

Asif Karim
Research Active Lecturer
Information Technology



Research interests

Dr. Asif Karim currently works at the Faculty of Science and Technology, Charles Darwin University. Asif does research in Machine Learning based Health Informatics and Blockchain Applications. He has considerable Industry Experience in the field of IT, primarily in Software Engineering. Complete Information about his Research Publications, Teaching and Grants are available at <https://asifkarim.com/>.

Employment

Lecturer in Information Technology

Research Active Lecturer
Information Technology
Faculty of Science and Technology
3 Aug 2023 → present

Research outputs

Deep learning-based analysis of COVID-19 X-ray images: Incorporating clinical significance and assessing misinterpretation

Islam Bhuiyan, MR., Azam, S., Montaha, S., Jim, RI., Karim, A., Khan, IU., Brady, M., Hasan, MZ., De Boer, F. & Mukta, MSH., Dec 2023, In: Digital Health. 9, p. 1-27 27 p.

Development of an automated optimal distance feature-based decision system for diagnosing knee osteoarthritis using segmented X-ray images

Fatema, K., Rony, M. A. H., Azam, S., Mukta, M. S. H., Karim, A., Hasan, M. Z. & Jonkman, M., 3 Nov 2023, In: Heliyon. 9, 11, p. 1-27 27 p., e21703.

Automated breast tumor ultrasound image segmentation with hybrid UNet and classification using fine-tuned CNN model

Hossain, S., Azam, S., Montaha, S., Karim, A., Chowha, S. S., Mondol, C., Hasan, M. Z. & Jonkman, M., Nov 2023, In: Heliyon. 9, 11, p. 1-36 36 p., e21369.

Pixel-level image analysis to derive the broncho-artery (BA) ratio employing HRCT scans: A computer-aided approach

Azam, S., Montaha, S., Rakibul Haque Rafid, A. K. M., Karim, A., Jonkman, M., De Boer, F., McCallum, G., Masters, I. B. & Chang, A. B., Nov 2023, In: Intelligent Systems with Applications. 20, p. 1-20 20 p., 200279.

Ergonomic Risk Prediction for Awkward Postures from 3D Keypoints Using Deep Learning

Hossain, M. S., Azam, S., Karim, A., Montaha, S., Quadir, R., De Boer, F. & Altaf-Ul-Amin, M., 16 Oct 2023, In: IEEE Access. 11, p. 114497 - 114508 12 p.

A novel Data and Model Centric artificial intelligence based approach in developing high-performance Named Entity Recognition for Bengali Language

Lima, K. A., Md Hasib, K., Azam, S., Karim, A., Montaha, S., Noori, S. R. H. & Jonkman, M., 22 Sept 2023, In: PLoS One. 18, 9 September, p. 1-36 36 p., e0287818.

MCNN-LSTM: Combining CNN and LSTM to Classify Multi-Class Text in Imbalanced News Data

Hasib, K. M., Azam, S., Karim, A., Marouf, A. A., Shamrat, F. M. J. M., Montaha, S., Yeo, K. C., Jonkman, M., Alhajj, R. & Rokne, J. G., 5 Sept 2023, In: IEEE Access. 11, p. 93048-93063 16 p., 93048.

Camera-based interactive wall display using hand gesture recognition

Zahra, R., Shehzadi, A., Sharif, M. I., Karim, A., Azam, S., De Boer, F., Jonkman, M. & Mehmood, M., Sept 2023, In: Intelligent Systems with Applications. 19, p. 1-8 8 p., 200262.

An Automated Broncho-Arterial (BA) Pair Segmentation Process and Assessment of BA Ratios in Children with Bronchiectasis Using Lung HRCT Scans: A Pilot Study

Azam, S., Montaha, S., Rafid, A. K. M. R. H., Karim, A., Jonkman, M., De Boer, F., McCallum, G., Masters, I. B. & Chang, A., Jul 2023, In: Biomedicine. 11, 7, p. 1-26 26 p., 1874.

Brain Tumor Segmentation from 3D MRI Scans Using U-Net

Montaha, S., Azam, S., Rakibul Haque Rafid, A. K. M., Hasan, M. Z. & Karim, A., Jul 2023, In: SN Computer Science. 4, 4, p. 3-11 11 p., 386.

High-precision multiclass classification of lung disease through customized MobileNetV2 from chest X-ray images

Shamrat, F. M. J. M., Azam, S., Karim, A., Ahmed, K., Bui, F. M. & De Boer, F., Mar 2023, In: Computers in Biology and Medicine. 155, 106646.

Automated Detection of Broncho-Arterial Pairs Using CT Scans Employing Different Approaches to Classify Lung Diseases

Azam, S., Rakibul Haque Rafid, A. K. M., Montaha, S., Karim, A., Jonkman, M. & De Boer, F., 5 Jan 2023, In: Biomedicine. 11, 1, p. 1-30 30 p., 133.

Analysis of Diabetic Retinopathy (DR) Based on the Deep Learning

Fayyaz, A. M., Sharif, M. I., Azam, S., Karim, A. & El-Den, J., Jan 2023, In: Information (Switzerland). 14, 1, p. 1-14 14 p., 30.

AlzheimerNet: An Effective Deep Learning Based Proposition for Alzheimer's Disease Stages Classification From Functional Brain Changes in Magnetic Resonance Images

Shamrat, F. M. J. M., Akter, S., Azam, S., Karim, A., Ghosh, P., Tasnim, Z., Hasib, K. M., De Boer, F. & Ahmed, K., 2023, In: IEEE Access. 11, p. 16376-16395 20 p.

An Apriori Algorithm-Based Association Rule Analysis to detect Human Suicidal Behaviour

Hassan, M. M., Karim, A., Mollick, S., Azam, S., Ignatious, E. & Farhan Al Haque, A. S. M., 2023, In: Procedia Computer Science. 219, p. 1279-1288 10 p.

Dementia Prediction Using Machine Learning

Dhakal, S., Azam, S., Hasib, K. M., Karim, A., Jonkman, M. & Farhan Al Haque, A. S. M., 2023, In: Procedia Computer Science. 219, p. 1297-1308 12 p.

Intelligent identification of hate speeches to address the increased rate of individual mental degeneration

Ava, L. T., Karim, A., Hassan, M. M., Faisal, F., Azam, S., Al Haque, A. S. M. F. & Zaman, S., 2023, In: Procedia Computer Science. 219, p. 1527-1537 11 p.

An effective ensemble machine learning approach to classify breast cancer based on feature selection and lesion segmentation using pre-processed mammograms

Rafid, A. K. M. R. H., Azam, S., Montaha, S., Karim, A., Fahim, K. U. & Hasan, M. Z., 11 Nov 2022, In: Biology. 11, 11, p. 1-26 26 p., 1654.

A Forecasting Prognosis of the Monkeypox Outbreak Based on a Comprehensive Statistical and Regression Analysis

Yasmin, F., Hassan, M. M., Zaman, S., Aung, S. T., Karim, A. & Azam, S., Oct 2022, In: Computation. 10, 10, p. 1-26 26 p., 177.

Entropy-based Emotion Recognition from Multichannel EEG Signals using Artificial Neural Network

Aung, S. T., Hassan, M., Brady, M., Mannan, Z. I., Azam, S., Karim, A., Zaman, S. & Wongsawat, Y., Oct 2022, In: Computational Intelligence and Neuroscience. 2022, p. 1-13 13 p., 6000989.

MNet-10: A robust shallow convolutional neural network model performing ablation study on medical images assessing the effectiveness of applying optimal data augmentation technique

Montaha, S., Azam, S., Rafid, A. K. M. R. H., Hasan, M. Z., Karim, A., Hasib, K. M., Patel, S. K., Jonkman, M. & Mannan, Z. I., 16 Aug 2022, In: *Frontiers in Medicine*. 9, p. 1-27 27 p., 924979.

SkinNet-16: A deep learning approach to identify benign and malignant skin lesions

Ghosh, P., Azam, S., Quadir, R., Karim, A., Shamrat, F. M. J. M., Bhowmik, S. K., Jonkman, M., Hasib, K. M. & Ahmed, K., 8 Aug 2022, In: *Frontiers in Oncology*. 12, p. 1-22 22 p., 931141.

A Machine Learning based Proposition for Automated and Methodical Prediction of Liver Disease

Tajmen, S., Karim, A., Hasan Mridul, A., Azam, S., Ghosh, P., Dhaly, A. A. & Hossain, M. N., 29 Jul 2022, *Proceedings of the 10th International Conference on Computer and Communications Management, ICCCM 2022*. Association for Computing Machinery, Inc, p. 46-53 8 p. (ACM International Conference Proceeding Series).

A Robust Deep Learning based Framework for High-Precision Detection of Liver Disease

Al Mahmud, A., Karim, A., Ullah Khan, I., Ghosh, P., Azam, S. & Haque, E., 29 Jul 2022, *Proceedings of the 10th International Conference on Computer and Communications Management, ICCCM 2022*. Association for Computing Machinery, Inc, p. 9-18 10 p. (ACM International Conference Proceeding Series).

LungNet22: A Fine-Tuned Model for Multiclass Classification and Prediction of Lung Disease Using X-ray Images

Javed Mehedi Shamrat, F. M., Azam, S., Karim, A., Islam, R., Tasnim, Z., Ghosh, P. & De Boer, F., May 2022, In: *Journal of Personalized Medicine*. 12, 5, p. 1-29 29 p., 680.

An Image Recognition System of Aboriginal Artefact for Knowledge Sharing using Machine Learning

Ma, Y., Karim, A. & Haque, A. S. M. F. A., 2022, *Eurographics Workshop on Graphics and Cultural Heritage*. Ponchio, F. & Pintus, R. (eds.). The Eurographics Association, p. 15-18 4 p.

LFR Waiter: Arduino Based Android Application Controlled Waiter Robot

Hasib, K. M., Rahman, M. A., Tahsin, M., Karim, A., Azam, S. & DeBoer, F., 2022, *Proceedings of 2022 IEEE Region 10 International Conference, TENCON 2022*. IEEE, Institute of Electrical and Electronics Engineers, p. 1-6 6 p. (IEEE Region 10 Annual International Conference, Proceedings/TENCON; vol. 2022-November).

TimeDistributed-CNN-LSTM: A Hybrid Approach Combining CNN and LSTM to Classify Brain Tumor on 3D MRI Scans Performing Ablation Study

Montaha, S., Azam, S., Rafid, A. K. M. R. H., Hasan, M. Z., Karim, A. & Islam, A., 2022, In: *IEEE Access*. 10, p. 60039-60059 21 p.

A Performance Based Study on Deep Learning Algorithms in the Efficient Prediction of Heart Disease

Islam, R., Beeravolu, A. R., Islam, M. A. H., Karim, A., Azam, S. & Mukti, S. A., Dec 2021, *2nd International Informatics and Software Engineering Conference, IISEC 2021*. Varol, A., Yazici, A., Varol, C. & Eryilmaz, M. (eds.). 1 ed. Piscataway, NJ: IEEE, Institute of Electrical and Electronics Engineers, p. 1-6 6 p. (2nd International Informatics and Software Engineering Conference, IISEC 2021).

Chronic Renal Disease Prediction using Clinical Data and Different Machine Learning Techniques

Raihan, M. M. S., Ahmed, E., Karim, A., Azam, S., Raihan, M., Akter, L. & Hassan, M. M., Dec 2021, *2nd International Informatics and Software Engineering Conference, IISEC 2021*. Varol, A., Yazici, A., Varol, C. & Eryilmaz, M. (eds.). 1 ed. Piscataway, NJ: IEEE, Institute of Electrical and Electronics Engineers, p. 1-5 5 p. (2nd International Informatics and Software Engineering Conference, IISEC 2021).

Identifying Long-Term Deposit Customers: A Machine Learning Approach

Rony, M. A. T., Hassan, M. M., Ahmed, E., Karim, A., Azam, S. & Reza, D. S. A. A., Dec 2021, *2nd International Informatics and Software Engineering Conference, IISEC 2021*. Varol, A., Yazici, A., Varol, C. & Eryilmaz, M. (eds.). 1 ed. Piscataway, NJ: IEEE, Institute of Electrical and Electronics Engineers, p. 1-6 6 p. (2nd International Informatics and Software Engineering Conference, IISEC 2021).

Covid-19 detection using deep learning algorithm on chest X-ray images

Akter, S., Shamrat, F. M. J. M., Chakraborty, S., Karim, A. & Azam, S., Nov 2021, In: *Biology*. 10, 11, p. 1-23 23 p., 1174.

An Unsupervised Approach for Content-Based Clustering of Emails into Spam and Ham through Multiangular Feature Formulation

Karim, A., Azam, S., Shanmugam, B. & Kannoorpatti, K., Sept 2021, In: *IEEE Access*. 9, p. 135186-135209 24 p.

A Performance Based Study on Deep Learning Algorithms in the Effective Prediction of Breast Cancer

Ghosh, P., Azam, S., Hasib, K. M., Karim, A., Jonkman, M. & Anwar, A., 18 Jul 2021, *IJCNN 2021 - International Joint Conference on Neural Networks, Proceedings*. Piscataway, NJ: IEEE, Institute of Electrical and Electronics Engineers, 8 p. (Proceedings of the International Joint Conference on Neural Networks; vol. 2021-July).

Deep Learning Predictive Model for Colon Cancer Patient using CNN-based Classification

Tasnim, Z., Chakraborty, S., Shamrat, F. M. J. M., Chowdhury, A. N., Nuha, H. A., Karim, A., Zahir, S. B. & Billah, M. M., Jul 2021, In: *International Journal of Advanced Computer Science and Applications*. 12, 8, p. 687-696 10 p.

Mitigating the Latency Induced Delay in IP Telephony Through an Enhanced De-Jitter Buffer

Karim, A., Ahmed, E., Azam, S., Shanmugam, B. & Ghosh, P., Jul 2021, *Mobile Computing and Sustainable Informatics*. Shakya, S., Bestak, R., Palanisamy, R. & Kamel, K. A. (eds.). Singapore: Springer Singapore, Vol. 68. p. 1-16 16 p. (Lecture Notes on Data Engineering and Communications Technologies; vol. 68).

Expert cancer model using supervised algorithms with a LASSO selection approach

Ghosh, P., Karim, A., Atik, S. T., Afrin, S. & Saifuzzaman, M., Jun 2021, In: *International Journal of Electrical and Computer Engineering*. 11, 3, p. 2632-2640 9 p.

Machine Learning Based PV Power Generation Forecasting in Alice Springs

Mahmud, K., Azam, S., Karim, A., Zobaed, S., Shanmugam, B. & Mathur, D., 17 Mar 2021, In: *IEEE Access*. 9, p. 46117-46128 12 p., 9380330.

Cognitive learning environment and classroom analytics (CLECA): A method based on dynamic data mining techniques

Al Karim, M., Karim, A., Azam, S., Ahmed, E., De Boer, F., Islam, A. & Nur, F. N., Feb 2021, *Lecture Notes on Data Engineering and Communications Technologies*. Raj, J. S., Ilyasu, A. M., Bestak, R. & Baig, Z. A. (eds.). 1 ed. Singapore: Springer Singapore, p. 787-797 11 p. (Lecture Notes on Data Engineering and Communications Technologies; vol. 59).

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Ghosh, P., Azam, S., Jonkman, M., Karim, A., Shamrat, F. M. J. M., Ignatious, E., Shultana, S., Beeravolu, A. R. & De Boer, F., 22 Jan 2021, In: *IEEE Access*. 9, p. 19304-19326 23 p., 9333574.

A combined framework of interplanetary file system and blockchain to securely manage electronic medical records

Al Mamun, A., Faruk Jahangir, M. U., Azam, S., Kaiser, M. S. & Karim, A., 2021, *Proceedings of International Conference on Trends in Computational and Cognitive Engineering - Proceedings of TCCE 2020*. Kaiser, M. S., Bandyopadhyay, A., Mahmud, M. & Ray, K. (eds.). Singapore: Springer Science and Business Media Deutschland GmbH, Vol. 1309. p. 501-511 11 p. (Advances in Intelligent Systems and Computing; vol. 1309).

A Comparative Study of Different Deep Learning Model for Recognition of Handwriting Digits

Ghosh, P., Anjum, A. A., Karim, A., Junayed, M. S., Hasan, M. Z., Md. Hasib, K. & Bin Emran, A. N., 2021, *Proceedings of the International Conference on IoT based Control Networks and Intelligent Systems (ICICNIS 2020)*. India: SSRN, p. 857-866 10 p.

A comparative study of different machine learning tools in detecting diabetes

Ghosh, P., Azam, S., Karim, A., Hassan, M., Roy, K. & Jonkman, M., 2021, In: *Procedia Computer Science*. 192, 1, p. 467-477 11 p.

Applying Big Data Analytics in DDoS Forensics: Challenges and Opportunities

Sarmiento, A. G., Yeo, K. C., Azam, S., Karim, A., Al Mamun, A. & Shanmugam, B., 2021, *Cybersecurity, Privacy and Freedom Protection in the Connected World: Proceedings of the 13th International Conference on Global Security, Safety and Sustainability, London, January 2021*. Jahankhani, H., Jamal, A. & Lawson, S. (eds.). 1 ed. Cham, Switzerland: Springer Nature, p. 235-252 18 p. (Advanced Sciences and Technologies for Security Applications).

A Robust Deep Learning based Prediction System of Heart Disease using a Combination of Five Datasets

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DeepFakes: Detecting Forged and Synthetic Media Content Using Machine Learning

Zobaed, S., Rabby, F., Hossain, I., Hossain, E., Hasan, S., Karim, A. & Md. Hasib, K., 2021, *Artificial Intelligence in Cyber Security: Impact and Implications: Security Challenges, Technical and Ethical Issues, Forensic Investigative Challenges*. Montasari, R. & Jahankhani, H. (eds.). 1 ed. Cham, Switzerland: Springer Nature, p. 177-201 25 p. (Advanced Sciences and Technologies for Security Applications).

Smart Electrification of Rural Bangladesh Through Smart Grids

Debnath, D., Siddique, A. H., Hasan, M., Faisal, F., Karim, A., Azam, S. & De Boer, F., 2021, *Sustainable Communication Networks and Application: Proceedings of ICSCN 2020*. Karuppusamy, P., Perikos, I., Shi, F. & Nguyen, T. N. (eds.). Singapore: Springer Singapore, Vol. 55. p. 41-55 15 p. (Lecture Notes on Data Engineering and Communications Technologies; vol. 55).

Smart Parking Management System to Reduce Congestion in Urban Area

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Use of Efficient Machine Learning Techniques in the Identification of Patients with Heart Diseases

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A Framework to Address Security Concerns in Three Layers of IoT

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An investigation into the level of valence offered by different pointing devices against challenging tasks

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Bithi, M. H., Faisal, F., Karim, A., Azam, S., Shanmugam, B. & Lakshmganathan, R., 7 Oct 2020, *Proceedings of the 4th International Conference on IoT in Social, Mobile, Analytics and Cloud, ISMAC 2020*. 1 ed. Piscataway, NJ: IEEE, Institute of Electrical and Electronics Engineers, p. 25-29 5 p. 9243492. (Proceedings of the 4th International Conference on IoT in

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Efficient clustering of emails into spam and ham: the foundational study of a comprehensive unsupervised framework
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Islam Chowdhury, A., Munem Shahriar, M., Islam, A., Ahmed, E., Karim, A. & Rezwanaul Islam, M., 5 Aug 2020, *Proceedings of 2020 2nd International Conference on Image Processing and Machine Vision, IPMV 2020 and International Conference on Pattern Recognition and Machine Learning*. New York: Association for Computing Machinery (ACM), p. 57-62 6 p. (ACM International Conference Proceeding Series).

A novel IoT based accident detection and rescue system
Karmakar, P., Bairagi, S., Mondal, A., Nur, F. N., Moon, N. N., Karim, A. & Yeo, K. C., Aug 2020, *Proceedings of the 3rd International Conference on Smart Systems and Inventive Technology, ICSSIT 2020*. 1 ed. Piscataway, NJ: IEEE, Institute of Electrical and Electronics Engineers, p. 322-327 6 p. 9214296. (Proceedings of the 3rd International Conference on Smart Systems and Inventive Technology, ICSSIT 2020).

Intrusion detection system for the internet of things based on blockchain and multi-agent systems
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A proposition for a low-cost effective attendance management system
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Empirical study of password strength meter design
Yang, Y., Yeo, K. C., Azam, S., Karim, A., Ahammad, R. & Mahmud, R., Jun 2020, *Proceedings of the 5th International Conference on Communication and Electronics Systems, ICCES 2020*. 1 ed. Piscataway, NJ: IEEE, Institute of Electrical and Electronics Engineers, p. 436-442 7 p. 09137964. (Proceedings of the 5th International Conference on Communication and Electronics Systems, ICCES 2020).

A Comprehensive Survey for Intelligent Spam Email Detection
Karim, A., Azam, S., Shanmugam, B., Krishnan, K. & Alazab, M., 20 Nov 2019, In: IEEE Access. 7, p. 168261-168295 35 p., 08907831.

Using blockchain technology for file synchronization
Khan, M. I., Faisal, F., Azam, S., Karim, A., Shanmugam, B. & De Boer, F., 12 Nov 2019, In: *IOP Conference Series: Materials Science and Engineering*. 561, 1, p. 1-9 9 p., 012117.

D-CARE: A Non-invasive Glucose Measuring Technique for Monitoring Diabetes Patients
Alam, M. M., Saha, S., Saha, P., Nur, F. N., Moon, N. N., Karim, A. & Azam, S., 4 Jul 2019, *Proceedings of International Joint Conference on Computational Intelligence: IJCCI 2018*. Uddin, M. S. & Bansal, J. C. (eds.). Singapore: Springer Singapore, p. 443-453 11 p. (Algorithms for Intelligent Systems (AIS)).

AcneNet - A deep CNN based classification approach for acne classes
Junayed, M. S., Jeny, A. A., Atik, S. T., Neehal, N., Karim, A., Azam, S. & Shanmugam, B., Jul 2019, *Proceedings of 2019 International Conference on Information and Communication Technology and Systems, ICTS 2019*. 1 ed. Piscataway, NJ: IEEE, Institute of Electrical and Electronics Engineers, p. 203-208 6 p. 8850935. (Proceedings of 2019 International Conference on Information and Communication Technology and Systems, ICTS 2019).

An intelligent spam detection model based on artificial immune system
Saleh, A. J., Karim, A., Shanmugam, B., Azam, S., Kannoopatti, K., Jonkman, M. & De Boer, F., 12 Jun 2019, In: *Information (Switzerland)*. 10, 6, p. 1-17 17 p., 209.

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Islam, S., Narin Nur, F., Nessa Moon, N., Karim, A., Azam, S. & Shanmugam, B., 3 Jun 2019, In: Journal of Communications Software and Systems. 15, 2, p. 193-201 9 p.

An Overview of Blockchain Applications and Attacks

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An Intelligent and Secured Tracking System for Monitoring School Bus

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Analysis of Complex Networks for Security Issues using Attack Graph

Musa, T., Yeo, K. C., Azam, S., Shanmugam, B., Karim, A., Boer, F. D., Nur, F. N. & Faisal, F., 2019, *2019 International Conference on Computer Communication and Informatics, ICCCI 2019*. Piscataway, NJ: IEEE, Institute of Electrical and Electronics Engineers, Vol. 1. p. 1-6 6 p. 8822179. (2019 International Conference on Computer Communication and Informatics, ICCCI 2019).

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Kathed, A., Azam, S., Shanmugam, B., Karim, A., Yeo, K. C., Boer, F. D. & Jonkman, M., 2019, *2019 International Conference on Computer Communication and Informatics, ICCCI 2019*. 1 ed. Piscataway, NJ: IEEE, Institute of Electrical and Electronics Engineers, p. 1-6 6 p. 8822117. (2019 International Conference on Computer Communication and Informatics, ICCCI 2019).

Novel machine learning approach for analyzing anonymous credit card fraud patterns

Manlangit, S., Azam, S., Shanmugam, B. & Karim, A., 2019, In: International Journal of Electronic Commerce Studies. 10, 2, p. 175-201 27 p.

Shot-Net: A Convolutional Neural Network for Classifying Different Cricket Shots

Foysal, M. F. A., Islam, M. S., Karim, A. & Neehal, N., 2019, *Recent Trends in Image Processing and Pattern Recognition - 2nd International Conference, RTIP2R 2018, Revised Selected Papers*. Hegadi, R. S. & Santosh, K. C. (eds.). 1 ed. Singapore: Springer-Verlag London Ltd., p. 111-120 10 p. (Communications in Computer and Information Science; vol. 1035).

Activities

Awards

Projects

Machine Learning Diagnostics System for Bronchiectasis

Azam, S., De Boer, F., Jonkman, M. & Karim, A.
1/07/22 → 31/12/23

Student theses

A Comprehensive Framework of Machine Learning Model for Clustering Ham and Spam Emails based on Unsupervised Learning

Author: Karim, A., Dec 2021

Supervisor: Krishnan, K. (Supervisor), Azam, S. (Supervisor) & Shanmugam, B. (Supervisor)