driven sensing technique using machine learning techniques.
2. Implementation of a robust cooperative spectrum sensing scheduling schemes for multi-channels CRNs.
3. Implementation of an energy efficient spectrum sharing technique in multi-channels overlay CRNs.

13. Publications (only publications listed in Scopus/Web of Science)

Title	Authors	Journals/ Conferences	Year	Vol.	No.	Pages
UIFDBC: Effective density based clustering to find clusters of arbitrary shapes without user input in	HA Chowdhury, DK Bhattacharyya, JK Kalita	Expert Systems with Applications, Elsevier	2021	186	--	115746
UICPC: Centrality-based Clustering for scRNA-seq Data Analysis without User Input	HA Chowdhury, DK Bhattacharyya, JK Kalita	Computers in Biology and Medicine, Elsevier	2021	137	--	104820
Identification of potential Parkinson's disease biomarkers using computational biology approaches	HA Chowdhury, Pankaj Barah, DK Bhattacharyya, JK Kalita	Network Modeling Analysis in Health Informatics and Bioinformatics, Springer	2021	10	1	1-16
PD_BiBIM: Biclustering-based biomarker identification in ESCC microarray data	Pallabi Patowary, Dhruba K Bhattacharyya	Journal of biosciences, springer	2021	46	3	1-18
DDoS attacks: Tools, mitigation approaches, and probable impact on private cloud environment	Rup Kumar Deka, Dhruba Kumar Bhattacharyya, Jugal Kumar Kalita,	Big Data Analytics for Internet of Things, John Wiley & Sons, Inc.	2021	--	--	285-319
Rank-preserving biclustering algorithm: a case study on miRNA breast cancer	Koyel Mandal, Rosy Sarmah, Dhruba Kumar Bhattacharyya, Jugal Kumar Kalita, Bhogeswar Borah	Medical & Biological Engineering & Computing, Springer	2021	59	4	989-1004
Cost Effective Method for Ransomware Detection: An Ensemble approach	Parthajit Borah, DK Bhattacharyya, JK Kalita	17th ICDCIT'21	2021			203-219
Hyperspectral Image Classification using Support Vector Machine: A Spectral	D.K. Pathak, S.K.Kalita, D.K.Bhattacharyya,	Evolutionary Intelligence.	2021			1-15

Spatial Feature Based Approach						
An Integrative Systems Biology Approach Identifies Molecular Signatures Associated with Gallbladder Cancer Pathogenesis	N Roy, M Kshattry, S Mandal, M K Jolly, D K Bhattacharyya, Pankaj Barah	Journal of clinical medicine	2021	10	16	3520
Determining crucial genes associated with COVID-19 based on COPD Findings	Pooja Sharma, Anuj K Pandey, Dhruba K Bhattacharyya	Computers in biology and medicine, Elsevier	2021	128	--	104126
KNN-DK: A Modified K-NN Classifier with Dynamic *k* Nearest Neighbors	Nazrul Hoque, Dhruba K Bhattacharyya, Jugal K Kalita	Advances in Applications of Data-Driven Computing, Springer	2021	--	--	21-34
Secure: An Effective Smartphone Safety Solution	Sampreet Kalita, Dhruba Kumar Bhattacharyya	Computational Intelligence in Pattern Recognition, Springer, Singapore	2020	--	--	621-633
Empirical Analysis of Proximity Measures in Machine Learning	Nazrul Hoque, Hasin A Ahmed, Dhruba Kumar Bhattacharyya	Computational Intelligence in Pattern Recognition	2020	--	--	399-411
NCBI: A Novel Correlation Based Imputing Technique Using Biclustering	H A Chowdhury, H A Ahmed, D K Bhattacharyya, Jugal K Kalita	Computational Intelligence in Pattern Recognition, Springer, Singapore	2020	--	--	509-519
Identifying critical genes in esophageal squamous cell carcinoma using an ensemble approach	Pallabi Patowary, Dhruba K Bhattacharyya, Pankaj Barah	Informatics in Medicine Unlocked, Elsevier	2020	18	--	100277
Detecting Gene Modules Using a Subspace Extraction Technique	Pooja Sharma, DK Bhattacharyya, Jugal K Kalita	Int'nl Conf on Intelligent Computing and Smart Comm. Springer, Singapore,	2020	--	--	311-318
Developing an effective biclustering technique	Pallabi Patowary, Rosy Sarmah,	Network Modeling Analysis in Health	2020	9	1	1-17

using an enhanced proximity measure	Dhruba K Bhattacharyya	Informatics and Bioinformatics				
X-Module: A novel fusion measure to associate co-expressed gene modules from condition-specific expression profiles	T Kakati, DK Bhattacharyya, JK Kalita	Journal of Biosciences	2020	45	1	1-13
Crucial Gene Identification for Esophageal Squamous Cell Carcinoma Using Differential Expression Analysis	P Patowary, DK Bhattacharyya,	International Conference on Machine Learning, Image Processing, Network Security and Data Sciences	2020	--	--	424-436
POPBic: Pathway-based Order Preserving Biclustering algorithm towards the analysis of gene expression data	Koyel Mandal, Rosy Sarmah, and Dhruba Kumar Bhattacharyya	IEEE/ACM Transactions on Computational Biology and Bioinformatics	2020	18	6	2659-2670
An effective approach for improving the accuracy of a random forest classifier in the classification of Hyperion data	Dibyajyoti Chutia, Naiwrita Borah, Diganta Baruah, Dhruba Kumar Bhattacharyya, PLN Raju, KK Sarma	Applied Geomatics	2020	12		95-105
Integrative network analysis identifies differential regulation of neuroimmune system in Schizophrenia and Bipolar disorder	A Sahu, HA Chowdhury, MGaikwad, C Chongtham, U Talukdar, J K Phukan, D K Bhattacharyya, Pankaj Barah	Brain, Behavior, & Immunity-Health	2020	2		100023
TUKNN: A Parallel KNN Algorithm to handle large Data doi: 10.1007/978-981-33-4788-	Parthajit Borah, Aguru Teja, Saurabh Anand Jha and D.K.Bhattacharyya	BigDML	2020			1--13
Implementation of Minimally Shared Blockchains using Big Data Applications	K. P. Kalita, D. Boro and D. K. Bhattacharyya	Third ISEA Conference on Security and Privacy (ISEA-ISAP), Guwahati, India	2020			48-54

XSSD: A Cross-site Scripting Attack Dataset and its Evaluation	U Sarmah, DK Bhattacharyya, JK Kalita	Third ISEA Conference on Security and Privacy (ISEA-ISAP), Guwahati, India,	2020			21-39
Singleton Flow Traceback (SFT) Mechanism	Ram Charan Baishya; D. K. Bhattacharyya	Third ISEA Conference on Security and Privacy (ISEA-ISAP), Guwahati, India	2020			139-140
A Complete Detection and Mitigation Framework to Protect a Network from DDoS Attacks	Baishya, R. C.; Bhattacharyya, D. K.	IETE Journal of Research	2019	67	7	1--18
A fast self-similarity matrix based method for shrew DDoS attack detection	D. Boro, M. Haloi and D K Bhattacharyya	Information Security Journal: A Global Perspective, Taylor and Francis	2020	29	2	73-90
Detection of Malicious Network Traffic using Machine Learning	Adirtha Borgohain, Sourish Sarmah, Dhruba K Bhattacharyya	International Conference on Recent Trends in Science & Technology	2020			
A Smart Feature Reduction Approach to Detect Botnet Attack in IoT	R. K. Deka, K. P. Kalita, D. K. Bhattacharyya, and D. Boro	EGTET'20, Guwahati, India	2020			17-23
Classification of Hyperspectral Image Using Ensemble Learning methods:A Comparative Study	D.K. Pathak, S.K.Kalita, D.K.Bhattacharyya	INDICON 2020, IEEE	2020			1-6
Malware Dataset Generation and Evaluation	Parthajit Borah, DK Bhattacharyya, JK Kalita	IEEE Conference on Information and Communication Technology	2020			1-6
An effective approach for improving the accuracy of a random forest classifier in the classification of Hyperion data	Chutia, D.; Borah, N.; Baruah, D.; Bhattacharyya, D. K.; Raju, P. L. N.; Sarma, K. K.	Applied Geomatics	2019	12	1	95--105

Defeating SQL injection attack in authentication security: an experimental study	Das, D.; Sharma, U.; Bhattacharyya, D. K.	International Journal of Information Security	2019	18	1	1--22
Active learning to detect DDoS attack using ranked features	Deka, R. K.; Bhattacharyya, D. K.; Kalita, J. K.	Computer Communications	2019	145		203-222
BicBioEC: biclustering in biomarker identification for ESCC	Kakati, P.; Bhattacharyya, D. K.; Kalita, J. K.	Network Modeling Analysis in Health Informatics and Bioinformatics	2019	8	1	1--21
Comparison of Methods for Differential Co-expression Analysis for Disease Biomarker Prediction	Kakati, T.; Bhattacharyya, D. K.; Barah, P.; Kalita, J. K.	Computers in Biology and Medicine	2019	113		103380
(Differential) Co-Expression Analysis of Gene Expression: A Survey of Best Practices	Chowdhury, H. A.; Bhattacharyya, D. K.; Kalita, J. K.	IEEE/ACM Transactions on Computational Biology and Bioinformatics	2018	17	4	1154--1173
Biomarker Identification for Cancer Disease Using Biclustering Approach: An Empirical Study	Mandal, Koyel; Sarmah, Rosy; Bhattacharyya, Dhruba Kumar	IEEE/ACM Transactions on Computational Biology and Bioinformatics	2019	16	2	490--509
MaNaDAC: An Effective Alert Correlation Method	Saikia, M.; Hoque, N.; Bhattacharyya, D. K.	Advances in Intelligent Systems and Computing	2019	740		249-260
Differential Expression Analysis of RNA-seq Reads: Overview, Taxonomy and Tools	Chowdhury, H. A.; Bhattacharyya, D. K.; Kalita, J. K.	IEEE/ACM Transactions on Computational Biology and Bioinformatics	2018	17	2	566--586
Subspace module extraction from MI-based co-expression network	Deb, S.; Mahanta, P.; Bhattacharyya, D. K.; Ananda Dutta, M.	International Journal of Bioinformatics Research and Applications	2018	14	3	207-234
A common neighbor based technique to detect protein complexes in PPI networks	Haque, M.; Sarmah, R.; Bhattacharyya, D. K.	Journal of Genetic Engineering and Biotechnology	2018	16	1	227-238
HLR_DDoS: A Low-Rate and High-Rate DDoS Attack Detection Method Using ? -Divergence	Hoque, N.; Bhattacharyya, D. K.	Lecture Notes in Networks and Systems	2018	24		655-662

PNME A gene-gene parallel network module extraction method	Jaiswal, B.; Utkarsh, K.; Bhattacharyya, D. K.	Journal of Genetic Engineering and Biotechnology	2018	16	2	447-457
THD-Tricluster: A robust triclustering technique and its application in condition specific change analysis in HIV-1 progression data	Kakati, T.; Ahmed, H. A.; Bhattacharyya, D. K.; Kalita, J. K.	Computational Biology and Chemistry	2018	75		154-167
A survey of detection methods for XSS attacks	Sarmah, U.; Bhattacharyya, D. K.; Kalita, J. K.	Journal of Network and Computer Applications	2018	118		113-143
DCRS: A Multi-objective Protein Complex Finding Method	Sharma, P.; Bhattacharyya, D.	Lecture Notes in Networks and Systems	2018	24		801-809
Detecting protein complexes based on a combination of topological and biological properties in protein-protein interaction network	Sharma, P.; Bhattacharyya, D. K.; Kalita, J. K.	Journal of Genetic Engineering and Biotechnology	2018	16	1	217-226
DDoS attack detection using unique source IP deviation	Baishya, R. C.; Hoque, N.; Bhattacharyya, D. K.	International Journal of Network Security	2017	19	6	929-939
DyProSD: a dynamic protocol specific defense for high-rate DDoS flooding attacks	Boro, D.; Bhattacharyya, D. K.	Microsystem Technologies	2017	23	3	593-611
mRMR$\mathplus$: An Effective Feature Selection Algorithm for Classification	Chowdhury, Hussain A.; Bhattacharyya, Dhruba K.	PReMI'17	2017			424--430
An effective ensemble classification framework using random forests and a correlation based feature selection technique	Chutia, D.; Bhattacharyya, D. K.; Sarma, J.; Raju, P. N. L.	Transactions in GIS	2017	21	6	1165-1178
Materialized view selection using evolutionary algorithm for speeding up big data query processing	Goswami, R.; Bhattacharyya, D. K.; Dutta, M.	Journal of Intelligent Information Systems	2017	49	3	407-433
An unsupervised method for detection of XSS attack	Goswami, S.; Hoque, N.; Bhattacharyya, D. K.; Kalita, J.	International Journal of Network Security	2017	19	5	761-775

An alert analysis approach to DDoS attack detection	Hoque, N.; Bhattacharyya, D. K.; Kalita, J. K.	2016 International Conference on Accessibility to Digital World, ICADW 2016 - Proceedings	2017			33-38
Real-time DDoS attack detection using FPGA	Hoque, N.; Kashyap, H.; Bhattacharyya, D. K.	Computer Communications	2017	110		48-58
A gene ontology based approach to protein complex detection	Mahanta, P.; Devi, N.; Bhattacharyya, D. K.; Kalita, J. K.	2016 International Conference on Accessibility to Digital World, ICADW 2016 - Proceedings	2017			129-134
Complex detection from PPI data using ensemble method	Nagi, S.; Bhattacharyya, D. K.; Kalita, J. K.	Network Modeling Analysis in Health Informatics and Bioinformatics	2017	6	1	1--13
Centrality analysis in PPI networks	Sharma, P.; Bhattacharyya, D. K.; Kalita, J. K.	2016 International Conference on Accessibility to Digital World, ICADW 2016 - Proceedings	2017			135-140
Disease biomarker identification from gene network modules for metastasized breast cancer /631/114 /692/699/67 /38 /13 article	Sharma, P.; Bhattacharyya, D. K.; Kalita, J.	Scientific Reports **NATURE**	2017	7	1	1-11
Protein complex finding and ranking: An application to Alzheimer?s disease	Sharma, P.; Bhattacharyya, D. K.; Kalita, J. K.	Journal of Biosciences	2017	42	3	383-396
Rank correlation for low-rate DDoS attack detection: An empirical evaluation	Ain, A.; Bhuyan, M. H.; Bhattacharyya, D. K.; Kalita, J. K.	International Journal of Network Security	2016	18	3	474-480
DDoS attacks: Evolution, detection, prevention, reaction, and tolerance	Bhattacharyya, D. K.; Kalita, J. K.	DDoS Attacks: Evolution, Detection, Prevention, Reaction, and Tolerance	2016			1-283
A multi-step outlier-based anomaly detection approach to network-wide traffic	Bhuyan, M. H.; Bhattacharyya, D. K.; Kalita, J. K.	Information Sciences	2016	348		243-271

E-LDAT: a lightweight system for DDoS flooding attack detection and IP traceback using extended entropy metric	Bhuyan, M. H.; Bhattacharyya, D. K.; Kalita, J. K.	Security and Communication Networks	2016	9	16	3251-3270
UDP flooding attack detection using information metric measure	Boro, D.; Basumatary, H.; Goswami, T.; Bhattacharyya, D. K.	Advances in Intelligent Systems and Computing	2016	408		143-153
Hyperspectral Remote Sensing Classifications: A Perspective Survey	Chutia, D.; Bhattacharyya, D. K.; Sarma, K. K.; Kalita, R.; Sudhakar, S.	Transactions in GIS	2016	20	4	463-490
Self-similarity based DDoS attack detection using Hurst parameter	Deka, R. K.; Bhattacharyya, D. K.	Security and Communication Networks	2016	9	17	4468-4481
Evaluating the effectiveness of soft K-Means in detecting overlapping clusters	Dkhar, R. A.; Nath, K.; Roy, S.; Bhattacharyya, D. K.; Nandi, S.	ACM International Conference Proceeding Series	2016			4
Approaches and issues in view selection for materialising in data warehouse	Goswami, R.; Bhattacharyya, D. K.; Dutta, M.; Kalita, J. K.	International Journal of Business Information Systems	2016	21	1	17-47
A Fuzzy Mutual Information-based Feature Selection Method for Classification	Hoque, N.; Ahmed, H. A.; Bhattacharyya, D. K.; Kalita, J. K.	Fuzzy Information and Engineering	2016	8	3	355-384
A novel measure for low-rate and high-rate DDoS attack detection using multivariate data analysis	Hoque, N.; Bhattacharyya, D. K.; Kalita, J. K.	2016 8th International Conference on Communication Systems and Networks, COMSNETS 2016	2016			1--2
Denial of service attack detection using multivariate correlation analysis	Hoque, N.; Bhattacharyya, D. K.; Kalita, J. K.	ACM International Conference Proceeding Series	2016			100--106
FFSc: a novel measure for low-rate and high-rate DDoS attack detection using multivariate data analysis	Hoque, N.; Bhattacharyya, D. K.; Kalita, J. K.	Security and Communication Networks	2016	9	13	2032-2041
A Fast Gene Expression Analysis using Parallel Biclustering and	Kakati, T.; Ahmed, H. A.; Bhattacharyya,	ACM International	2016			122

Distributed Triclustering Approach	D. K.; Kalita, J. K.	Conference Proceeding Series				
THD-Module Extractor: An Application for CEN Module Extraction and Interesting Gene Identification for Alzheimer's Disease	Kakati, T.; Kashyap, H.; Bhattacharyya, D. K.	Scientific Reports NATURE	2016	6	1	1--11
Big data analytics in bioinformatics: architectures, techniques, tools and issues	Kashyap, H.; Ahmed, H. A.; Hoque, N.; Roy, S.; Bhattacharyya, D. K.	Network Modeling Analysis in Health Informatics and Bioinformatics	2016	5	1	1--28
PDComp: An effective ppi complex finding method	Mahanta, P.; Bhattacharyya, D. K.; Ghosh, A.	ACM International Conference Proceeding Series	2016			123
Information Theoretic Approaches for Detecting Causality in Gene Regulatory Networks	Medhi, K.; Ahmed, S. S.; Roy, S.; Bhattacharyya, D. K.; Kalita, J. K.	ACM International Conference Proceeding Series	2016			128
Segmentation of cortical gray and white matters from MRI using density based clustering approach	Roy, S.; Bhattacharyya, D. K.	2015 International Symposium on Advanced Computing and Communication, ISACC 2015	2016			181-185
Analysis of gene expression patterns using biclustering	Roy, S.; Bhattacharyya, D. K.; Kalita, J. K.	Methods in Molecular Biology	2016	1375		91-103
Non-exclusive clustering: A partitioning approach	Agarwal, N.; Ahmed, H. A.; Bhattacharyya, D. K.	Proceedings - 2015 2nd International Conference on Emerging Information Technology and Engineering Solutions, EITES 2015	2015			7-12
Core and peripheral connectivity based cluster analysis over PPI network	Ahmed, H. A.; Bhattacharyya, D. K.; Kalita, J. K.	Computational Biology and Chemistry	2015	59		32-41
Strew index: An effective feature?class correlation measure	Ahmed, H. A.; Bhattacharyya, D. K.; Kalita, J. K.	Network Modeling Analysis in Health	2015	4	1	24

		Informatics and Bioinformatics				
An empirical evaluation of information metrics for low-rate and high-rate DDoS attack detection	Bhuyan, M. H.; Bhattacharyya, D. K.; Kalita, J. K.	Pattern Recognition Letters	2015	51		1-7
Towards generating real-life datasets for network intrusion detection	Bhuyan, M. H.; Bhattacharyya, D. K.; Kalita, J. K.	International Journal of Network Security	2015	17	6	683-701
Low-Rate and High-Rate Distributed DoS Attack Detection Using Partial Rank Correlation	Bhuyan, M. H.; Kalwar, A.; Goswami, A.; Bhattacharyya, D. K.; Kalita, J. K.	Proceedings - 2015 5th International Conference on Communication Systems and Network Technologies, CSNT 2015	2015			706-710
Botnet in DDoS Attacks: Trends and Challenges	Hoque, N.; Bhattacharyya, D. K.; Kalita, J. K.	IEEE Communications Surveys and Tutorials	2015	17	4	2242-2270
Lattice based secure data transmission in MANETs	Jasdanwala, F.; Dutta, N.; Bhattacharyya, D. K.	2014 IEEE International Conference on Computational Intelligence and Computing Research, IEEE ICCIC 2014	2015			1--5
MIPCE: An MI-based protein complex extraction technique	Mahanta, P.; Bhattacharyya, D. K.; Ghosh, A.	Journal of Biosciences	2015	40	4	701-708
TDAC: Co-expressed gene pattern finding using attribute clustering	Rahman, T. A.; Bhattacharyya, D. K.	International Journal of Bioinformatics Research and Applications	2015	11	1	45-71
Detecting protein complexes using connectivity among nodes in a PPI Network	Sharma, P.; Ahmed, H. A.; Roy, S.; Bhattacharyya, D. K.	Network Modeling Analysis in Health Informatics and Bioinformatics	2015	4	1	35
Unsupervised methods for finding protein complexes from PPI networks	Sharma, P.; Ahmed, H. A.; Roy, S.; Bhattacharyya, D. K.	Network Modeling Analysis in Health Informatics and Bioinformatics	2015	4	1	

Shifting-and-scaling correlation based biclustering algorithm	Ahmed, H. A.; Mahanta, P.; Bhattacharyya, D. K.; Kalita, J. K.	IEEE/ACM Transactions on Computational Biology and Bioinformatics	2014	11	6	1239-1252
A similarity measure for clustering gene expression data	Baishya, R. C.; Sarmah, R.; Bhattacharyya, D. K.; Dutta, M. A.	Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)	2014	8321		245-256
Information metrics for low-rate DDoS attack detection: A comparative evaluation	Bhuyan, M. H.; Bhattacharyya, D. K.; Kalita, J. K.	2014 7th International Conference on Contemporary Computing, IC3 2014	2014			80-84
Network anomaly detection: Methods, systems and tools	Bhuyan, M. H.; Bhattacharyya, D. K.; Kalita, J. K.	IEEE Communications Surveys and Tutorials	2014	16	1	303-336
Towards an unsupervised method for network anomaly detection in large datasets	Bhuyan, M. H.; Bhattacharyya, D. K.; Kalita, J. K.	Computing and Informatics	2014	33	1	1-34
Detecting distributed denial of service attacks: Methods, tools and future directions	Bhuyan, M. H.; Kashyap, H. J.; Bhattacharyya, D. K.; Kalita, J. K.	Computer Journal	2014	57	4	537-556
A model on achieving higher performance in the classification of hyperspectral satellite data: A case study on Hyperion data	Chutia, D.; Bhattacharyya, D. K.; Kalita, R.; Goswami, J.; Singh, P. S.; Sudhakar, S.	Applied Geomatics	2014	6	3	181-195
Fusion of fingerprint and iris biometrics using binary ant colony optimization	Gogoi, M.; Bhattacharyya, D. K.	Advances in Intelligent Systems and Computing	2014	258		601-613
MLH-IDS: A multi-level hybrid intrusion detection method	Gogoi, P.; Bhattacharyya, D. K.; Borah, B.; Kalita, J. K.	Computer Journal	2014	57	4	602-623
An effective measure corresponding to biological significance	Goyal, A.; Ahmed, H. A.; Bhattacharyya, D. K.	Network Modeling Analysis in Health Informatics and Bioinformatics	2014	3	1	
MIFS-ND: A mutual information-based	Hoque, N.; Bhattacharyya,	Expert Systems with Applications	2014	41	14	6371-6385

feature selection method	D. K.; Kalita, J. K.					
Network attacks: Taxonomy, tools and systems	Hoque, N.; Bhuyan, M. H.; Baishya, R. C.; Bhattacharyya, D. K.; Kalita, J. K.	Journal of Network and Computer Applications	2014	40	1	307-324
FUMET: A fuzzy network module extraction technique for gene expression data	Mahanta, P.; Ahmed, H. A.; Bhattacharyya, D. K.; Ghosh, A.	Journal of Biosciences	2014	39	3	351-364
Cluster analysis of cancer data using semantic similarity, sequence similarity and biological measures	Nagi, S.; Bhattacharyya, D. K.	Network Modeling Analysis in Health Informatics and Bioinformatics	2014	3	1	67
TDAC: Co-expressed gene pattern finding using attribute clustering	Rahman, T. A.; Bhattacharyya, D. K.	Advances in Intelligent Systems and Computing	2014	236		601-607
Reconstruction of gene co-expression network from microarray data using local expression patterns	Roy, S.; Bhattacharyya, D. K.; Kalita, J. K.	BMC Bioinformatics	2014	15		S10
Refining the features transferred from pre-trained inception architecture for aerial scene classification	Devi, Nilakshi; Borah, Bhogeswar	International Journal of Remote Sensing	2019			1–19
A Blind, Semi-Fragile 3D mesh Watermarking Algorithm Using Minimum Distortion Angle Quantization Index Modulation (3D-MDAQIM)	Borah, Sagarika; Borah, Bhogeswar	Arabian Journal for Science and Engineering	2019	44	4	3867–3882
Achieving Robustness of Mesh Watermarking Techniques Toward Mesh Geometry and Topology-Invariant Operations	Borah, Sagarika; Borah, Bhogeswar	Smart Intelligent Computing and Applications	2019			721–728
Improvement of query-based text summarization using word sense disambiguation	Rahman, Nazreena; Borah, Bhogeswar	Complex & Intelligent Systems	2019			

Watermarking Techniques for Three Dimensional (3D) Mesh Authentication in Spatial Domain	Borah, Sagarika; Borah, Bhogeswar	3D Research	2018	9	3	43
A Spell Correction Method for Query-Based Text Summarization	Rahman, Nazreena; Borah, Bhogeswar	Proceedings of the International Conference on Computing and Communication Systems	2018			337-345
Quantization index modulation (QIM) based watermarking techniques for 3D meshes	Borah, Sagarika; Borah, Bhogeswar	2017 Fourth International Conference on Image Information Processing (ICIIP)	2017			1–6
A Method for Semantic Relatedness Based Query Focused Text Summarization	Rahman, Nazreena; Borah, Bhogeswar	International Conference on Pattern Recognition and Machine Intelligence	2017			387–393
Context Sensitive Query Correction Method for Query-Based Text Summarization	Rahman, Nazreena; Borah, Bhogeswar	International Conference on Computational Science and Its Applications	2017			17–30
A survey on feature remeshing of 3D triangular boundary meshes	Borah, Sagarika; Borah, Bhogeswar	2016 International Conference on Accessibility to Digital World (ICADW)	2016			57–62
An Iterative Search based Technique to Find or Predict Older Face Images of a Child	Ahmed, Rustam Ali; Borah, Bhogeswar	International Journal of Computer Applications	2016	151	6	
On analysis of time-series data with preserved privacy	Chettri, Sarat Kumar; Borah, Bhogeswar	Innovations in Systems and Software Engineering	2015	11	3	155-165
Anonymizing Classification Data for Preserving Privacy	Chettri, Sarat kr.; Borah, B.	Security in Computing and Communications	2015			99-109

A survey on existing extractive techniques for query-based text summarization	Rahman, Nazreena; Borah, Bhogeswar	2015 International Symposium on Advanced Computing and Communication (ISACC)	2015			98-102
Defeating SQL injection attack in authentication security: an experimental study	Das, D., Sharma, U., Bhattacharyya, D.K.	International Journal of Information Security	2019	18	1	`1-22
Text-to-speech synthesis system for mymensinghiya dialect of bangla language	Begum, A., Askari, S.M.S., Sharma, U.	Advances in Intelligent Systems and Computing	2019	714		291-303
Problems and Issues in Parsing Manipuri Text	Nirmal, Y., Sharma, U.	Lecture Notes in Networks and Systems	2018	24		393-401
Development and analysis of speech recognition systems for assamese language using HTK	Sarma, H., Saharia, N., Sharma, U.	ACM Transactions on Asian and Low-Resource Language Information Processing	2017	17	1	7:1-1:14
Transforming the vowel/diphthong formants of one assamese variety to another: A GMM based Approach	Nath, S., Sharma, U.	2016 International Conference on Accessibility to Digital World, ICADW 2016 - Proceedings	2017			157-162
Named entity recognition in Assamese: A hybrid approach	Sharma, P., Sharma, U., Kalita, J.	2016 International Conference on Advances in Computing, Communications and Informatics, ICACCI 2016	2016			2114-2120
Phrase and Idiom Identification in Assamese	Borah, S.K., Sharma, U.	Procedia Computer Science	2016	84		65-69

A preliminary study on the VOT patterns of the assamese language and its nalbaria variety	Nath, S., Sarma, H., Sharma, U.	Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)	2014	8404		542-552
Named entity recognition in Assamese using CRF and rules	Sharma, P., Sharma, U., Kalita, J.	Proceedings of the International Conference on Asian Language Processing 2014, IALP 2014	2014			15-18
Development of Assamese speech corpus and automatic transcription using HTK	Sarma, H., Saharia, N., Sharma, U.	Advances in Intelligent Systems and Computing	2014	264		119-132
PKHSN: A bilinear pairing based key management scheme for heterogeneous sensor networks	Buragohain, M.,Sarma, N.	Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics) 11227 LNCS ,pp.102	2019	11227		102
A general framework for spectrum assignment in cognitive radio networks	Devi, M.,Sarma, N.,Deka, S.K.	Advances in Intelligent Systems and Computing 702 ,pp.163	2019			163
Performance of Dispersion-Reduced Wavelength Assignment in Wavelength-Routed Optical Networks	Chatterjee, B.C.,Sarma, N.,Mitra, A.,Srivastava, A.,Stol, N.,Oki, E.	International Conference on Transparent Optical Networks 2018-July	2018			

Dynamic Threshold based Cooperative Spectrum Sensing using Coalitional Game for CRNs	Deka, S.K.,Chauhan, P.,Sarma, N.	2018 5th International Conference on Signal Processing and Integrated Networks, SPIN 2018 ,pp.49	2018			49
Sequential bidding auction mechanism for spectrum sharing in cognitive radio networks	Devi, M.,Sarma, N.,Deka, S.K.,Chauhan, P.	11th IEEE International Conference on Advanced Networks and Telecommunications Systems, ANTS 2017 ,pp.1	2018			1
Efficient proactive channel switching in cognitive radio networks	Shil, S.,Chauhan, P.,Deka, S.Kr.,Sarma, N.	2017 Conference on Information and Communication Technology, CICT 2017 2018-April ,pp.1	2018			1
Scauth: Selective cloud user authorization for ciphertext-policy attribute-based access control	Sultan, N.H.,Barbhuiya, F.A.,Sarma, N.	Proceedings - 2017 IEEE International Conference on Cloud Computing in Emerging Markets, CCEM 2017 2018-January,pp.93	2018			93
PKSN: A pairing based key management scheme for heterogeneous sensor network	Buragohain, M.,Sarma, N.	2018 10th International Conference on Communication Systems and Networks, COMSNETS 2018 2018-January ,pp.198	2018			198
Utility Aware Cooperative Spectrum Sensing Using Coalitional Game Theory	Chauhan, P.,Sharma, M.,Deka, S.K.,Sarma, N.	Lecture Notes in Networks and Systems 24 ,pp.167	2018			167
Probability of Detection Analysis in Fading and Nonfading Scenario Using Cooperative Sensing Technique	Sharma, M.,Chauhan, P.,Sarma, N.	Lecture Notes in Networks and Systems 24 ,pp.197	2018			197

Effects of Various Factors on Performance of MAC Protocols for Underwater Wireless Sensor Networks	Roy, A.,Sarma, N.	Materials Today: Proceedings 5 (1) ,pp.2263	2018			2263
Spectrum allocation in cognitive radio networks—A centralized approach	Devi, M.,Sarma, N.,Deka, S.K.	Lecture Notes in Electrical Engineering 475 ,pp.92	2018			92
Applying classification methods for spectrum sensing in cognitive radio networks: An empirical study	Basumatary, N.,Sarma, N.,Nath, B.	Lecture Notes in Electrical Engineering 443 ,pp.85	2018			85
A Universal Cloud User Revocation Scheme With Key-Escrow Resistance for Ciphertext-Policy Attribute-Based Access Control	Sultan, N.H.,Barbhuiya , F.A.,Sarma, N.	ACM International Conference Proceeding Series ,pp.11	2017			11
A distributed solution for cooperative spectrum sensing scheduling in multi-band cognitive radio networks	Nath, A.,Sarma, N.	Journal of Network and Computer Applications 94 ,pp.69	2017	94		69
A Cross-Layer Based Location-Aware Forwarding Using Distributed TDMA MAC for Ad-Hoc Cognitive Radio Networks	Yarnagula, H.K.,Deka, S.K.,Sarma, N.	Wireless Personal Communications 95 (4) ,pp.4517	2017	95	4	4517
Signal type detection in CRN : A hierarchical modulation classification framework using SVM and decision tree approaches	Basumatary, N.,Sarma, N.,Nath, B.	2016 International Conference on Accessibility to Digital World, ICADW 2016 - Proceedings ,pp.6 3	2017			
Malware detection vectors and analysis techniques: A brief survey	Deka, D.,Sarma, N.,Panicker, N.J.	2016 International Conference on Accessibility to Digital World, ICADW 2016 - Proceedings ,pp.8 1	2017			

A brief review of cooperative spectrum sensing: Issues and challenges	Sharma, M.,Chauhan, P.,Sarma, N.	2016 International Conference on Accessibility to Digital World, ICADW 2016 - Proceedings ,pp.1 13	2017			
Allocation and access mechanisms for spectrum sharing in CRNs -A brief review	Devi, M.,Sarma, N.,Deka, S.K.	2016 International Conference on Accessibility to Digital World, ICADW 2016 - Proceedings ,pp.1 17	2017			
Opportunity prediction at MAC-layer sensing for ad-hoc cognitive radio networks	Deka, S.K.,Sarma, N.	Journal of Network and Computer Applications 82 ,pp.140	2017	82		140
Coalitional game theory based Cooperative Spectrum Sensing in CRNs	Gupta, J.,Chauhan, P.,Nath, M.,Manvithasree, M.,Deka, S.K.,Sarma, N.	ACM International Conference Proceeding Series	2017			
A reliable fault resilience scheme	Chatterjee, B.C.,Sarma, N.,Sahu, P.P.,Oki, E.	Lecture Notes in Electrical Engineering 410 ,pp.85	2017	410		85
Performance analysis of major conventional routing and wavelength assignment approaches	Chatterjee, B.C.,Sarma, N.,Sahu, P.P.,Oki, E.	Lecture Notes in Electrical Engineering 410 ,pp.35	2017	410		35
End-to-end traffic grooming	Chatterjee, B.C.,Sarma, N.,Sahu, P.P.,Oki, E.	Lecture Notes in Electrical Engineering 410 ,pp.45	2017	410		45
Introduction to optical network	Chatterjee, B.C.,Sarma, N.,Sahu, P.P.,Oki, E.	Lecture Notes in Electrical Engineering 410 ,pp.1	2017	410		1
Priority-based routing and wavelength assignment scheme	Chatterjee, B.C.,Sarma, N.,Sahu, P.P.,Oki, E.	Lecture Notes in Electrical Engineering 410 ,pp.51	2017	410		51

Literature survey	Chatterjee, B.C.,Sarma, N.,Sahu, P.P.,Oki, E.	Lecture Notes in Electrical Engineering 410 ,pp.17	2017	410		17
Priority-based dispersion-reduced wavelength assignment scheme	Chatterjee, B.C.,Sarma, N.,Sahu, P.P.,Oki, E.	Lecture Notes in Electrical Engineering 410 ,pp.65	2017	410		65
Limitations of conventional WDM optical networks and elastic optical networks for possible solutions	Chatterjee, B.C.,Sarma, N.,Sahu, P.P.,Oki, E.	Lecture Notes in Electrical Engineering 410 ,pp.101	2017	410		101
A QoS aware routing protocol in Wireless Sensor Networks with mobile base stations	Bhuyan, B.,Sarma, N.	ACM International Conference Proceeding Series 22-23-March-2016	2016			
Dynamic virtual backbone based routing in cognitive radio networks	Devi, M.,Sarma, N.,Deka, S.K.	International Symposium on Advanced Networks and Telecommunicatio n Systems, ANTS 2016-February	2016			
PairVoting: A secure online voting scheme using Pairing-Based Cryptography and Fuzzy Extractor	Sultan, N.H.,Barbhuiya , F.A.,Sarma, N.	International Symposium on Advanced Networks and Telecommunicatio n Systems, ANTS 2016-February	2016			
An Efficient TDMA MAC Protocol for Multi-hop WiFi-Based Long Distance Networks	Hussain, M.I.,Ahmed, Z.I.,Sarma, N.,Saikia, D.K.	Wireless Personal Communications 86 (4) ,pp.1971	2016	86	4	1971
Selection of communication carrier for underwater wireless sensor networks	Roy, A.,Sarma, N.	2015 International Symposium on Advanced Computing and Communication, ISACC 2015 ,pp.334	2016			334
A capacity constraint distributed data dissemination protocol for ad hoc cognitive radio networks	Deka, D.,Deka, S.K.,Sarma, N.	Advances in Intelligent Systems and Computing 409 ,pp.621	2016			621

A QoS-aware dynamic bandwidth allocation scheme for multi-hop WiFi-based long distance networks	Hussain, I.,Ahmed, Z.I.,Saikia, D.K.,Sarma, N.	Eurasip Journal on Wireless Communications and Networking 2015 (1)	2015			
Routing and Spectrum Allocation in Elastic Optical Networks: A Tutorial	Chatterjee, B.C.,Sarma, N.,Oki, E.	IEEE Communications Surveys and Tutorials 17 (3) ,pp.1776	2015	17	3	1776
Performance analysis of energy-efficient MAC protocols for underwater sensor networks	Roy, A.,Sarma, N.	2015 International Conference on Computing for Sustainable Global Development, INDIACom 2015 ,pp.297	2015			297
A QoS-aware multipath routing protocol for WiFi-based long distance mesh networks	Hussain, I.,Ahmed, N.,Saikia, D.K.,Sarma, N.	Proceedings on 2014 2nd International Conference on "Emerging Technology Trends in Electronics, Communication and Networking", ET2ECN 2014	2015			
Constraint based cooperative spectrum sensing for cognitive radio network	Deka, S.K.,Chauhan, P.,Sarma, N.	Proceedings - 2014 13th International Conference on Information Technology, ICIT 2014 ,pp.63	2014			63
PAPAR: Pairing based authentication protocol with anonymous roaming for wireless mesh networks	Sultan, N.H.,Sarma, N.	Proceedings - 2014 13th International Conference on Information Technology, ICIT 2014 ,pp.155	2014			155
A tightly synchronized TDMA MAC protocol for multi-hop WiFi-based long distance networks	Hussain, I.,Ahmed, Z.I.,Saikia, D.K.,Sarma, N.	International Conference on Ubiquitous and Future Networks, ICUFN ,pp.543	2014			543

A fine-tuned packet scheduling for WiFi-based long distance networks	Hussain, I.,Saikia, D.K.,Sarma, N.,Ahmed, N.	Proceedings - International Conference on 2014 Applications and Innovations in Mobile Computing, AIMoC 2014 ,pp.97	2014			97

14. Patents filed/to be filed: NIL

15. Technology transferred, if any: NIL

16. Manpower Trained:

a) (i) PhD Awarded :

Sl No	Name	Year	Supervisor(s)
1	Hiten Choudhury	2014	*Prof. D. K. Saikia*
2	Monowar Hussain Bhuyan	2014	*Prof. D. K. Bhattacharyya*
3	Nayan Moni Kakoty	2014	*Prof. S. M. Hazarika*
4	Bijoy Chand Chatterjee	2014	*Prof. N. Sarma, Prof. P. P. Sahu*
5	Pritpal Singh	2015	*Dr. B. Borah*
6	Bobby Sharma Kakoty	2015	*Prof. S. M. Hazarika, Prof. N. Sarma*
7	Minaskhi Gogoi	2015	*Prof. D. K. Bhattacharyya*
8	Navanath Saharia	2015	*Prof. U. Sharma*
9	Debasish Das	2015	*Prof. U. Sharma, Prof. D. K. Bhattacharyya*
10	Iftekhar Hussain	2015	*Prof. D. K. Saikia, Prof. N. Sarma*
11	Dibyajyoti Chutia	2015	*Prof. D. K. Bhattacharyya*
12	Udayan Baruah	2015	*Prof. S. M. Hazarika*
13	Sajid Nagi	2015	*Prof. D. K. Bhattacharyya*
14	Adity Saikia	2015	*Prof. S. M. Hazarika*
15	Dushyanta Dutta	2015	*Prof. D.K. Saikia Dr. Arindam Karmakar*
16	Sanjib Kr. Deka	2016	*Prof. N. Sarma*
17	Rajib Goswami	2016	*Prof. M. Dutta, Prof. D. K. Bhattacharyya*
18	Padmaja Sarmah	2016	*Prof. U. Sharma, Prof J K Kalita*
19	Rupam Baruah	2016	Prof. S. M. Hazarika
20	Priyakshi Mahanta	2016	*Prof. D. K. Bhattacharyya*
21	Bhaskar Bhuyan	2017	*Prof. N. Sarma*
22	Hasin Afjal Ahmed	2017	*Prof. D.K. Bhattacharyya*
23	Sarat Kumar Chettri	2017	*Prof. B. Borah*
24	Debojit Boro	2017	*Prof. D.K. Bhattacharyya*
25	Juwesh Binong	2017	*Prof. S.M. Hazarika*
26	Nazrul Hoque	2017	*Prof. D.K. Bhattacharyya*
27	Manoj Kr Muchahari	2017	*Prof S K Sinha*

28	Pooja Sharma	2018	*Prof D K Bhattacharyya*
29	Sobhanjana Kalita	2018	*Prof S M Hazarika*
30	Sanghamitra Nath	2018	*Prof U Sharma*

(ii) PhD Ongoing :

Names of PhD scholars enrolled	**Year of enrolment**
Mr Parthajit Borah	2017
Ms Upasona Sarmah	2017
Ms Pallabi Patowari	2017
Ms. Meenakshi Sharma	2017
Mr Hussain Choudhury	2016
Ms Manaswita Saikia	2016
Mr Yumnam Nirmal	2015
Ms Tulika Kakoty	2015
Ms. Monisha Devi	2015
Mr Prakash Chauhan	2015

b) Research Scientists or Research Associates:

1. Dr Mala Dutta
2. Mr Nazrul Hoque
3. Mr Ram Charan Baishya
4. Ms Tulika Kakoty
5. Mr Prakash Chauhan
6. Ms Upasona Talukdar
7. Ms Prarthana Dutta
8. Mr Rup Kr Deka
9. Mr Bikash Jaiswal
10. Mr Sampreet Kalita
11. Mr Manchjyoti Malakar, JRF (Speech Processing)
12. Ms Jyothi Garapathy
13. Ms. Minakshi Sharma
14. Ms. Monisha Devi

c) Other Technical Personnel trained :

1. Mr Bijoy Hazarika (Language lab)
2. Ms Anita Ghosh
3. Mr Mukhtarul Hoque
4. Ms Parineeta Kathbarua
5. Mr Purbarag Choudhury
6. Mr Chaitanya Borgohain

17. National/Int'nl Collaborations:

(a) University of Colorado at Colorado Springs, USA

(b) Prof. Christian Freksa, University of Bremen, Germany

(c) Prof. Eiji Oki,Professor, IEEE Fellow, IEICE Fellow, Communication and Computer Engineering Graduate School of Informatics, Kyoto University

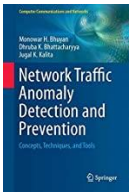
18.Any other achievements of the CoE:

(a) Books Authored in the field of network security:

- *Title* : ***Network Anomaly Detection : A Machine Learning Perspective***
  Authors : Prof D K Bhattacharyya and Prof J K Kalita (UCCS, USA)
  Publisher : CRC Press (a Taylor & Francis Gr)
  ISBN Number : 978-1466582088

- *Title* :***DDoS Attacks: Evolution, Detection, Prevention, Reaction and Tolerance***
  Authors : Prof D K Bhattacharyya and Prof J K Kalita (UCCS, USA)
  Publisher : CRC Press (a Taylor & Francis Gr)
  ISBN Number : 978-1498729642

- *Title* : ***Network Traffic Anomaly Detection and Prevention***
  Authors : Dr M H Bhuyan, Prof D K Bhattacharyya and Prof J K Kalita (UCCS, USA)
  Publisher : Springer



b) **Software Tools** developed to support disease diagnosis and network defence validation.

Sl	Tool name	Brief Description	Source
01	ComFiR	A protein-protein network complex finding and ranking tool to support diagnosis of disease like HIV1 and Alzheimer.	http://agnigarh.tezu.ernet.in/~dkb/resources.html (MATLAB Executable is available)
02	CNCM	An unsupervised connectivity based protein-protein interaction network (PPIN) complex finding tool.	http://agnigarh.tezu.ernet.in/~dkb/resources.html (MATLAB Executable is available)
03	ICS	A novel correlation measure for bicluster analysis of gene expression data. The measure is able to handle shifting, scaling and shifting-and-scaling patterns.	http://agnigarh.tezu.ernet.in/~dkb/resources.html (MATLAB Executable is available)
04	IFS-KNN	A tool for incremental feature selection and large data classification.	http://agnigarh.tezu.ernet.in/~dkb/resources.html (MATLAB Executable is available)
05	GO based PPI tool	A tool to extract biologically enriched complexes from PPI networks using GO semantic similarity.	http://agnigarh.tezu.ernet.in/~dkb/resources.html (C++ Executable is available)
06	THDTricluster	A robust tricluster algorithm-based tool to support diagnosis of time series gene expression data such as HIV1, Alzheimer, etc	http://agnigarh.tezu.ernet.in/~dkb/resources.html (MATLAB Executable is available)
07	TUCANNON	A robust tool to support generation of DDoS attacks of all types and their analysis.	http://agnigarh.tezu.ernet.in/~dkb/resources.html (C++ Executable is available)

c) Partially funded to organize –

Workshops Title	Venue	Date	Total Participants
Cyber Security" and "Knowing Cyber Attacks Adopting Honeynet	Tezpur University	6th and 7th March 2018	96
Machine Learning in R & Python	Tezpur University	28th Jan 2019 to 1st Feb 2019	70
Cyber Security Issues and Challenges	Tezpur University	29th and 30th Jan 2018	96
IoT and Security	Tezpur University	28th March 2017 to 28th March 2017	83
Workshop on High Performance Computing	Tezpur University	15th March 2017 to 16th March 2017	72

19. Is the CoE self-sustainable for future use : No

(D K Bhattacharyya)