

## REFERENCES

---

- [1] Acharyya, A., Rakshit, S., Sarkar, R., Basu, S., and Nasipuri, M., (2013), "Handwritten Word Recognition Using MLP Based Classifier: A Holistic Approach," *International Journal of Computer Science Issues*, **10**(2), pp. 422–427.
- [2] Adak, C., Chaudhuri, B. B., and Blumenstein, M., (2016), "Offline Cursive Bengali Word Recognition Using CNNs with A Recurrent Model," *Proc. 15<sup>th</sup> International Conference on Frontiers in Handwriting Recognition*, Shenzhen, China, pp. 429–434.
- [3] Arani, S. A. A. A. , Kabir, E., and Ebrahimpour, R., (2019), "Handwritten Farsi Word Recognition Using NN-Based Fusion of HMM Classifiers with Different Types of Features," *International Journal of Image and Graphics*, **19**(1), pp. 1–21.
- [4] Arora, S., Bhattacharjee, D., Nasipuri, M., Basu, K. D., and Kundu, M., (2008), "Combining Multiple Feature Extraction Techniques for Handwritten Devnagari Character Recognition," *Proc. IEEE Region 10 and 3<sup>rd</sup> International Conference on Industrial and Information Systems (ICIIS)*, Kharagpur, India, pp. 1–6.
- [5] Assayony, M. O., and Mahmoud, S. A., (2017), "Integration of Gabor Features with Bag-of-Features Framework for Arabic Handwritten Word Recognition," *Proc. 9<sup>th</sup> IEEE-GCC Conference and Exhibition (GCCCE)*, Manama, Bahrain, pp. 1–4.
- [6] Bartnik, D. C., Govindaraju, V., Srihari, S. N., and Phan, B. C., (1998), "Postal Reply Card Processing," *Proc. 14<sup>th</sup> International Conference on Pattern Recognition (ICPR)*, Brisbane, Queensland, Australia, **1**, pp. 633–636.
- [7] Barua, S., Malakar, S., Bhowmik, S., Sarkar, R., and Nasipuri, M., (2017), "Bangla Handwritten City Name Recognition Using Gradient-Based Feature," *Proc. 5<sup>th</sup> International Conference on Frontiers in Intelligent Computing: Theory and Applications*, S. Satapathy, V. Bhateja, S. Udgata, P. Pattnaik, eds., *Advances in Intelligent Systems and Computing*, Springer, Singapore, **515**, pp. 343–352.

- [8] Basu, S., Das, N., Sarkar, R., Kundu, M., Nasipuri, M., and Basu, D. K., (2009), "A Hierarchical Approach to Recognition of Handwritten Bangla Characters," *Pattern Recognition*, **42**(7), pp. 1467–1484.
- [9] Bhowmik, S., Malakar, S., Sarkar, R., and Nasipuri, M., (2014a), "Handwritten Bangla Word Recognition Using Elliptical Features," *Proc. International Conference on Computational Intelligence and Communication Networks (CICN)*, Bhopal, India, pp. 257–261.
- [10] Bhowmik, S., Roushan, M. G., Sarkar, R., Nasipuri, M., Polley, S., and Malakar, S., (2014b), "Handwritten Bangla Word Recognition Using HOG Descriptor," *Proc. 4<sup>th</sup> International Conference on Emerging Applications of Information Technology*, Kolkata, India, pp. 193–197.
- [11] Bhowmik, S., Malakar, S., Sarkar, R., Basu, S., Kundu, M., and Nasipuri, M., (2019), "Off-Line Bangla Handwritten Word Recognition: A Holistic Approach," *Neural Computing and Applications*, **31**, pp. 5783–5798.
- [12] Bhunia, A. K., Das, A., Bhunia, A. K., Kishore, P. S. R., and Roy, P. P., (2019), "Handwriting Recognition in Low-Resource Scripts Using Adversarial Learning," *Proc. IEEE/CVF Conference on Computer Vision and Pattern Recognition (CVPR)*, Long Beach, CA, USA, pp. 4762–4771.
- [13] Bhunia, A. K., Mukherjee, S., Sain, A., Bhunia, A. K., Roy, P. P., and Pal, U., (2020), "Indic Handwritten Script Identification Using Offline-Online Multi-Modal Deep Network," *Information Fusion*, **57**, pp. 1–14.
- [14] Bianne-Bernard, A., Menasri, F., Mohamad, R. A., Mokbel, C., Kermorvant, C., and Likforman-Sulem, L., (2011), "Dynamic and Contextual Information in HMM Modeling for Handwritten Word Recognition," *IEEE Transactions on Pattern Analysis and Machine Intelligence*, **33**(10), pp. 2066–2080.
- [15] Blessie E. C., and Karthikeyan E., (2012), "Sigmis: A Feature Selection Algorithm Using Correlation Based Method," *Journal of Algorithms & Computational Technology*, **6**(3), pp. 385–394.
- [16] Blumenstein, M., and Verma, B., (1999), "A New Segmentation Algorithm for Handwritten Word Recognition," *Proc. International Joint Conference on Neural Networks '99 (IJCNN'99)*, Washington, DC, USA, **4**, pp.2893–2898.

- [17] Bouaziz, S., Mezghani, A., and Kanoun, S., (2014), "Arabic Handwritten Word Recognition with Large Vocabulary Based on Explicit Segmentation," *Proc. International Conference on Information and Communication Technologies Innovation and Application (ICTIA)*, Sousse, Tunisia, pp. 1–4.
- [18] Bouwhuis, D., and Bouma, H., (1979), "Visual Word Recognition of Three Letter Words as Derived from the Recognition of the Constituent Letters," *Perception and Psychophysics*, **25**, pp. 12–22.
- [19] Bozinovic, M. R., and Srihari, N. S., (1989), "Off-Line Cursive Script Word Recognition," *IEEE Transactions on Pattern Analysis and Machine Intelligence*, **11**(1), pp. 68–83.
- [20] Breiman, L., (1994), "Bagging Predictors," (PDF), Technical Report No. 421, Department of Statistics, University of California, Berkeley, California.
- [21] Breiman, L., (2001), "Random Forests," *Machine Learning*, **45** (1), pp. 5–32.
- [22] Cattell, J., (1886), "The Time Taken Up by Cerebral Operations," *Mind*, **11**, pp. 220–242.
- [23] Cattoni, R., Coianiz, T., Messoldi, S., and Modena, C. M., (1998), "Geometric Layout Analysis Techniques for Document Image Understanding: A Review," Technical Report No. 9703–09, ITC–irst, Trento, Italy.
- [24] Chaudhuri, B. B., Pal, U., and Mitra, M., (2002), "Automatic Recognition of Printed Oriya Script," *Sadhana*, **27**, pp. 23–34.
- [25] Cheikh, I. B., and Kacem, A., (2007), "Neural Network for the Recognition of Handwritten Tunisian City Names," *Proc. 9<sup>th</sup> International Conference on Document Analysis and Recognition (ICDAR)*, Parana, Brazil, pp. 1108–1112.
- [26] Chen, T., and Guestrin, C., (2016), "XGBoost: A Scalable Tree Boosting System," *Proc. 22<sup>nd</sup> ACM SIGKDD International Conference on Knowledge Discovery and Data Mining*, San Francisco, CA, USA, pp. 785–794.
- [27] Chherawala, Y., Roy, P. P., and Cheriet, M., (2016), "Feature Set Evaluation for Offline Handwriting Recognition Systems: Application to the Recurrent Neural Network Model," *IEEE Transactions on Cybernetics*, **46** (12), pp. 2825–2836.

- [28] Chowdhury, K., Alam, L., Sarmin, S., Arefin, S., and Hoque, M. M., (2015), "A Fuzzy Features Based Online Handwritten Bangla Word Recognition Framework," *Proc. 18<sup>th</sup> International Conference on Computer and Information Technology (ICCIT)*, Dhaka, Bangladesh, pp. 484–489.
- [29] Dai, R., Liu, C., and Xiao, B., (2007), "Chinese Character Recognition: History, Status and Prospects," *Frontiers of Computer Science in China*, **1**, pp. 126–136.
- [30] Das, S., and Banerjee, S., (2015), "An Algorithm for Japanese Character Recognition," *International Journal of Image, Graphics and Signal Processing*, **7**(1), pp. 9–15.
- [31] Das, S., Singh, P. K., Bhowmik, S., Sarkar, R., and Nasipuri, M., (2016), "A Harmony Search Based Wrapper Feature Selection Method for Holistic Bangla Word Recognition," *Procedia Computer Science*, **89**, pp. 395–403.
- [32] Dasgupta, J., Bhattacharya, K., and Chanda, B., (2016), "A Holistic Approach for Off-Line Handwritten Cursive Word Recognition Using Directional Feature Based on Arnold Transform," *Pattern Recognition Letters*, **79**, pp. 73–79.
- [33] Dash, M., and Liu, H., (2003), "Consistency-Based Search in Feature Selection," *Artificial Intelligence*, **151**, pp. 155–176.
- [34] De Oliveira, J. J., de A. Freitas, C. O., de Carvalho, J. M., and Sabourin, R., (2009), "Handwritten Word Recognition Using Multi-view Analysis," E. Bayro-Corrochano, J. O. Eklundh, eds., *Progress in Pattern Recognition, Image Analysis, Computer Vision, and Applications*, CIARP 2009, Lecture Notes in Computer Science, Springer, Berlin, Heidelberg, **5856**, pp. 371–378.
- [35] Dehghan, M., Faez, K., Ahmadi, M., and Shridhar, M., (2001), "Handwritten Farsi (Arabic) Word Recognition: A Holistic Approach Using Discrete HMM," *Pattern Recognition Letters*, **34**(5), pp. 1057–1065.
- [36] Dhandra, B. V., Mallikarjun, H., Hegadi, R., and Malemath, V. S., (2007), "Word-Wise Script Identification from Bilingual Documents Based on Morphological Reconstruction," *Proc. 1<sup>st</sup> International Conference on Digital Information Management*, Bangalore, India, pp. 389–394

- 
- [37] Dhiman, S., and Lehal, G. S., (2017), "Performance Comparison of Gurmukhi Script: k-NN Classifier with DCT and Gabor Filter," *International Journal of Advanced Research in Computer Science*, **8**(5), pp. 762–764.
- [38] Edelman, S., Flash, T., and Ullman, S., (1990), "Reading Cursive Handwriting by Alignment of Letter Prototypes," *International Journal of Computer Vision*, **5**(3), pp. 303–331.
- [39] Fan, D., Gao, G., and Wu, H., (2018), "MHW Mongolian Offline Handwritten Dataset and Its Application," *Journal of Chinese Information Processing*, **32**(1), pp. 89–95.
- [40] Farrahi, M. R., Cheriet, M., Adankon, M. M., Filonenko, K., and Wisnovsky, R., (2010), "IBN SINA: A Database for Research on Processing and Understanding of Arabic Manuscripts Images," *Proc. 9<sup>th</sup> IAPR International Workshop on Document Analysis Systems*, Boston, Massachusetts, USA, pp. 11–18.
- [41] Fernández-Delgado, M., Cernadas, E., Barro, S., and Amorim, D., (2014), "Do We Need Hundreds of Classifiers to Solve Real World Classification Problems," *Journal of Machine Learning Research*, **15**(1), pp. 3133–3181
- [42] Fisher, D.F., (1975), "Reading and Visual Search," *Memory and Cognition*, **3**, pp. 188–196.
- [43] Freund, Y., and Schapire, R. E., (1997), "A Decision-Theoretic Generalization of On-Line Learning and An Application to Boosting," *Journal of Computer and System Sciences*, **55**(1), pp. 119–139.
- [44] Gao, X., and Jin, L., (2012), "A Vision-Based Fast Chinese Postal Envelope Identification System," *Journal of Information Science and Engineering*, **28**(1), pp. 31–49.
- [45] Ghadhban H. Q., Othman M., Samsudin N. A., Ismail M. N. B., and Hammoodi M. R., (2020), "Survey of Offline Arabic Handwriting Word Recognition," *Proc. International Conference on Soft Computing and Data Mining*, R. Ghazali, N. Nawi, M. Deris, J. Abawajy, eds., Recent Advances on Soft Computing and Data Mining, Advances in Intelligent Systems and Computing, Springer, Cham, **978**, pp. 358–372.

- [46] Ghosh, R., and Roy, P. P., (2016), "Comparison of Zone-Features for Online Bengali and Devanagari Word Recognition Using HMM," *Proc. 15<sup>th</sup> International Conference on Frontiers in Handwriting Recognition (ICFHR)*, Shenzhen, China, pp. 435–440.
- [47] Ghosh, M., Malakar, S., Bhowmik, S., Sarkar, R., and Nasipuri, M., (2019), "Feature Selection for Handwritten Word Recognition Using Memetic Algorithm," *Advances in Intelligent Computing*, J. Mandal, P. Dutta, S. Mukhopadhyay, eds., Studies in Computational Intelligence, Springer, Singapore, **687**, pp. 103–124.
- [48] Gough, P.B., (1972), "One second of reading," J. F. Kavanagh and I. G. Mattingly, eds., *Language by ear and by eye: The relationship between speech and reading*, Massachusetts Institute of Technology, Cambridge, Massachusetts, United States.
- [49] Gowda, P. K., Chethan, S., Harsha, J., Rakesh, J., and Tanushree, K. N., (2017), "Offline Kannada Handwritten Word Recognition Using Locality Preserving Projections (LPP)," *International Journal of Innovative Research in Computer and Communication Engineering*, **5**(5), pp. 9955–9960.
- [50] Graves, A., Liwicki, M., Bunke, H., Schmidhuber, J., and Fernández, S., (2008), "Unconstrained On-Line Handwriting Recognition with Recurrent Neural Networks," *Proc. 21<sup>st</sup> Annual Conference on Neural Information Processing Systems*, Vancouver, British Columbia, Canada, pp. 577–584.
- [51] Gunter, S., and Bunke, H., (2004), "Optimization of Weights in a Multiple Classifier Handwritten Word Recognition System Using a Genetic Algorithm," *Electronic Letters on Computer Vision and Image Analysis*, **3**(1), pp. 25–41.
- [52] Gupta, J. D., Samanta, S., and Chanda, B., (2018), "Ensemble Classifier-Based Off-Line Handwritten Word Recognition System in Holistic Approach," *IET Image processing*, **12**(8), pp. 1467–1474.
- [53] Hafiz, A. M., and Bhat, G. M., (2016), "Arabic OCR Using A Novel Hybrid Classification Scheme," *Journal of Pattern Recognition Research*, **11**(1), pp. 55–60.

- [54] Hallale, S. B., and Salunke, G. D., (2013), "Twelve Directional Feature Extraction for Handwritten English Character Recognition," *International Journal of Recent Technology and Engineering (IJRTE)*, **2**(2), pp. 39–42.
- [55] Hamida, S., Cherradi, B., and Ouajji, H., (2020), "Handwritten Arabic Words Recognition System Based on HOG and Gabor Filter Descriptors," *Proc. 1<sup>st</sup> International Conference on Innovative Research in Applied Science, Engineering and Technology (IRASET)*, Meknes, Morocco, pp. 1–4.
- [56] Ibrayim, M., and Hamdulla, A., (2015), "On-Line Handwritten Uyghur Word Recognition Using Segmentation-Based Techniques," *International Journal of Signal Processing, Image Processing and Pattern Recognition*, **8**(6), pp. 51–60.
- [57] Idris, F., and Panchanathan, S., (1997), "Review of Image and Video Indexing Techniques," *Journal of Visual Communication and Image Representation*, **8**(2), pp. 146–166.
- [58] Ikram, S. T., and Cherukuri, A. K., (2017), "Intrusion Detection Model Using Fusion of Chi-Square Feature Selection and Multi Class SVM," *Journal of King Saud University - Computer and Information Sciences*, **29**(4), pp. 462–472.
- [59] Imani, Z., Ahmadyfard, A. R., and Zohrevand, A., (2016), "Holistic Farsi Handwritten Word Recognition Using Gradient Features," *Journal of Artificial Intelligence and Data Mining*, **4**(1), pp. 19–25.
- [60] Jaeger, S., Manke, S., Reichert, J., and Waibel, A., (2001), "Online Handwriting Recognition: the NPen++ Recognizer," *International Journal on Document Analysis and Recognition*, **3**(3), pp. 169–180.
- [61] Jayadevan, R., Kolhe, S. R., Patil, P. M., and Pal, U., (2011), "Database Development and Recognition of Handwritten Devanagari Legal Amount Words," *Proc. International Conference on Document Analysis and Recognition*, Beijing, China, pp. 304–308.
- [62] Jayech, K., Mahjoub, M., and Amara, N. B., (2016), "Arabic Handwritten Word Recognition Based on Dynamic Bayesian Network," *International Arab Journal of Information Technology*, **13**(6B), pp. 1024–1031.

- [63] Jino, P. J., and Balakrishnan, K., (2017), "Offline Handwritten Malayalam Word Recognition Using Wavelet Transform," *International Journal of Scientific Research in Computer Science, Engineering and Information Technology*, **2**(5), pp. 948–954.
- [64] Jino, P. J., Balakrishnan, K., and Bhattacharya, U., (2019), "Offline Handwritten Malayalam Word Recognition Using a Deep Architecture," J. Bansal, K. Das, A. Nagar, K. Deep, A. Ojha, eds., *Soft Computing for Problem Solving*, Advances in Intelligent Systems and Computing, Springer, Singapore, **816**, pp. 913–925.
- [65] Karim, A., and Kadhm, M. S., (2015a), "Handwriting Word Recognition Based on Neural Networks," *International Journal of Applied Engineering Research*, **10**(22), pp. 43120–43124.
- [66] Karim, A., and Kadhm, M. S., (2015b), "Handwriting Word Recognition Based on SVM Classifier," *International Journal of Advanced Computer Science and Applications*, **6**(11), pp. 64–68.
- [67] Kaur, H., and Kumar, M., (2019), "Benchmark Dataset: Offline Handwritten Gurmukhi City Names for Postal Automation", *Proc. Workshop on Document Analysis and Recognition, DAR 2018*, S. Sundaram, G. Harit, eds., Communications in Computer and Information Science, Springer, Singapore, **1020**, pp. 152–159.
- [68] Kessentini, Y., Paquet, T., and Hamadou, A. M. B., (2010), "Off-Line Handwritten Word Recognition Using Multi-Stream Hidden Markov Models," *Pattern Recognition Letters*, **31**(1), pp. 60–70.
- [69] Khemiri, A., Echi, A. K., Belaid, A., and Elloumi, M., (2016), "A System for Off-Line Arabic Handwritten Word Recognition Based on Bayesian Approach," *Proc. 15<sup>th</sup> International Conference on Frontiers in Handwriting Recognition*, Shenzhen, China, pp. 560–565.
- [70] Khlif, H., Prum, S., Kessentini, Y., Kanoun, S., and Ogier, J. M., (2016), "Fusion of Explicit Segmentation Based System and Segmentation-Free Based System for On-Line Arabic Handwritten Word Recognition," *Proc. 15<sup>th</sup> International Conference on Frontiers in Handwriting Recognition (ICFHR)*, Shenzhen, China, pp. 399–404.

- 
- [71] Kim, G., and Govindaraju, V., (1998), "Handwritten Phrase Recognition as Applied to Street Name Images," *Pattern Recognition*, **31**(1), pp. 41–51.
- [72] Kimura, F., Miyake, Y., and Sridhar, M., (1995), "Handwritten ZIP Code Recognition Using Lexicon Free Word Recognition Algorithm," *Proc. 3<sup>rd</sup> International Conference on Document Analysis and Recognition (ICDAR)*, Montreal, Quebec, Canada, **2**, pp. 906–910.
- [73] Kotsiantis, S.B., (2013), "Decision Trees: A Recent Overview," *Artificial Intelligence Review*, **39**, pp. 261–283.
- [74] Kumar, M., Jindal, M. K., and Sharma, R. K., (2013a), "PCA Based Offline Handwritten Gurmukhi Character Recognition," *Smart Computing Review*, **3**(5), pp. 346–357.
- [75] Kumar, M., Sharma, R. K., and Jindal, M. K., (2013b), "A Novel Feature Extraction Technique for Offline Handwritten Gurmukhi Character Recognition," *IETE Journal of Research*, **59**(6), pp. 687–692.
- [76] Kumar, M., Jindal, M. K., and Sharma, R. K., (2014a), "A Novel Hierarchical Technique for Offline Handwritten Gurmukhi Character Recognition," *National Academy Science Letters*, **37**(6), pp. 567–572.
- [77] Kumar, M., Jindal, M. K., and Sharma, R. K., (2014b), "Efficient Feature Extraction Techniques for Offline Handwritten Gurmukhi Character Recognition," *National Academy Science Letters*, **37**(4), pp. 381–391.
- [78] Kumar, M., and Chandran, S., (2015), "Handwritten Malayalam Word Recognition System Using Neural Networks," *International Journal of Engineering Research and Technology (IJERT)*, **4**(4), pp. 90–99.
- [79] Kumar, M., Jindal, M. K., Sharma, R. K., and Jindal, S. R., (2016), "Offline Handwritten Pre-Segmented Character Recognition of Gurmukhi Script," *Machine Graphics and Vision*, **25**(1), pp. 45–55.
- [80] Kumar, M., Jindal, M. K., and Sharma, R. K., (2017), "Offline Handwritten Gurmukhi Character Recognition: Analytical Study of Different Transformations," *Proc. National Academy of Sciences, India Section A: Physical Sciences*, **87**, pp. 137–143.

- [81] Kumar, M., Jindal, M. K., Sharma, R. K., and Jindal, S. R., (2018), "Performance Comparison of Several Feature Selection Techniques for Offline Handwritten Character Recognition," *Proc. International Conference on Research in Intelligent and Computing in Engineering (RICE)*, San Salvador, El Salvador, pp. 1–6.
- [82] Kumar, M., Jindal, S. R., Jindal, M. K., and Lehal, G. S., (2019), "Improved Recognition Results of Medieval Handwritten Gurmukhi Manuscripts Using Boosting and Bagging Methodologies," *Neural Processing Letters*, **50**, pp. 43–56.
- [83] Kumar, S., (2016), "A Study for Handwritten Devanagari Word Recognition," *Proc. International Conference on Communication and Signal Processing (ICCSP)*, Melmaruvathur, India, pp.1009–1014.
- [84] Lee, H., and Verma, B., (2011), "Binary Segmentation Algorithm for English Cursive Handwriting Recognition," *Pattern Recognition*, **45**(4), pp. 1306–1317.
- [85] Lehal, G. S., and Singh, C., (2002), "A Post-Processor for Gurmukhi OCR," *Sadhana*, **27**(1), pp. 99–111.
- [86] Li, H., Doermann, D., and Kia, O., (2000), "Automatic Text Detection and Tracking in Digital Video," *IEEE Transactions on Image Processing*, **9**(1), pp. 147–156.
- [87] Liu, L., Koga, M., and Fujisawa, H., (2002), "Lexicon Driven Segmentation and Recognition of Handwritten Character Strings for Japanese Address Reading," *IEEE Transactions on Pattern Analysis and Machine Intelligence (PAMI)*, **24**(11), pp. 1425–1437.
- [88] Liu, L., Lu, S., Lu, Y., and Suen, C. Y., (2014), "Application of PR Techniques to Mail Sorting in China," *Proc. International Conference on Computer Science & Software Engineering (C3S2E)*, Montreal, QC, Canada, pp. 1–7.
- [89] Liu, J., Ma, L. -L. and Wu, J., (2016), "Online Handwritten Mongolian Word Recognition Using MWRCNN and Position Maps," *Proc. 15<sup>th</sup> International*

- Conference on Frontiers in Handwriting Recognition (ICFHR)*, Shenzhen, China, pp. 60–65.
- [90] Lu, L., Pei-liang, Y., Wei-wei, S., and Jian-wei, M., (2017), "Similar Handwritten Chinese Character Recognition Based on CNN-SVM," *Proc. International Conference on Graphics and Signal Processing*, Singapore, pp. 16–20.
- [91] Ma, L.-L., Liu, J., and Wu, J., (2016), "A New Database for Online Handwritten Mongolian Word Recognition," *Proc. 23<sup>rd</sup> International Conference on Pattern Recognition (ICPR)*, Cancun, Mexico, pp. 1131–1136.
- [92] Madhvanath, S., and Govindaraju, V., (2001), "The Role of Holistic Paradigms in Handwritten Word Recognition," *IEEE Transactions on Pattern Analysis and Machine Intelligence*, **23**(2), pp. 149–164.
- [93] Mahadevan, U., and Srihari, S. N., (1999), "Parsing and Recognition of City, State, and ZIP Codes in Handwritten Addresses," *Proc. 5<sup>th</sup> International Conference on Document Analysis and Recognition (ICDAR'99)*, Bangalore, India, pp. 325–328.
- [94] Malakar, S., Sharma, P., Singh, P. K., Das, M., Sarkar, R., and Nasipuri, M., (2017), "A Holistic Approach for Handwritten Hindi Word Recognition," *International Journal of Computer Vision and Image Processing*, **7**(1), pp. 59–78.
- [95] Malakar, S., Ghosh, M., Bhowmik, S., Sarkar, R., and Nasipuri, M., (2020), "A GA Based Hierarchical Feature Selection Approach for Handwritten Word Recognition," *Neural Computing and Applications*, **32**, pp. 2533–2552.
- [96] Märgner, V., Pechwitz, M., and El Abed, H., (2005), "Arabic Handwriting Recognition Competition," *Proc. 8<sup>th</sup> International Conference on Document Analysis and Recognition (ICDAR)*, Seoul, Korea, pp. 70–74.
- [97] Maruyama, K., and Nakano, Y., (2000), "Recognition Method for Cursive Japanese Word Written in Latin Characters," *Proc. 7<sup>th</sup> International Workshop on Frontiers in Handwriting Recognition*, Amsterdam, Netherlands, pp. 133–142.

- [98] Mookdarsanit, P., and Mookdarsanit, L., (2020), "ThaiWrittenNet: Thai Handwritten Script Recognition using Deep Neural Networks," *Azerbaijan Journal of High Performance Computing*, **3**(1), pp. 75–93.
- [99] Moubtahij, H. E., Satori, K., and Halli, A., (2016), "Recognition of Off-Line Arabic Handwriting Words Using HMM Toolkit (HTK)," *Proc. 13<sup>th</sup> International Conference on Computer Graphics, Imaging and Visualization*, Beni Mellal, Morocco, pp. 167–171.
- [100] Mucherino, A., Papajorgji, P. J., and Pardalos, P.M., (2009), "k-Nearest Neighbor Classification," *Data Mining in Agriculture, Springer Optimization and Its Applications*, **34**, Springer, New York, pp. 83–106.
- [101] Naik, V., and Desai, A., (2019), "Online Handwritten Gujarati Word Recognition," *International Journal of Computer Vision and Image Processing*, **9**(1), pp. 35–50.
- [102] Namane, A., Guessoum, A., and Meyrueis, P., (2005), "New Holistic Handwritten Word Recognition and Its Application to French Legal Amount," *Proc. International Conference on Pattern Recognition and Image Analysis*, S. Singh, M. Singh, C. Apte, P. Perner, eds., Pattern Recognition and Data Mining, Lecture Notes in Computer Science, Springer, Berlin, Heidelberg, **3686**, pp.654–663.
- [103] Narang, S. R., Jindal, M. K., and Kumar, M., (2019), "Devanagari Ancient Documents Recognition Using Statistical Feature Extraction Techniques," *Sādhanā*, **44**, pp. 1–8.
- [104] Narang, S. R., Jindal, M. K., Ahuja, S., and Kumar, M., (2020), "On the Recognition of Devanagari Ancient Handwritten Characters Using SIFT and Gabor Features," *Soft Computing*, **24**, pp. 17279–17289.
- [105] Obaidullah, S. M., Das, S. K., and Roy, K., (2013), "A System for Handwritten Script Identification from Indian Document," *Journal of Pattern Recognition Research*, **8**(1), pp. 1–12.
- [106] Obaidullah, S. M., Halder, C., Santosh, K. C., Das, N., and Roy, K., (2018), "PHDIndic\_11: Page-Level Handwritten Document Image Dataset of 11

- Official Indic Scripts for Script Identification," *Multimedia Tools and Applications*, **77**(2), pp. 1643–1678.
- [107] Pal, U., Roy, K., and Kimura, F., (2006), "A Lexicon Driven Method for Unconstrained Bangla Handwritten Word Recognition," *Proc. 10<sup>th</sup> International Workshop on Frontiers in Handwriting Recognition (IWFHR)*, La Baule, France, pp. 601–606.
- [108] Pal, U., Roy, K., and Kimura, F., (2009), "A Lexicon-Driven Handwritten City Name Recognition Scheme for Indian Postal Automation," *IEICE Transactions on Information and Systems*, **92**(5), pp. 1146–1158.
- [109] Pal, U., Roy, R. K., and Kimura, F., (2011), "Handwritten Street Name Recognition for Indian Postal Automation," *Proc. International Conference on Document Analysis and Recognition*, Beijing, China, pp. 483–487.
- [110] Pal, U., Roy, R. K., and Kimura, F., (2012), "Multi-Lingual City Name Recognition for Indian Postal Automation," *Proc. International Conference on Frontiers in Handwriting Recognition*, Bari, Italy, pp. 169–173.
- [111] Paneri, P. R., Narang, R., and Goswami, M. M., (2017), "Offline Handwritten Gujarati Word Recognition," *Proc. 4<sup>th</sup> International Conference on Image Information Processing (ICIIP)*, Shimla, India, pp. 1–5.
- [112] Patel, C., and Desai, A., (2011), "Zone Identification for Gujarati Handwritten Word," *Proc. 2<sup>nd</sup> International Conference on Emerging Applications of Information Technology*, Kolkata, India, pp. 194–197.
- [113] Patel, M. S., and Reddy, S. C., (2014), "An Impact of Grid Based Approach in Offline Handwritten Kannada Word Recognition," *Proc. International Conference on Contemporary Computing and Informatics (IC3I)*, Mysore, India, pp. 630–633.
- [114] Patel, M. S., Kumar, R. and Reddy, S. C., (2015a), "Offline Kannada Handwritten Word Recognition Using Locality Preserving Projection (LPP) for Feature Extraction," *International Journal for Innovative Research in Science, Engineering and Technology*, **4**(7), pp. 5078–5086.
- [115] Patel, M. S., Reddy, S. L., and Naik, A. J., (2015b), "An Efficient Way of Handwritten English Word Recognition," *Proc. 3rd International Conference*

- on *Frontiers of Intelligent Computing: Theory and Applications (FICTA)*, S. Satapathy, B. Biswal, S. Udgata, J. Mandal, eds., *Advances in Intelligent Systems and Computing*, Springer, Cham, **328**, pp. 563–571.
- [116] Patil, P., and Ansari, S., (2014), "Online Handwritten Devanagari Word Recognition Using HMM Based Technique," *International Journal of Computer Applications*, **95**(17), pp. 17–21.
- [117] Pechwitz, M., Maddouri, S. S., Märgner, V., Ellouze, N., and Amiri, H., (2002), "IFN/ENIT-Database of Handwritten Arabic Words," *Proc. Conference: Francophone International Conference on writing and Document (CIFED'02)*, Hammamet, Tunisia, pp. 1–8.
- [118] Plamondon, R., and Srihari, S. N., (2000), "On-Line and Off-Line Handwritten Recognition: A Comprehensive Survey," *IEEE Transactions on Pattern Analysis and Machine Intelligence (PAMI)*, **22**(1), pp. 63–84.
- [119] Pradeep, J., Srinivasan, E., and Himavathi, S., (2011), "Diagonal Based Feature Extraction for Handwritten Alphabets Recognition System Using Neural Network," *International Journal of Computer Science and Information Technology*, **3**(1), pp. 27–38.
- [120] Pramanik, R., Raj, V., and Bag, S., (2018), "Finding the Optimum Classifier: Classification of Segmentable Components in Offline Handwritten Devanagari Words," *Proc. 4<sup>th</sup> International Conference on Recent Advances in Information Technology (RAIT)*, Dhanbad, India, pp. 1–5.
- [121] Pramanik, R., and Bag, S., (2020), "Segmentation-Based Recognition System for Handwritten Bangla and Devanagari Words Using Conventional Classification and Transfer Learning," *IET Image Processing*, **14**(5), pp. 959–972.
- [122] Rajashekararadhya, S. V., and Ranjan, P. V., (2008), "Neural Network Based Handwritten Numeral Recognition of Kannada and Telugu Scripts," *Proc. IEEE Region 10 International Conference TENCON*, Hyderabad, India, pp. 1–5.
- [123] Rani, R., Dhir, R., and Lehal, G. S., (2013), "Modified Gabor Feature Extraction Method for Word Level Script Identification—Experimentation

- with Gurumukhi and English Scripts," *International Journal of Signal Processing, Image Processing and Pattern Recognition*, **6**(5), pp. 25–38.
- [124] Roy, A., Bhowmik, K. T., Parui, K. S., and Roy, U., (2005a), "A Novel Approach to Skew Detection and Character Segmentation for Handwritten Bangla Words," *Proc. Digital Image Computing: Techniques and Applications(DICTA)*, Queensland, Australia, pp. 1–8.
- [125] Roy, K., Vajda, S., Pal, U., Chaudhuri, B.B., and Belaid, A., (2005b), "A System for Indian Postal Automation," *Proc. 8<sup>th</sup> International Conference on Document Analysis and Recognition (ICDAR'05)*, Seoul, South Korea, pp.1060–1064.
- [126] Roy, K., and Pal, U., (2006), "Word-Wise Hand-Written Script Separation for Indian Postal Automation," *Proc. 10<sup>th</sup> International Workshop on Frontiers in Handwriting Recognition*, La Baule, France, pp. 1–6.
- [127] Roy, K., (2008), "On the Development of an Optical Character Recognition System for Indian Postal Automation," Ph.D. Thesis, Jadavpur University, Kolkata, India.
- [128] Roy, K., Alaei, A., and Pal, U., (2010), "Word-Wise Handwritten Persian and Roman Script Identification," *Proc. 12<sup>th</sup> International Conference on Frontiers in Handwriting Recognition*, Kolkata, India, pp. 628–633.
- [129] Roy, P. P., Chherawala, Y., and Cheriet, M., (2014), "Deep-Belief-Network Based Rescoring for Handwritten Word Recognition," *Proc. 14<sup>th</sup> International Conference on Frontiers in Handwriting Recognition*, Heraklion, Greece, pp. 506–511.
- [130] Roy, P.P., Bhunia, A. K., Das, A., Dey, P., and Pal, U., (2016), "HMM-Based Indic Handwritten Word Recognition Using Zone Segmentation," *Pattern Recognition*, **60**, pp. 1057–1075.
- [131] Roy, P. P., Bhunia, A. K., and Pal, U., (2017), "HMM-Based Writer Identification in Music Score Documents Without Staff-Line Removal," *Expert System Applications*, **89**, pp. 222–240.

- [132] Roy, R. K., Pal, U., Roy, K., and Kimura, F., (2020), "A System for Recognition of Destination Address in Postal Documents of India," *Malaysian Journal of Computer Science*, **33**(3), pp. 202–216.
- [133] Rushiraj, I., Kundu, S., and Ray, B., (2016), "Handwritten Character Recognition of Odia Script," *Proc. International Conference on Signal Processing, Communication, Power and Embedded System (SCOPES)*, Paralakhemundi, Odisha, India, pp. 764–767
- [134] Sahoo, S., Nandi, S. K., Barua, S., Pallavi, Bhowmik, S., Malakar, S., and Sarkar, R., (2018), "Handwritten Bangla Word Recognition Using Negative Refraction Based Shape Transformation," *Journal of Intelligent & Fuzzy Systems*, **35**(2), pp. 1765–1777.
- [135] Sarkar, R., Malakar, S., Das, N., Basu, S., Kundu, M., and M. Nasipuri, (2011), "Word Extraction and Character Segmentation from Text Lines of Unconstrained Handwritten Bangla Document Images," *Journal of Intelligent Systems*, **20**(3), pp. 227–260.
- [136] Sarkar, R., Das, N., Basu, S., Kundu, M., Nasipuri, M., and Basu, D. K., (2012), "CMATERdb1: A Database of Unconstrained Handwritten Bangla and Bangla-English Mixed Script Document Image," *International Journal of Document Analysis and Recognition*, **15**(1), pp. 71–83.
- [137] Sen, S., Bhattacharyya, A., Mitra, M., Roy, K., Naskar, S. K., and Sarkar, R., (2020), "Online Bangla Handwritten Word Recognition Using HMM and Language Model," *Neural Computing and Applications*, **32**, pp. 9939–9951.
- [138] Septi, M., and Bedda, M., (2006), "Contribution to the Recognition of Hand Arabic Word Based on Neural Network," *Proc. 2<sup>nd</sup> International Conference on Information and Communication Technologies*, Damascus, Syria, pp. 1635–1639.
- [139] Sharma, D. V., and Jhajj, P., (2010), "Recognition of Isolated Handwritten Characters in Gurmukhi Script," *International Journal of Computer Applications*, **4**(8), pp. 9–17.
- [140] Sharma, N., Sengupta, A., Sharma, R., Pal, U., and Blumenstein, M., (2017), "Pincode Detection Using Deep CNN for Postal Automation," *Proc.*

- International Conference on Image and Vision Computing New Zealand (IVCNZ)*, Christchurch, New Zealand, pp. 1–6.
- [141] Shaw, B., Parui, S. K., and Shridhar, M., (2008), "Offline Handwritten Devanagari Word Recognition: A Holistic Approach Based on Directional Chain Code Feature and HMM," *Proc. International Conference on Information Technology*, Bhubaneswar, India, pp. 203–208.
- [142] Shaw, B., Bhattacharya, U., and Parui, S. K., (2015), "Offline Handwritten Devanagari Word Recognition: Information Fusion at Feature and Classifier Levels," *Proc. 3<sup>rd</sup> IAPR Asian Conference on Pattern Recognition (ACPR)*, Kuala Lumpur, Malaysia, pp. 720–724.
- [143] Shi, B., Bai, X., and Yao, C., (2017), "An End-to-End Trainable Neural Network for Image-Based Sequence Recognition and Its Application to Scene Text Recognition," *IEEE Transactions on Pattern Analysis and Machine Intelligence*, **39**(11), pp. 2298–2304.
- [144] Shridhar, M., Kimura, F., Truijen, B., and Houle, G. F., (2002), "Impact of Lexicon Completeness on City Name Recognition," *Proc. 8<sup>th</sup> International Workshop on Frontiers in Handwriting Recognition (IWFHR'02)*, Niagara on the Lake, Ontario, Canada, pp. 513–518.
- [145] Simayi, W., Ibrahim, M., Zhang, X. Y., Liu, C. L., and Hamdulla, A., (2020), "A Benchmark for Unconstrained Online Handwritten Uyghur Word Recognition," *International Journal of Document Analysis and Recognition (IJ DAR)*, **23**, pp. 205–218.
- [146] Singh, H., Sharma, R. K., Kumar, R., Verma, K., Kumar, R., and Kumar, M., (2020), "A Benchmark Dataset of Online Handwritten Gurmukhi Script Words and Numerals," *Proc. International Conference on Computer Vision and Image Processing*, N. Nain, S. Vipparthi, B. Raman, eds., Communications in Computer and Information Science, Springer, Singapore, **1148**, pp. 457–466.
- [147] Singh, P. K., Sarkar, R., Das, N., Basu, S., Kundu, M., and Nasipuri, M., (2017), "Benchmark Databases of Handwritten Bangla-Roman and Devanagari-Roman Mixed-Script Document Images," *Multimedia Tools and Applications*, **77**(7), pp. 8441–8473.

- [148] Smith, F., (1969), "Familiarity of Configuration vs. Discriminability of Features in the Visual Identification of Words," *Psychonomic Science*, **14**, pp. 261–262.
- [149] Sperling, G., (1963), "A model for visual memory tasks," *Human Factors*, **5**, pp. 19–31.
- [150] Srihari, S. N., and Keubert, E. J., (1997), "Integration of Hand Written Address Interpretation Technology into the United States Postal Service Remote Computer Reader System," *Proc. 4<sup>th</sup> International Conference on Document Analysis and Recognition (ICDAR)*, Ulm, Germany, pp. 892–896.
- [151] Stamatopoulos, N., Gatos, B., Louloudis, G., Pal, U., and Alaei, A., (2013), "ICDAR 2013 Handwriting Segmentation Contest," *Proc. 12<sup>th</sup> International Conference on Document Analysis and Recognition (ICDAR 2013)*, Washington, DC, USA, pp. 1402–1406.
- [152] Sudholt, S., and Fink, G. A., (2016), "Phocnet: A Deep Convolutional Neural Network for Word Spotting in Handwritten Documents." *Proc. 15<sup>th</sup> International Conference on Frontiers in Handwriting Recognition (ICFHR)*, Shenzhen, China, pp. 277–282.
- [153] Sundaram, S., and Ramakrishnan, A. G.,(2008), "Two Dimensional Principal Component Analysis for Online Tamil Character Recognition," *Proc. 11<sup>th</sup> International Conference on Frontiers in Handwriting Recognition*, Montreal, Quebec, Canada, pp. 88–94.
- [154] Tamen, Z., Drias, H., andBoughaci, D., (2017), "An Efficient Multiple Classifier System for Arabic Handwritten Words Recognition," *Pattern Recognition Letters*, **93**, pp. 123–132.
- [155] Tavoli, R., Keyvanpour, M., and Mozaffari, S., (2018), "Statistical Geometric Components of Straight Lines (SGCSL) Feature Extraction Method for Offline Arabic/Persian Handwritten Words Recognition," *IET Image Processing*, **12**(9), pp. 1606–1616.
- [156] Tay, Y. H., Lallican, P. M., Khalid, M., Viard-Gaudin, C., and Knerr, S., (2001), "An Offline Cursive Handwritten Word Recognition System," *Proc.*

- IEEE Region 10 International Conference on Electrical and Electronic Technology (TENCON 2001)*, Singapore, **2**, pp. 519–524.
- [157] Thadchanamoorthy, S., Kodikara, N. D., and Premaretne, H. L., (2013), "Tamil Handwritten City Name Database Development and Recognition for Postal Automation," *Proc. 12<sup>th</sup> International Conference on Document Analysis and Recognition*, Washington, DC, USA, pp. 793–797.
- [158] Tripathy, N., and Pal, U.,(2004), "Handwriting Segmentation of Unconstrained Oriya Text," *Proc. 9<sup>th</sup> International Workshop on Frontiers in Handwriting Recognition (IWFHR-9 2004)*, Kokubunji, Tokyo, Japan, pp. 306–311.
- [159] Viard-Gaudin, C., Lallican, P., and Knerr, S., (2005), "Recognition-Directed Recovering of Temporal Information from Handwriting Images," *Pattern Recognition Letters*, **26** (16), pp. 2537–2548.
- [160] Vichianchai, V., (2011), "Thai-Word Segmentation Through Thai Writing Structure Matching," *Proc. International Conference on Modeling, Simulation and Control*, Singapore, **10**, pp. 184–188.
- [161] Waard, W. P. D., (1995), "An Optimized Minimal Edit Distance for Handwritten Word Recognition," *Pattern Recognition Letters*, **16**(10), pp. 1091–1096.
- [162] Wang, X., and Tsutsumida, T., (1999), "A New Method of Character Line Extraction from Mixed-Unformatted Document Image for Japanese Mail Address Recognition," *Proc. 5<sup>th</sup> International Conference on Document Analysis and Recognition (ICDAR'99)*, Bangalore, India, pp. 769–772.
- [163] Wei H., Liu C., Zhang H., Bao F., and Gao G., (2019), "End-to-End Model for Offline Handwritten Mongolian Word Recognition," *Proc. CCF International Conference on Natural Language Processing and Chinese Computing*, J. Tang, MY. Kan, D. Zhao, S. Li, H. Zan, eds., NLPCC 2019. Lecture Notes in Computer Science, Springer, Cham, **11839**. pp. 220–230.
- [164] Wen, Y., Lu, Y., and Shi, P., (2007), "Handwritten Bangla Numeral Recognition System and Its Application to Postal Automation," *Pattern Recognition*, **40**(1), pp. 99–107.

- [165] Woodworth, R.S., (1938), "Experimental psychology," H. Holt and Company, New York.
- [166] Yue, S., Li, P., and Hao, P., (2003), "SVM Classification: Its Contents and Challenges," *Applied Mathematics—A Journal of Chinese Universities*, **18**, pp. 332–342.
- [167] Zhang, T. Y., and Suen, C. Y., (1984), "A Fast Parallel Algorithm for Thinning Digital Patterns," *Communications of the ACM*, **27**(3), pp. 236–239.
- [168] Zhang, Q., Yuan, Y., Li, N., Wei, X., and Miao, J., (2009), "A New Way for Chinese Place Name Recognition," *Proc. International Conference on Asian Language Processing*, Singapore, pp. 129–134.
- [169] Zinjore, R. S., and Ramteke, R. J., (2015), "Identification and Removal of Devanagari Script and Extraction of Roman Words from Printed Bilingual Text Document," *IJCA Proc. National Conference on Digital Image and Signal Processing (DISP)*, pp. 17–20.

## **Web Links**

[w1] <https://www.omniglot.com/chinese/index.htm>

[w2] <https://www.ethnologue.com/language/nld>

[w3] <https://www.omniglot.com/writing/mongolian.htm>

[w4] <https://asianstudies.unc.edu/persian/>

[w5] <https://www.ethnologue.com/language/ben>

[w6] <https://www.censusindia.gov.in/2011Census/Language-2011/Statement-1.pdf>

[w7] <https://www.ethnologue.com/language/pan>

[w8] <https://www.ethnologue.com/language/pnb>

[w9] <https://www.ethnologue.com/language/kan>

## LIST OF PUBLICATIONS

---

### Research Articles in SCI Indexed Journals

- [1] **Harmandeep Kaur** and M. Kumar, (2018), "A Comprehensive Survey on Word Recognition for Non-Indic and Indic Scripts," *Pattern Analysis and Applications*, **21**(4), pp. 897-929. <https://doi.org/10.1007/s10044-018-0731-2> (Electronic ISSN: 1433-755X; Print ISSN: 1433-7541) (**SCI Indexed with I.F. 1.512**).
- [2] **Harmandeep Kaur** and M. Kumar, (2020), "Offline Handwritten Gurumukhi Word Recognition Using eXtreme Gradient Boosting Methodology," *Soft Computing*. <https://doi.org/10.1007/s00500-020-05455-w> (Electronic ISSN: 1433-7479; Print ISSN: 1432-7643) (**SCI Indexed with I.F. 3.050**).
- [3] **Harmandeep Kaur** and M. Kumar, (2021), "On the Recognition of Offline Handwritten Word Using Holistic Approach and AdaBoost Methodology," *Multimedia Tools and Applications*. <https://doi.org/10.1007/s11042-020-10297-7> (Electronic ISSN: 1573-7721; Print ISSN: 1380-7501) (**SCI Indexed with I.F. 2.313**).

### Research Articles in Conference Proceedings

- [1] **Harmandeep Kaur** and M. Kumar, (2019), "Benchmark Dataset: Offline Handwritten Gurmukhi City Names for Postal Automation," *Proc. Workshop on Document Analysis and Recognition, DAR 2018*, S. Sundaram, G. Harit, eds., Communications in Computer and Information Science, Springer, Singapore, **1020**, pp. 152–159. [https://doi.org/10.1007/978-981-13-9361-7\\_14](https://doi.org/10.1007/978-981-13-9361-7_14)
- [2] **Harmandeep Kaur** and M. Kumar, (2020), "Performance Evaluation of Various Feature Selection Techniques for Offline Handwritten Gurumukhi Place Name Recognition," *Proc. International Conference on Machine Intelligence and Data Science Applications (MIDAS 2020)*, Dehradun, Uttarakhand, India. (**Accepted for publication**) (**BEST PAPER AWARD**).