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AI - IoT Integrated Railway Safety Framework for Real - Time Collision Mitigation and Animal Intrusion Detection

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ABSTRACT: Recent and next-generation wireless broadcasting standards, such as DVB-T2 or DVB-NGH, are considering distributed multi-antenna transmission in order to increase bandwidth efficiency and signal quality. The main goal is to combine diversity and spatial multiplexing in order to fully exploit the channel capacity. Full-rate full-diversity (FRFD) space-time codes (STC), such as the Golden code, have been reported to be excellent candidates, being their main drawback their detection complexity, which is enhanced when soft output is required when combined with a bit interleaved coded modulation (BICM) scheme based on low-density parity check (LDPC) codes. We present a novel low-complexity soft detection algorithm for the reception of Golden codes in LDPC based orthogonal frequency-division multiplexing (OFDM) systems. Complexity and simulation-based performance results are provided which show that the proposed detector performs close to the optimal detector in a variety of DVB-T2 broadcasting scenarios.

KEYWORDS: MAP detection, Space-Frequency Block Coding (SFBC), Low-density parity check (LDPC) codes, Orthogonal Frequency Division Multiplexing (OFDM).

I. INTRODUCTION

The second generation of the terrestrial digital video broadcasting standard (DVB-T2) [1] has adopted a space-frequency block code (SFBC) based on the well-known Alamouti technique. In order to increase the capacity and reach the full multiple-input multiple-output (MIMO) diversity-multiplexing frontier, the proposals for the future generations of terrestrial, portable and mobile digital video broadcasting standards, such as DVB-NGH, focus on the combination of both diversity and spatial multiplexing [2, 3] through full-rate full diversity (FRFD) codes such as the Golden code.The main disadvantage of Golden codes arises from their very high decoding complexity, which is enhanced when iterative decoders, such as turbo or low-density parity check (LDPC) codes, are included in the reception chain, since soft information on the conditional probabilities for all possible transmitted symbols is required in the form of log-likelihood

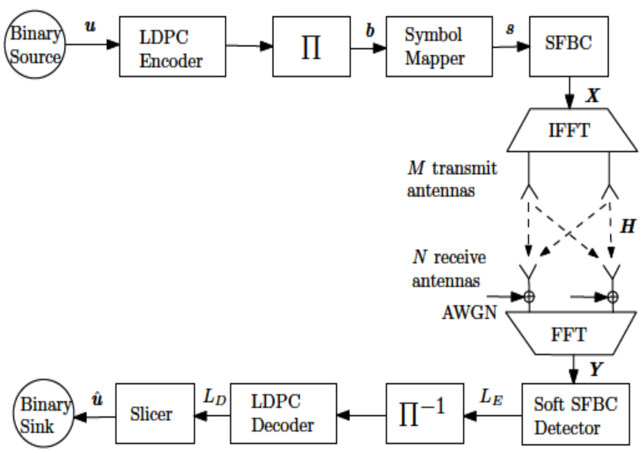

Figure 1 .Simplified diagram of a LDPC-based SFBC OFDM transmission and reception scheme based on DVB-T2.

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ratios (LLR), which is unfeasible for high constellation sizes.

This paper presents the design of a low-complexity soft detection algorithm for Golden codes in bit-interleaved coded modulation (BICM) OFDM systems based on LDPC coding. The generation of the candidate list is carried out by means of a fixed tree search, whose complexity does not depend on the channel conditions or the noise level. Since the complexity of the proposed soft detector is closely linked to the architecture of the tree search, we analyze different tree configurations in

Order to find the best balance between complexity and performance. Simulation results are provided for the Golden [14] code in a DVB-T2 framework [15]. Although this has been carried out on a terrestrial TV system.

The contribution of this paper is a new low-complexity soft detection algorithm for FRFD SFBC and its assessment in an LDPC-based BICM scenario. The generation of the candidate list is carried out by means of a fixed tree search, whose complexity does not depend on the channel conditions or the noise level. Since the complexity of the proposed soft detector is closely linked to the architecture of the tree search, we analyze different tree configurations in order to find the best balance between complexity and performance. Simulation results are provided for the Golden [14] and the FRFD Sezginer-Sari (SS) codes [8] in a DVB-T2 framework [15]. Although our research has been carried out on a terrestrial TV system, the results can be generalized for any MIMO bit interleaved coded modulation (MIMO-BICM) scheme.

In section II, we present the system model. In section III, we present the Fixed Complexity Detection. In section IV, we present the simulation results are discussed. Section VI concludes the paper.

II. SYSTEM MODEL

Fig. 1 shows the considered LDPC-coded OFDM scheme with two transmit (M = 2) and two receive (N = 2) antennas. As can be seen, the bit stream is coded, interleaved and mapped onto a complex constellation. Next, a vector of Q symbols **S** is coded into space and frequency forming the code word **X**, which is transformed into the time domain by an inverse fast Fourier transform (IFFT) block and transmitted after the addition of a cyclic prefix. At the receiver side, the prefix is removed, a fast Fourier transform (FFT) is carried out and the resulting signal **Y** of dimensions N×T can be represented mathematically as

$$Y = HX + Z \qquad (1)$$

Where H denotes the N × M complex channel matrix, X is any M×T codeword matrix composed by a linear combination of Q data symbols and Z represents the N × T zero-mean additive white Gaussian noise (AWGN) matrix whose complex coefficients fulfill $(\mathrm{CN}(0, 2\sigma)$, being σ2 the noise variance per real component. The design of the codeword X follows the criteria defined in [16], [17] and will provide full rate when Q = MT, being T the frequency depth of the codeword. By taking the elements column-wise from matrices X, Y and Z, equation (1) can be vectorized as

$$y = \breve{H}Gs + z \qquad (2)$$

where y, s and z are column vectors. The matrix $\breve{H}$ is the equivalent NT × MT MIMO channel written as

$$\breve{H} = \begin{bmatrix} H\dot{1} & \cdots & 0 \\ \vdots & \ddots & \vdots \\ 0 & \cdots & HT \end{bmatrix} \qquad (3)$$

where we have a block diagonal of channel realizations Hc at the carriers c = 1, . . . , T . The complex coefficient hcij corresponds to the channel from transmit antenna j to receive antenna i at the c-th carrier. The off-diagonal entries are zero matrices with dimensions N × M. The matrix G is the generator matrix for the SFBC such that X = Gs, where s corresponds to the symbol column vector [s1, . . . , sQ]T .

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III. FIXED-COMPLEXITY DETECTION

The design of efficient detection algorithms is one of the greatest challenges when implementing full-rate SFBC. Given the high complexity of performing an exhaustive search, special focus has been drawn into developing lower complexity detection algorithms that yield a close-to-ML performance. The LSD is one of the most remarkable approach but its complexity order is bounded by O(PQ) in the same way as the SD [9]. Even though the list of candidates corresponds to the set L of the smallest metrics, the complexity of performing such a selection may be considerably high for low signal-to noise ratio (SNR) scenarios. Furthermore, an unsuitable choice of the initial radius may lead to a shortage in candidate points, which forces the algorithm to restart with a looser sphere Constraint.

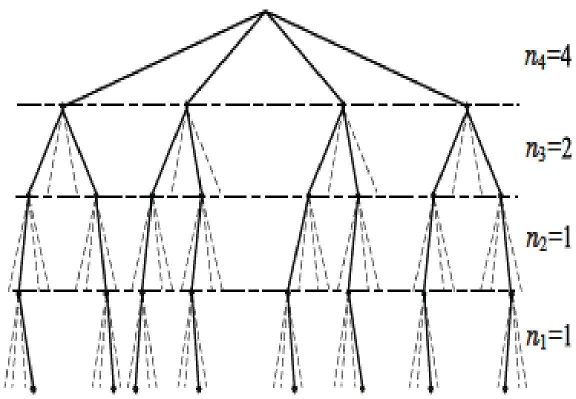

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Figure2. Fixed-complexity tree search of a QPSK-modulated signal using a tree configuration vector of n = [1, 1, 2, 4].

In order to limit the complexity and to facilitate the computation of soft detected symbols, a fixed-complexity tree-search style algorithm was proposed in [18] for spatial multiplexing schemes, coined list fixed-complexity sphere decoder (LFSD). The main feature of the LFSD is that, instead of constraining the search to those nodes whose accumulated Euclidean distances are within a certain radius from the received signal, the search is performed in an unconstrained fashion. The tree search is defined instead by a tree configuration vector n = [n1……nMT], which determines the number of child nodes (ni) to be considered at each level. Therefore, the tree is traversed level by level regardless of the sphere constraints. Once the bottom of the tree is reached, the detector retrieves a list of Ncand candidate symbol vectors. It is worth noting that the set G composed of the Ncand selected symbol vectors may not correspond to the vectors of the set L with the smallest metrics given by the LSD, but provides sufficiently small metrics and diversity of bit values to obtain accurate soft information. A representation of an LFSD tree search is depicted in Figure 2 for a QPSK modulation and a tree configuration vector of n = [1, 1, 2, 4].

3.1. Ordering algorithm

The performance of the LFSD soft-detector in un coded scenarios is strongly dependent on the ordering algorithm of the channel matrix and the choice of the tree configuration vector [7]. However, in the specific case of space-frequency-coded systems the effect of the ordering algorithm on the overall performance relies on the symbol power distribution in spatial and frequency directions. The structure of the Golden code generates a difference in the norms of the equivalent sub channels of each symbol in a pair, which allows for the implementation of an ordering procedure in order to improve the overall system's performance.

An important feature when considering the optimum ordering approach is the tree configuration vector that will shape the search tree. As opposed to the LFSD detector presented in [7], the tree configuration vector for the detection of the Golden Code has been set to n=[k,k,p,p], where k < p ,

p≤ Pand k<p. With such a tree structure, if p = P an exact ML search is performed in the first two levels of the tree, and therefore, there is no error propagation down to the next levels. Consequently, by ordering the equivalent channel matrix in such a way that the worst sub channel and the sub channel associated to the same pair are processed in the first two levels of the tree, respectively, the probability of finding vectors with smaller metrics is increased. The

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proposed matrix ordering process only requires the computation of MT vector norms as opposed to other ordering algorithms such as the FSD [7] or the V-BLAST [8], which need to perform MT - 1 matrix inversion operations.

Considering the generation of bit LLRs for the proposed list fixed-complexity detector, comply with the equivalent system using the set G of the LFSD:

$$L_E(b_k|Y) \approx \frac{1}{2}\min_{b\in\mathfrak{G}\cap\mathbb{B}_{k,+1}} \frac{1}{\sigma^2}\|y - H_{eq}s\|^2 + b_{[k]}^T L_{A,[k]}$$
$$-\frac{1}{2}\min_{b\in\mathfrak{G}\cap\mathbb{B}_{k,-1}} \frac{1}{\sigma^2}\|y - H_{eq}s\|^2 + b_{[k]}^T L_{A,[k]},$$

where for the sake of simplicity, the metric has been written as
_y −**H**eq**s**_2 with **H**eq = **H**˜ **G** as the effective equivalent channel.

IV. SIMULATION RESULTS

The performance of the overall system has been assessed by means of the bit error rate (BER) after the LDPC decoder. The bits of length of the LDPC block, code rate R = 2/3, 16-QAM modulation, OFDM symbol of 2048 carriers (2K) and 1/4 of guard interval. The simulations have been carried out over a Rayleigh channel (Typical Urban of six path, TU6), commonly used as the simulation environment for terrestrial digital television systems. Perfect CSI and non-iterative detection has been considered at the receiver.

4.1. Candidate choice

As has been previously stated, the calculation of the extrinsic information LE can be approximated using a list L or G with Ncand symbol vectors, respectively. When working with the ML metrics, i.e. the list L, the higher the number of candidates is, the more accurate the LE approximation is. Nevertheless, when considering the G list, the optimum value for Ncand will depend on the tree configuration vector **n**. Thus, the higher the value of nT , the better the approximation is. In order to choose a suitable number of candidates for the detection algorithm, a battery of tests have been carried out. Fig. 3 depicts the bit error performance after the detection stage for a given SNR of 14.4 dB and several values of Ncand and tree search configurations. The analyzed tree search configuration vectors **n** have been obtained by setting k = 1, 2, 3 and p = P, which is equivalent to calculating nT = P2, 4P2, 9P2 Euclidean distances, respectively. On one hand, one can observe that the list ML approximation (8) might be considered accurate enough for Ncand > 30. On the other hand, a similar behavior for the fixed-complexity detector can be noticed, where the higher the value of k, the better the performance we obtain. Furthermore, it is noticeable that the ordering algorithm provides a performance enhancement such that the k = 2 LFSD approximates the BER values of the exhaustive ML detector.

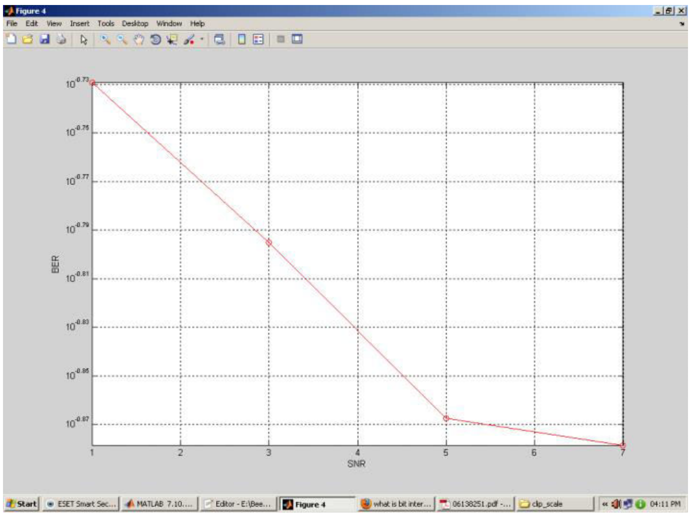

Figure 3 .BER performance of the LDPC-based SFBC OFDM transmission and reception scheme based on DVB-T2.

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4.2. Performance comparison over DVB-T2 BICM system

This section presents the performance assessment and the complexity analysis of the new list fixed-complexity soft detector of the Golden code over a SFBC DVB-T2 broadcasting scenario. Fig. 4 shows the BER curves versus SNR for different configurations of the proposed algorithm. It is noteworthy that the ordering algorithm provides a gain of 0.4 compared to the non-ordering case for nT = P2 in the case k = 1, p = P and Ncand = 50. In addition, the performance difference between LFSD and ordered LSD is 0.3 dB for the LFSD configuration k = 1, p = P and Ncand = 25. However, this grows up to 1.3 dB with a less complex configuration, i.e. k = 2, p = 8. On the other hand, one should note that the LSD performance difference between Ncand = 25 and 50 is negligible resulting advantageous in the complexity degree of the algorithm.

In order to analyze the complexity of the detection algorithms, the cumulative distribution functions of the overall visited nodes have been depicted in Fig. 5. We see that the reduction of Ncand decreases the complexity of the LSD decoder compared to the LFSD. For Ncand = 50, 75 % of the LSD solutions are obtained visiting lower number of nodes than the LFSD algorithm. If Ncand is reduced up to 25, this value rises to 95 %. Despite these differences, the sequential nature of the LSD tree search and its variable complexity results in a problem for real hardware implementations. Nevertheless, the design of LFSD makes it possible a parallel architecture of the algorithm that can be fully pipelined and maintains fixed the search complexity.

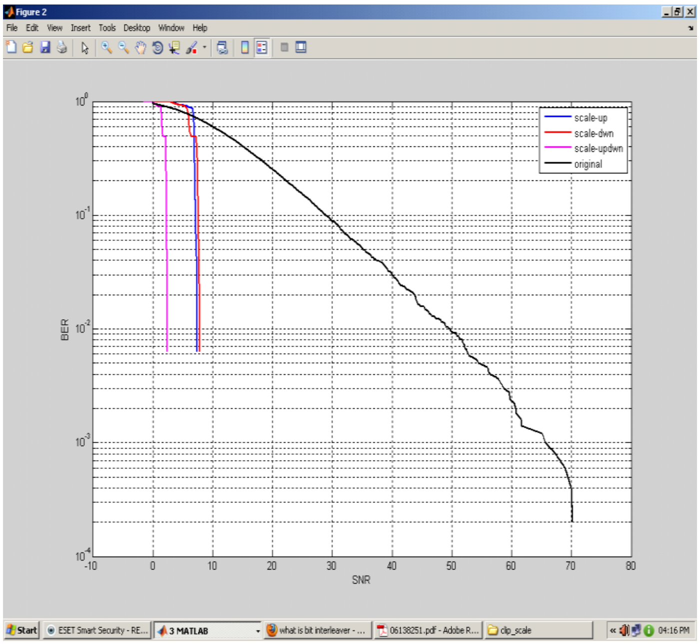

Figure3. BER performance of PAPR Reduction Based on Clipping and Differential Scaling

V. CONCLUSION

In this paper, we have presented a fixed-complexity detector for Golden codes and the analysis of its implementation on future digital TV broadcasting systems based on LDPC-coded BICM-OFDM. The main drawback of the LSD detection is its variable complexity that is strongly dependent on the noise and channel conditions, which leads to a complexity order upper-bounded by O(P4). A list fixed-complexity detector with a novel ordering algorithm is proposed in this paper with the aim of approaching the performance of the LSD using fixed complexity. The analysis of the number of candidates shows that the list approximation does not need a high list size in order to converge to the exact soft information value. Provided simulation results show that a close-to-optimal detection can be achieved considering a reduced number of candidates.

BER simulation results show the close-to-optimal performance of the proposed low-complexity detector in a typical LDPC-based DVB-T2 broadcasting scenario. The proposed detection algorithm can enable the realistic implementation and the inclusion of Golden codes in the forthcoming digital video broadcasting standards or in any similar BICM-OFDM system.

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REFERENCES

1. Low-Complexity Detection of Full-Rate SFBC in BICM-OFDM Systems, Iker Sobrón, Member, IEEE, Maitane Barrenechea, Member, IEEE, Pello Ochandiano, Lorena Martínez, Mikel Mendicute, Member, IEEE, and Jon Altuna,March 2012.
2. Sobron, M. Mendicute, and J. Altuna, "Full-rate full-diversity space- frequency block coding for digital TV broadcasting,"in Proc. European Signal Processing Conf. (EUSIPCO-2010),Aalborg, Denmark, August 2010.
3. S. Sezginer, H. Sari, and E. Biglieri, "On high-rate full-diversity 2 x 2 space-time codes with low-complexity optimum detection," IEEE Trans. Commun., vol. 57, no. 5, pp. 1532–1541, May 2009.
4. L. Barbero, "Rapid prototyping of a fixed-complexity sphere decoder and its application to iterative decoding of turbo-MIMO systems," Ph.D. dissertation, University of Edinburgh, 2006.
5. H. Zhu, B. Farhang-Boroujeny, and R.-R. Chen, "On performance of sphere decoding and Markov chain Monte Carlo detection methods," IEEE Signal Process. Lett., vol. 12, no. 10, p. 669–672, Oct. 2005.
6. C.Nagarajan and M.Madheswaran - 'Stability Analysis of Series Parallel Resonant Converter with Fuzzy Logic Controller Using State Space Techniques'- Taylor &Francis, Electric Power Components and Systems, Vol.39 (8), pp.780-793, May 2011. DOI: 10.1080/15325008.2010.541746
7. S.Thirunavukkarasu, C. Nagarajan, 2024, "Performance Investigation on OCF and SCF study in BLDC machine using FTANN Controller," Journal of Electrical Engineering And Technology, Volume 20, pages 2675–2688, (2025), doi.org/10.1007/s42835-024-02126-w
8. L. Barbero and J. Thompson, "Extending a fixed-complexity sphere decoder to obtain likelihood information for turbo-MIMO systems," IEEE Trans. Veh. Technol., vol. 57, no. 5, pp. 2804–14, Sep. 2008.
9. B. Hochwald and S. ten Brink, "Achieving near-capacity on a multipleantenna channel," IEEE Trans. Commun., vol. 51, no. 3, pp. 389– 399, 2003.
10. R. Wang and G. B. Giannakis, "Approaching MIMO channel capacity with reduced-complexity soft sphere decoding," in Proc. 2004 IEEE WCNC, pp. 1620–1625.
11. P. Radosavljevic, Y. Guo, and J. Cavallaro, "Probabilistically bounded soft sphere detection for MIMO-OFDM receivers: algorithm and system architecture," IEEE J. Sel. Areas Commun., vol. 27, no. 8, pp. 1318– 1330, 2009
12. COST207, "Digital land mobile radio communications (final report)," Commision of the European Communities, Directorate General Telecommunications, Information Industries and Innovation, Tech. Rep., 1989.
13. V. Tarokh, A. Naguib, N. Seshadri, and A. Calderbank, "Space-time codes for high data rate wireless communication: mismatch analysis," in Proc. 1997 IEEE Int. Conf. Commun., vol. 1, pp. 309–13.
14. J. Guey, M. Fitz, M. Bell, and W. Kuo, "Signal design for transmitter diversity wireless communication systems over Rayleigh fading channels," in Proc. 1996 IEEE VTC, vol. 1-3, pp. 136–140.
15. C.-P. Schnorr and M. Euchner, "Lattice basis reduction: improved practical algorithms and solving subset sum problems," in Proc. 1991 Fundamentals Computation Theory, pp. 68–85.
16. B. Hassibi and B. Hochwald, "High-rate codes that are linear in space and time," IEEE Trans. Inf. Theory, vol. 48, no. 7, pp. 1804–1824, 2002.
17. K. J. Kim and J. Yue, "Joint channel estimation and data detection algorithms for MIMO-OFDM systems," in Proc. 2002 Asilomar Conf. Signals, Syst., Comput., pp. 1857–1861.
18. J. Paredes, A. B. Gershman, and M. Gharavi-Alkhansari, "A 2 x 2 spacetime code with non-vanishing determinants and fast maximum likelihood decoding," in Proc. 2007 IEEE ICASSP, vol. 2, pp. 877–880.
19. X. Ma and G. B. Giannakis, "Full-diversity full-rate complex-field space-time coding," IEEE Trans. Signal Process., vol. 51, no. 11, pp. 2917–2930, 2003.
20. P. Wolniansky, G. J. Foschini, G. Golden, and R. Valenzuela, "VBLAST: an architecture for realizing very high data rates over the richscattering wirelss channel," in Proc. 1998 URSI Int. Symp. Signal. Syst. Electron., pp. 295–300.
21. Y. Nasser, J. Helard, and M. Crussière, "System level evaluation of innovative coded MIMO-OFDM systems for broadcasting digital TV," International J. Digital Multimedia Broadcasting, vol. 2008, pp. 1–12, 2008.
22. K.Prakashraj, G.Vijayakumar, S.Saravanan and S.Saranraj, "IoT Based Energy Monitoring and Management System for Smart Home Using Renewable Energy Resources," International Research Journal of Engineering and Technology, Vol.7, Issue 2, pp.1790-1797, 2020.
23. J Mohammed siddi, A. Senthil kumar, S.Saravanan, M. Swathisriranjani, "Hybrid Renewable Energy Sources for Power Quality Improvement with Intelligent Controller," International Research Journal of Engineering and Technology, Vol.7, Issue 2, pp.1782-1789, 2020.
24. T.R. Vignesh, M.Swathisriranjani, R.Sundar, S.Saravanan, T.Thenmozhi," Controller for Charging Electric Vehicles Using Solar Energy", Journal of Engineering Research and Application, vol.10, Issue.01,pp.49-53, 2020.

25. G. Poovarasan, S. Susikumar, S. Naveen, N. Mohananthini, S. Saravanan," Study of Poultry Fodder Passing Through Trolley in Feeder Box," International Journal of Engineering Technology Research & Management, vol.4, Issue.1, pp.76-83, 2020.
26. M.Revathi, S.Saravanan, R.Raja, P.Manikandan," A Multiport System for A Battery Storage System Based on Modified Converter with MANFIS Algorithm," International Journal of Engineering Technology Research & Management, vol.4, issue 2, pp.217-222, 2020.
27. D Boopathi, S Saravanan, Kaliannan Jagatheesan, B Anand, "Performance estimation of frequency regulation for a micro-grid power system using PSO-PID controller", International Journal of Applied Evolutionary Computation (IJAEC), Vol.12, Issue.4, pp.36-49, 2021.
28. V Kumarakrishnan, G Vijayakumar, D Boopathi, K Jagatheesan, S Saravanan, B Anand," Frequency regulation of interconnected power generating system using ant colony optimization technique tuned PID controller", Control and Measurement Applications for Smart Grid: Select Proceedings of SGESC 2021, pp..129-141.
29. G Vijayakumar, M Sujith, S Saravanan, Dipesh B Pardeshi, MA Inayathullaa," An optimized MPPT method for PV system with fast convergence under rapidly changing of irradiation", 2022 International Virtual Conference on Power Engineering Computing and Control: Developments in Electric Vehicles and Energy Sector for Sustainable Future (PECCON), pp.1-4.
30. VM Geetha, S Saravanan, M Swathisriranjani, CS Satheesh, S Saranraj, "Partial Power Processing Based Bidirectional Converter for Electric Vehicle Fast Charging Stations", Journal of Physics: Conference Series, Vol.2325, Issue.1, pp.012028, 2022.
31. M Santhosh Kumar, G Dineshkumar, S Saravanan, M Swathisriranjani, M Selvakumari, "Converter Design and Control of Grid Connected Hybrid Renewable Energy System Using Neuro Fuzzy Logic Model", 2022 Second International Conference on Computer Science, Engineering and Applications (ICCSEA), pp.1-6, 2022.
32. C Gnanavel, A Johny Renoald, S Saravanan, K Vanchinathan, P Sathishkhanna, "An Experimental Investigation of Fuzzy-Based Voltage-Lift Multilevel Inverter Using Solar Photovoltaic Application", Smart Grids and Green Energy Systems, pp.59-74, 2022.
33. V Kumarakrishnan, G Vijayakumar, D Boopathi, K Jagatheesan, S Saravanan, B Anand, "Optimized PSO technique based PID controller for load frequency control of single area power system", Solid State Technology, Vol.63. Issue.5, pp.7979-7990, 2020.
34. G. Poovarasan, S. Susikumar, S. Naveen, N. Mohananthini, S. Saravanan, "Implementation of IoT Based Poultry Feeder Box", International Journal of Innovative Research In Technology, Vol.6, Issue.2, pp.33-38, 2020.
35. N.Gokulnath, B.Jasim Khan, S.Kumaravel, Dr.A.Senthil Kumar and Dr.S.Saravanan, "Soldier Health and Position Tracking System", International Journal of Innovative Research In Technology, Vol-6 Issues 12, pp.39-45, 2020.
36. P.Navaneetha, R.Ramiya Devi, S.Vennila, P.Manikandan and Dr.S.Saravanan, " IOT Based Crop Protection System against Birds and Wild Animal Attacks", International Journal of Innovative Research In Technology, Vol-6 Issues 11, pp.133-143, 2020.
37. K. Punitha, M. Rajkumar, S. Karthick and Dr. S. Saravanan, " Impact of Solar And Wind Integration on Frequency Control System", International Research Journal of Engineering and Technology, Vol 7 Issue 3, pp.1357-1362,2020.
38. A.Arulkumar, S.Balaji, M.Balakrishnan, G.Dineshkumar and S.Saravanan, "Design And Implementation of Low Cost Automatic Wall Painting Machine" International Journal of Engineering Technology Research & Management, Vol-4 Issues 03, pp.170-176, 2020.
39. V.Periyasamy, S.Surya, K. Vasanth, Dr.G.Vijayakumar and Dr.S.Saravanan, "Design And Implementation of Iot Based Modern Weaving Loom Monitoring System" International Journal of Engineering Technology Research & Management, Vol-4 Issues 04, pp.11-18, 2020.
40. M.Yogheshwaran, D.Praveenkumar, S.Pravin, P.M.Manikandan and Dr.S.Saravanan, "IoT Based Intelligent Traffic Control System" International Journal of Engineering Technology Research & Management, Vol-4 Issues 04, pp.59-63, 2020.
41. R.Pradhap, R.Radhakrishnan, P.Vijayakumar, R.Raja and Dr.S.Saravanan, "Solar Powered Hybrid Charging Station For Electrical Vehicle" International Journal of Engineering Technology Research & Management, Vol-4 Issues 04, pp.19-27, 2020.
42. S.Shenbagavalli, T.Priyadharshini, S.Sowntharya, P.Manikandan and Dr.S.Saravanan, "Design and Implementation of Smart Traffic Controlling System" International Journal of Engineering Technology Research & Management, Vol-4 Issues 04, pp.28-36, 2020.
43. M.Pavithra, S.Pavithra, R.Rama Priya, M.Vaishnavee, M.Ranjitha and S.Saravanan, "Fingerprint Based Medical Information System Using IoT" International Journal of Engineering Technology Research & Management, Vol-4 Issues 04, pp.45-51, 2020.

44. A.Ananthan, A.M.Dhanesh, J.Gowtham, R.Dhinesh, G.Jeevitha and Dr.S.Saravanan, “IoT Based Clean Water Supply” International Journal of Engineering Technology Research & Management, Vol-4 Issues 03, pp.154-162, 2020.
45. R.Anbarsan, A.Arsathparvez, K.S.Arunachalam, M.Swathisriranjani and Dr.S.Saravanan, “Automatic Class Room Light Controlling Using Arduino” International Journal of Engineering Technology Research & Management, Vol-4 Issues 03, pp.192-201, 2020.
46. S.Karthikeyan, A.Krishnaraj, P.Magendran, T.Divya and Dr.S.Saravanan , “The Dairy Data Acquisition System” International Journal of Engineering Technology Research & Management, Vol-4 Issues 03, pp.163-169, 2020.
47. M.Amaran, S.Mannar Mannan, M.Madhu, Dr.R.Sagayaraj and Dr. S.Saravanan, “Design And Implementation of Low Cost Solar Based Meat Cutting Machine” International Journal of Engineering Technology Research & Management, Vol-4 Issues 03, pp.202-208, 2020.
48. N.Harish, R.Jayakumar, P.Kalaiyarasan, G.Vijayakumar and S. Saravanan, “IoT Based Smart Home Energy Meter” International Journal of Engineering Technology Research & Management, Vol-4 Issues 03, pp.177-183, 2020.
49. K.Subashchandrabose, G.Moulieshwaran, M.Raghul, V.Dhinesh and S.Saravanan, “Design of Portable Sanitary Napkin Vending Machine”, International Journal of Engineering Technology Research & Management, Vol-4 Issues 03, pp.52-58, 2020.
50. D.Hemalatha, S.Indhumathi, V.Myvizhi and S.Saravanan, “Design and Implementation of Intelligent Controller for Domestic Applications”, International Journal of New Innovations in Engineering and Technology, Vol.22, Issue.3, pp.4-7, 2023.
51. S. Divyasri, E. Indhu, M. P. Keerthana, M. Selvakumari and S. Saravanan, “Gas Cylinder Monitoring System using IoT”, International Journal of New Innovations in Engineering and Technology, Vol.22, Issue.3, pp.67-71, 2023.
52. J.Arul, R.Balaji, S.Jeyamoorthy, M.Manipathra, R.Sundar and S.Saravanan, “IoT based Air Conditioner Control using ESP32”, International Journal of New Innovations in Engineering and Technology, Vol.22, Issue.3, pp.48-52, 2023.
53. Vundel Munireddy, J.Prahathesvaran, C.R.Thirunavukarasu, M.Santhosh Kumar and S.Saravanan, “IoT Based Charge Controller for Direct Fast Charging of Electric Vehicles Using Solar Panel”, International Journal of New Innovations in Engineering and Technology, Vol.22, Issue.3, pp.77-81, 2023.
54. D.Monish Kumaar, K.Akash, S.Aswinkumar, S.Saravanan and R. Sagayaraj, “IoT based Industry Surveillance and Air Pollution Monitoring using Drones”, International Journal of New Innovations in Engineering and Technology, Vol.22, Issue.3, pp.14-18, 2023.
55. T.Silambarasan, R.Surya, J.Pravinkumar, R.Sundar and S Saravanan, “IoT based Monitoring System For Sewage Sweeper”, International Journal of New Innovations in Engineering and Technology, Vol.22, Issue.3, pp.88-93, 2023.
56. R.Aravinthan, Alwin.Augustin, P.Divagaran, S.Saravanan and P.Manikandan, “IoT Based Power Consumption and Monitoring System”, International Journal of New Innovations in Engineering and Technology, Vol.22, Issue.3, pp.43-47, 2023.
57. S.Partheeban, S.Sundaravel, S.Umapathi, R.Sagayaraj and S.Saravanan, “IoT based Safety Helmet for Mining Workers”, International Journal of New Innovations in Engineering and Technology, Vol.22, Issue.3, pp.116-120, 2023.
58. K.Eswaramoorthi, R.Manikandan, R.Balamurugan, C.Ramkumar and S.Saravanan, “Smart Parking System using IoT”, International Journal of New Innovations in Engineering and Technology, Vol.22, Issue.3, pp.53-57, 2023.
59. S.Nirmalraj, C.Pranavan, M.Prem and S.Saravanan, “Smart Trolley With IoT Based Billing System”, International Journal of New Innovations in Engineering and Technology, Vol.22, Issue.3, pp.111-115, 2023.
60. V.Gunasekaran, M.Gowtham , S. Anbubalaji, S.Saravanan and R.Prakash, “Solar based Electric Wheel Chair”, International Journal of New Innovations in Engineering and Technology, Vol.22, Issue.3, pp.8-13, 2023.
61. P Thava Prakash, P.Venketesan, D.Vignesh, S.Prakash, S.Saravanan, “Design of Low Cost E-Bicycle using Brushless DC Motor with Speed Regulator”, International Journal of New Innovations in Engineering and Technology, Vol.22, Issue.3, pp.148-153, 2023.
62. D.Tamilarasan, V.S.Vairamuthu, Y.Vasanth, K.Umadevi, S.Saravanan, “GSM based Agricultural Motor Control”, International Journal of New Innovations in Engineering and Technology, Vol.22, Issue.3, pp.172-177, 2023.
63. P. Vimal, S.Veerasigamani, R.Srihari, C.S.Satheesh, S.Saravanan, “IoT Based Optimal Power Management System For Smart Grid”, International Journal of New Innovations in Engineering and Technology, Vol.22, Issue.3, pp.160-165, 2023.

64. S.Abimanyu, P.Jagadheeswaran, S.Jaganath, K.Sanjay, R.Sivapranesh, K.Velmurugan, N.Mohananthini, C.S.Satheesh, S.Saravanan, "Portable Solar Tree", International Journal of New Innovations in Engineering and Technology, Vol.22, Issue.3, pp.154-159, 2023.
65. M.Karthikeyan, S.Bilalahamad, V.A.Chandru, V.Deepika and S.Saravanan, "Design and Development of IoT based Motor Starter", International Journal of New Innovations in Engineering and Technology, Vol.22, Issue.3, pp.178-183, 2023.
66. R.Anbarsan, A.Arsathparvez, K.S.Arunachalam, M.Swathisriranjani and S.Saravanan, "Automatic Class Room Light Controlling Using Arduino" International Journal of Engineering Technology Research & Management (IJETRM), Vol-4 Issues 03, pp.192-201, 2020.
67. S.Karthikeyan, A.Krishnaraj, P.Magendran, T.Divya and S.Saravanan , "The Dairy Data Acquisition System" International Journal of Engineering Technology Research & Management (IJETRM), Vol-4 Issues 03, pp.163-169, 2020.
68. N.Harish, R.Jayakumar, P.Kalaiyarasan, G.Vijayakumar and S. Saravanan, "IoT Based Smart Home Energy Meter" International Journal of Engineering Technology Research & Management (IJETRM), Vol-4 Issues 03, pp.177-183, 2020.
69. G. Poovarasan, S. Susikumar, S. Naveen, N. Mohananthini, S. Saravanan," Study of Poultry Fodder Passing Through Trolley in Feeder Box," International Journal of Engineering Technology Research & Management, vol.4, Issue.1, pp.76-83, 2020.
70. A.Ananthan, A.M.Dhanesh, J.Gowtham, R.Dhinesh, G.Jeevitha and S.Saravanan, "IoT Based Clean Water Supply" International Journal of Engineering Technology Research & Management (IJETRM), Vol-4 Issues 03, pp.154-162, 2020.
71. Ram Kumar C, Saravanan S, and Nagarajan C,"Hybrid LSTM and Deep Reinforcement Learning for Autonomous Battery Health Optimization in Electric Vehicles", Electrical Power Systems Research, Vol-253 Issues 112535, ISSN No:0378-7796,2025.
72. Gopinathan, V. R. (2024). Real-Time Fault-Tolerant Multi-Cloud Database Architectures for High Availability Applications. International Journal of Future Innovative Science and Technology (IJFIST), 7(4), 13148.
73. Chandra, S., Rengarajan, A., Sahoo, G. S., & Sharma, S. (2023, December). Identifying Neuronal Damage and Plasticity by Analyzing Changes in Diffusion Tensor Imaging. In International Conference on Data Science, Machine Learning and Applications (pp. 433-438). Singapore: Springer Nature Singapore.
74. Sugumar, R. (2025). Federated AI in Offline-First Mobile Health Architectures for Privacy-Preserving Clinical Intelligence. International Journal of Science, Research and Technology, 8(4), 14589-14600.
75. Murugeshwari, B., Rajalakshmi, S., & Sudharson, K. (2023). Hybrid Approach for Privacy Enhancement in Data Mining Using Arbitrariness and Perturbation. Computer Systems Science & Engineering, 44(3).
76. Pandey, V. K., Mishra, S., Rengarajan, A., Savita, & Roomi, M. M. (2024, March). Enhancing Weather Forecasting with Machine Learning Techniques. In International Conference on Renewable Power (pp. 147-156). Singapore: Springer Nature Singapore.
77. Soundappan, S. J. (2025). Next Generation AI Enabled Holistic Cognitive Platform for Secure Cloud Network Intelligence Enterprise Systems and Digital Trust Optimization. International Journal of Computer Technology and Electronics Communication, 8(5), 11534-11542.
78. Mathew, A. (2022). Leveraging Big Data Analytics to Power AI and ML (Machine Learning) Automation. Educational Research (IJMCER), 4(5), 131-134.
79. Sugumar, R. (2024). AI-Augmented Quality Engineering for Performance Optimization and Test Orchestration in Distributed Systems. International Journal of Science, Research and Technology, 7(5), 12835-12846.
80. Akila, R. (2024). A deep reinforcement learning approach for optimizing inventory management in the agri-food supply chain. J. Electrical Systems, 20(4s), 2238-2247.
81. Mahendran, M., Anbazhagan, K., Pavithran, G., Nivas, A., & Pandey, S. D. (2022). Earthquake Damage Prediction using Machine Learning. Grenze International Journal of Engineering & Technology (GIJET), 8(1).
82. Gopinathan, V. R. (2025). Enterprise AI Frameworks for Financial Data Engineering Behavioural Analytics and Intelligent Cloud Solutions. International Journal of Research Publications in Engineering, Technology and Management (IJRPETM), 8(4), 12499-12506.
83. Kondalsamy, P., & Kaliappan, K. (2025). An Optimal Prediction of Leaf Disease Based on Hybrid Deep Learnings and Metaheuristic Technique. Traitement du Signal, 42(1), 363.
84. Deivendran, P., Babu, P. S., Malathi, G., Anbazhagan, K., & Kumar, R. S. (2023). Emotion Recognition for Challenged People Facial Appearance in Social using Neural Network. arXiv preprint arXiv:2305.06842.
85. Sugumar, R. (2025). Unified AI Framework for Predictive Data Engineering and Real Time Prescription and Billing Systems. International Journal of Advanced Engineering Science and Information Technology (IJAESIT), 8(5), 17261.
86. Vekariya, V., Kumar, S., & Rengarajan, A. (2024). A distinctive and smart agricultural knowledge-based framework using ontology. In Sustainability in Digital Transformation Era: Driving Innovative & Growth (pp. 207-213). CRC Press.
87. Gopinathan, V. R. (2025). Software engineering practices for AI-driven systems: From development to deployment (MLOps perspective). International Journal of Science, Research and Technology, 8(1), 13493-13500.

88. Mathew, A. R. (2022). Threats and protection on E-sim: a prospective study. Novel Perspectives of Engineering Research, 8, 76-81.
89. Naveena, S., & Kavitha, K. (2025). Gossypium herbaceum: Folium disease identification and classification using Efficient Net-Coordinate Convolutional Neural Network (EcoNet). Engineering Applications of Artificial Intelligence, 152, 110701.
90. Rengarajan, A., Mishra, A., Kulhar, K. S., Shrivastava, V. P., & Alawneh, Y. J. J. (2024, March). Role of Deep Reinforcement Learning in Mitigating Cyber Security Issues: A Review. In International Conference on Renewable Power (pp. 37-48). Singapore: Springer Nature Singapore.
91. Achari, A. P. S. K., & Sugumar, R. (2024, November). Performance analysis and determination of accuracy using machine learning techniques for naive bayes and random forest. In AIP Conference Proceedings (Vol. 3193, No. 1, p. 020199). AIP Publishing LLC.
92. Mathew, A., & Alex, H. (2022). Detect & protect-medical device cybersecurity. Curr. Overview Sci. Technol. Res, 1, 60-68.
93. Sammy, F., Chettier, T., Boyina, V., Shingne, H., Saluja, K., Mali, M., ... & Shobana, A. (2025). Deep Learning-Driven Visual Analytics Framework for Next-Generation Environmental Monitoring. Journal of Applied Science and Technology Trends, 114-122.
94. Anbazhagan, K. (2024). Trustworthy and Adaptive AI Systems for Enterprise Analytics Cybersecurity and Decision Optimization Using API-First and Cloud-Native Architectures. International Journal of Technology, Management and Humanities, 10(03), 65-74.
95. Mathew, A. (2021). Deep reinforcement learning for cybersecurity applications. Int J Comput Sci Mob Compu, 10(12), 32-38.
96. Dhinakaran, D. (2022). Joe Prathap P. M, Selvaraj D, Arul Kumar D and Murugeshwari B," Mining Privacy-Preserving Association Rules based on Parallel Processing in Cloud Computing,". International Journal of Engineering Trends and Technology, 70(3), 284-294.
97. Karthika, K., Anusha, K., Kavitha, K., Harshadha, R., Dharshini, D. S., & Sundhar, N. A. (2025, April). Frequency Reconfigurable Antenna using Advanced Materials: A Study. In 2025 3rd International Conference on Advancements in Electrical, Electronics, Communication, Computing and Automation (ICAECA) (pp. 1-6). IEEE.
98. Thavamani, C., & Rengarajan, A. (2024). Clustering related behaviour of users by the use of partitioning and parallel transaction reduction algorithm. International Journal of Advanced Intelligence Paradigms, 29(2-3), 122-132.
99. Sugumar, R. (2025). Unified AI Framework for Predictive Data Engineering and Real Time Prescription and Billing Systems. International Journal of Advanced Engineering Science and Information Technology (IJAESIT), 8(5), 17261.
100. Soundappan, S. J., & Sugumar, R. (2016). Optimal knowledge extraction technique based on hybridisation of improved artificial bee colony algorithm and cuckoo search algorithm. International Journal of Business Intelligence and Data Mining, 11(4), 338-356.
101. SakthiPreetha, A., Kavitha, K., Karthika, K., & Manohari, R. G. (2025, April). A Novel Metasurface-Embedded Antenna for WBAN Communications. In 2025 3rd International Conference on Advancements in Electrical, Electronics, Communication, Computing and Automation (ICAECA) (pp. 1-4). IEEE.
102. Murugeshwari, B., Selvaraj, D., Sudharson, K., & Radhika, S. (2023). Data Mining with Privacy Protection Using Precise Elliptical Curve Cryptography. Intelligent Automation & Soft Computing, 35(1).
103. Gopinathan, V. R. (2025). Software engineering practices for AI-driven systems: From development to deployment (MLOps perspective). International Journal of Science, Research and Technology, 8(1), 13493-13500.
104. Anbazhagan, K., Kumar, R., Thilagavathy, R., & Anuradha, D. (2024, March). Shortest Job First with Gateway-based Resource Management Strategy for Fog Enabled Cloud Computing. In 2024 4th International Conference on Data Engineering and Communication Systems (ICDECS) (pp. 1-6). IEEE.
105. Kannadhasan, S., Vasuki, S., Kavitha, K., Karthikeyan, P., & Usha, S. G. A. (Eds.). (2025, April). Preface: Role of Artificial Intelligence and IoT in Engineering, Technology & Science [ICRAETS 2024]. In AIP Conference Proceedings (Vol. 3258, No. 1, p. 010001). AIP Publishing LLC.
106. Dhinakaran, D., Prathap, P. J., Selvaraj, D., Kumar, D. A., & Murugeshwari, B. (2022). Mining privacy-preserving association rules based on parallel processing in cloud computing. International Journal of Engineering Trends and Technology, 70(3), 284-294.