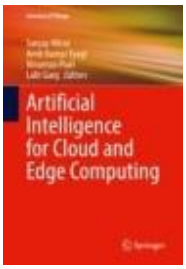

K-Nearest Neighbour Algorithm for Classification of IoT-Based Edge Computing Device

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Abstract

The world's population has boomed with the billions of connected devices in our households, towns, factories, hospitals, and so on. Limited-resource applications communicate with the world and users. To evaluate meaningful behavior to execute specific predictions and make decisions, several of these technologies are built on machine learning (ML) procedures. Hence, the need to integrate intelligence using machine learning algorithms on end devices is important. Implementing machine learning on edge devices enhances and makes it possible to perform computations near to the data sources. Therefore, the objective of this investigation is to provide a method that guarantees the implementation of low-performance ML techniques on hardware in the Internet of Things model, creating means for IoT awareness. The study employed the use of the KNN ML algorithm for the implementation, and a confusion matrix in terms of accuracy was used to evaluate the system. The result of the experiment shows an 85% accuracy which outperformed other methods that have been suggested and compared within the literature. However, this study proves to be relevant and can be adopted for better efficiency in IoT and edge/cloud computing applications.

Keywords: **Internet of Things, Edge computing, Cloud computing, Machine learning, KNN, Artificial intelligence**

References

1. Adeniyi EA, Ogundokun RO, Awotunde JB (2021) IoMT-based wearable body sensors network healthcare monitoring system. In: IoT in healthcare and ambient assisted living. Springer, Singapore, pp 103–121

Google Scholar

2. Merenda M, Porcaro C, Iero D (2020) Edge machine learning for AI-enabled IoT devices: a review. Sensors 20(9):2533. https://doi.org/10.3390/s20092533

CrossRef Google Scholar

3. Liu Y, Yang C, Jiang L, Xie S, Zhang Y (2019) Intelligent edge computing for IoT-based energy management in smart cities. IEEE Netw 33(2):111–117. https://doi.org/10.1109/MNET.2019.1800254

CrossRef Google Scholar

4. Odusami M, Abayomi-Alli O, Misra S, Shobayo O, Damasevicius R, Maskeliunas R (2018) Android malware detection: a survey. In: International conference on applied informatics. Springer, Cham, pp 255–266

Google Scholar

5. Adeyinka AA, Adebiyi MO, Akande NO, Ogundokun RO, Kayode AA, Oladele TO (2019) A deep convolutional encoder-decoder architecture for retinal blood vessels segmentation. In: International conference on computational science and it applications, Lecture notes in computer science (including subseries Lecture notes in artificial intelligence and Lecture notes in bioinformatics). Springer, Cham. 11623 LNCS, pp 180–189

Google Scholar

6. Oladele TO, Ogundokun RO, Kayode AA, Adegun AA, Adebiyi MO (2019) Application of data mining algorithms for feature selection and prediction of diabetic retinopathy. Lecture notes in computer science (including subseries Lecture notes in artificial intelligence and Lecture notes in bioinformatics), International conference on computational science and it applications. Springer, Cham. 11623 LNCS, pp. 716–730

Google Scholar

7. Ikedinachi AP, Misra S, Assibong PA, Olu-Owolabi EF, Maskeliūnas R, Damasevicius R (2019) Artificial intelligence, smart classrooms and online education in the 21st century: implications for human development. J Cases Inf Technol (JCIT) 21(3):66–79

Google Scholar

8. Alagbe V, Popoola SI, Atayero AA, Adebisi B, Abolade RO, Misra S (2019) Artificial intelligence techniques for electrical load forecasting in smart and connected communities. In: International conference on computational science and its applications. Springer, Cham, pp 219–230

Google Scholar

9. Xu H (2017) Machine learning based data analytics for IoT devices. Nanyang Technological University. https://doi.org/10.32657/10356/72342

CrossRef Google Scholar

10. Ieracitano C, Mammone N, Hussain A, Morabito FC (2020) A novel multi-modal machine learning based approach for automatic classification of EEG recordings in dementia. Neural Netw 123:176–190. https://doi.org/10.1016/j.neunet.2019.12.006

CrossRef Google Scholar

11. Panesar A (2021) Machine learning algorithms. Apress, Berkeley, pp 85–144. https://doi.org/10.1007/978-1-4842-6537-6_4

CrossRef Google Scholar

12. Yazici M, Basurra S, Gaber M (2018) Edge machine learning: enabling smart internet of things applications. Big Data Cogn Comput 2(3):26. https://doi.org/10.3390/bdcc2030026

CrossRef Google Scholar

13. Portal S (2018) Internet of things (IoT) connected devices installed base worldwide from 2015 to 2025. https://www.statista.com/statistics/471264/iot-number-of-connected-devices-worldwide/
14. Gubbi J et al (2013) Internet of things (IoT): a vision, architectural elements, and future directions. Futur Gener Comput Syst 29(7):1645–1660

Google Scholar

15. Lin J, Yu W, Zhang N, Yang X, Ge L (2017) On data integrity attacks against route guidance in transportation-based cyber-physical systems. In: Proceedings of the 14th IEEE annual conference in consumer communications and networking conference (CCNC 2017)

Google Scholar

16. Singh D, Tripathi G, Jara AJ (2014) A survey of internet-of-things: future vision, architecture, challenges and services. In: Proceedings of 2014 IEEE world forum on internet of things (WF-IoT)

Google Scholar

17. Chen X, Jiao L, Li W, Fu X (2016) Efficient multi-user computation offloading for mobile-edge cloud computing. IEEE/ACM Trans Netw 24(5):2795–2808

Google Scholar

18. Lee I, Lee K (2015) The internet of things (IoT): applications, investments, and challenges for enterprises. Bus Horiz 58(4):431–440

Google Scholar

19. Sha K et al (2018) On security challenges and open issues in internet of things. Futur Gener Comput Syst 83:326–337

Google Scholar

20. Brewster T (2016) How hacked cameras are helping launch the biggest attacks the internet has ever seen. https://www.forbes.com/sites/thomasbrewster/2016/09/25/brian-krebs-overwatch-ovh-smashed-by-largest-ddos-attacks-ever/#705007235899. Sept 2016
21. Russon M-A (2016) Hackers turning millions of smart CCTV cameras into botnets for DDoS attacks. http://www.ibtimes.co.uk/hackers-turning-millions-smart-cctv-cameras-into-botnets-ddos-attacks-1525736. Accessed Sept 2016
22. Sha K, Alatrash N, Wang Z (2017) A secure and efficient framework to read isolated smart grid devices. IEEE Trans Smart Grid 8(6):2519–2531

Google Scholar

23. Li S, Da Xu L, Zhao S (2015) The internet of things: a survey. Inf Syst Front 17(2):243–259

Google Scholar

24. Gokhale P, Bhat O, Bhat S (2018) Introduction to IOT. Int Adv Res J Sci Eng Technol 5(1):41–44

Google Scholar

25. Gubbi J, Buyya R, Marusic S, Palaniswami M (2013) Internet of things (IoT): a vision, architectural elements, and future directions. Futur Gener Comput Syst 29(7):1645–1660

Google Scholar

26. Stergiou C, Psannis KE, Kim BG, Gupta B (2018) Secure integration of IoT and cloud computing. Futur Gener Comput Syst 78:964–975

Google Scholar

27. Atzori L, Iera A, Morabito G (2017) Understanding the internet of things: definition, potentials, and societal role of a fast-evolving paradigm. Ad Hoc Netw 56:122–140

Google Scholar

28. Chahal RK, Kumar N, Batra S (2020) Trust management in social internet of things: a taxonomy, open issues, and challenges. Comput Commun 150:13–46

Google Scholar

29. Srivastava G, Parizi RM, Dehghantanha A (2020) The future of blockchain technology in healthcare internet of things security. In: Blockchain cybersecurity, trust and privacy. Springer, Cham, pp 161–184

Google Scholar

30. Shafique MN, Khurshid MM, Rahman H, Khanna A, Gupta D (2019) The role of big data predictive analytics and radio frequency identification in the pharmaceutical industry. IEEE Access 7:9013–9021

Google Scholar

31. Manavalan E, Jayakrishna K (2019) A review of internet of things (IoT) embedded sustainable supply chain for industry 4.0 requirements. Comput Ind Eng 127:925–953

Google Scholar

32. Georgakopoulos D, Jayaraman PP, Fazia M, Villari M, Ranjan R (2016) Internet of things and edge cloud computing roadmap for manufacturing. IEEE Cloud Comput 3(4):66–73

Google Scholar

33. Bilal K, Khalid O, Erbad A, Khan SU (2018) Potentials, trends, and prospects in edge technologies: fog, cloudlet, mobile edge, and micro data centers. Comput Netw 130:94–120. https://doi.org/10.1016/j.comnet.2017.10.002

CrossRef Google Scholar

34. Yousefpour A, Fung C, Nguyen T, Kadiyala K, Jalali F, Niakanlahiji A, Kong J, Jue JP (2019) All one needs to know about fog computing and related edge computing paradigms: a complete survey. J Syst Archit 98:289–330. https://doi.org/10.1016/j.sysarc.2019.02.009

CrossRef Google Scholar

35. Wang Y, Meng W, Li W, Liu Z, Liu Y, Xue H (2019) Adaptive machine learning-based alarm reduction via edge computing for distributed intrusion detection systems. Concurr Comput Pract Exp 31(19). https://doi.org/10.1002/cpe.5101
36. Wang S, Zhao Y, Xu J, Yuan J, Hsu C-H (2019) Edge server placement in mobile edge computing. J Parallel Distrib Comput 127:160–168. https://doi.org/10.1016/j.jpdc.2018.06.008

CrossRef Google Scholar

37. Wang Y, Xie L, Li W, Meng W, Li J (2017) A privacy-preserving framework for collaborative intrusion detection networks through fog computing, pp 267–279. https://doi.org/10.1007/978-3-319-69471-9_20
38. Agarwal P, Alam M (2019) A lightweight deep learning model for human activity recognition on edge devices. Journal title Sensors and page 1--17

Google Scholar

39. Makkar A (2020) Machine learning techniques. In: Machine learning in cognitive IoT. CRC Press, pp 67–85

Google Scholar

40. Gope D, Dasika G, Mattina M (2019) Ternary hybrid neural-tree networks for highly constrained iot applications. arXiv preprint arXiv:1903.01531

Google Scholar

41. Lin J, Yu W, Zhang N, Yang X, Zhang H, Zhao W (2017) A survey on internet of things: architecture, enabling technologies, security and privacy, and applications. IEEE Internet Things J 4(5):1125–1142

Google Scholar

42. Guevara JC, Torres RDS, da Fonseca NL (2020) On the classification of fog computing applications: a machine learning perspective. J Netw Comp Appl 159:102596

Google Scholar

43. Wang J, Pan J, Esposito F, Calyam P, Yang Z, Mohapatra P (2019) Edge cloud offloading algorithms: issues, methods, and perspectives. ACM Comput Surv (CSUR) 52(1):2

Google Scholar

44. Aazam M, Zeadally S, Harras KA (2018) Offloading in fog computing for IoT: review, enabling technologies, and research opportunities. Futur Gener Comput Syst 87:278–289

Google Scholar

45. Mach P, Becvar Z (2017) Mobile edge computing: a survey on architecture and computation offloading. IEEE Commun Surv Tutor 19(3):1628–1656

Google Scholar

46. Boukerche A, Guan S, Grande RED (2019) Sustainable offloading in mobile cloud computing: algorithmic design and implementation. ACM Comput Surv (CSUR) 52(1):11

Google Scholar

47. Peng K, Leung VC, Xu X, Zheng L, Wang J, Huang Q (2018) A survey on mobile edge computing: focusing on service adoption and provision. Wirel Commun Mob Comput 2018., Article ID: 8267838:1–16. https://doi.org/10.1155/2018/8267838

CrossRef Google Scholar

48. Shakarami A, Shahidinejad A, Ghobaei-Arani M (2020) A review on the computation offloading approaches in mobile edge computing: a game-theoretic perspective. Softw Pract Exp 50:1719–1759

Google Scholar

49. Cao B, Zhang L, Li Y, Feng D, Cao W (2019) Intelligent offloading in multi-access edge computing: a state-of-the-art review and framework. IEEE Commun Mag 57(3):56–62

Google Scholar

50. Taleb T, Samdanis K, Mada B, Flinck H, Dutta S, Sabella D (2017) On multi-access edge computing: a survey of the emerging 5G network edge cloud architecture and orchestration. IEEE Commun Surv Tutor 19(3) Third Quarter:1657–1681

Google Scholar

51. Madakam S, Ramaswamy R, Tripathi S (2015) Internet of things (IoT): a literature review. J Comput Commun 3:164–173

Google Scholar

52. Dolui K, Datta SK (2017) Comparison of edge computing implementations: fog computing, cloudlet and mobile edge computing. IEEE

Google Scholar

53. Mao Y, You C, Zhang J, Huang K, Letaief KB (2017) A survey on mobile edge computing: the communication perspective. IEEE

Google Scholar

54. Rodriguez-Zurrunero R, Ramiro U (2019) Dataset of process management in IoT operating systems: cross-influence between processing and communication tasks in end-devices. https://doi.org/10.17632/rxsdfg8ct9.1
55. Davis GA, Nihan NL (1991) Nonparametric regression and short-term freeway traffic forecasting. J Transp Eng 117(2):178–188

Google Scholar

56. Mehrotra R, Sharma A (2006) Conditional resampling of hydrologic time series using multiple predictor variables: a K-nearest neighbour approach. Adv Water Resour 29(7):987–999

Google Scholar

57. Bannayan M, Hoogenboom G (2008) Weather analogue: a tool for real-time prediction of daily weather data realizations based on a modified k-nearest neighbor approach. Environ Model Softw 23(6):703–713

Google Scholar

58. Mangalova E, Agafonov E (2014) Wind power forecasting using the k-nearest neighbors algorithm. Int J Forecast 30(2):402–406

Google Scholar

59. Cai P, Wang Y, Lu G, Chen P, Ding C, Sun J (2016) A spatiotemporal correlative k-nearest neighbor model for short-term traffic multistep forecasting. Transp Res Part C Emerg Technol 62:21–34

Google Scholar

60. Cheng S, Lu F, Peng P, Wu S (2018) Short-term traffic forecasting: an adaptive ST-KNN model that considers spatial heterogeneity. Comput Environ Urban Syst 71:186–198

Google Scholar

61. Martínez F, Frías MP, Pérez-Godoy MD, Rivera AJ (2018) Dealing with seasonality by narrowing the training set in time series forecasting with kNN. Expert Syst Appl 103:38–48

Google Scholar

62. Fan GF, Guo YH, Zheng JM, Hong WC (2019) Application of the weighted k-nearest neighbor algorithm for short-term load forecasting. Energies 12(5):916

Google Scholar

63. Xu D, Wang Y, Peng P, Beilun S, Deng Z, Guo H (2020) Real-time road traffic state prediction based on kernel-KNN. Transportmetrica A TranspSci 16(1):104–118

Google Scholar

64. Kück M, Freitag M (2020) Forecasting of customer demands for production planning by local k-nearest neighbor models. Int J Prod Econ 231:107837

Google Scholar

65. Hattori K, Takahashi M (1999) A new nearest-neighbor rule in the pattern classification problem. Pattern Recogn 32(3):425–432

Google Scholar

66. Hattori K, Takahashi M (2000) A new edited k-nearest neighbor rule in the pattern classification problem. Pattern Recogn 33(3):521–528

Google Scholar

67. Jiang S, Pang G, Wu M, Kuang L (2012a) An improved K-nearest-neighbor algorithm for text categorization. Expert Syst Appl 39(1):1503–1509

Google Scholar

68. Jiang JY, Tsai SC, Lee SJ (2012b) FSKNN: multi-label text categorization based on fuzzy similarity and k nearest neighbors. Expert Syst Appl 39(3):2813–2821

Google Scholar

69. Miao D, Duan Q, Zhang H, Jiao N (2009) Rough set based hybrid algorithm for text classification. Expert Syst Appl 36(5):9168–9174

Google Scholar

70. Cui B, Shen HT, Shen J, Tan KL (2005, December) Exploring bit-di® erence for approximate KNN search in high-dimensional databases. In: Conferences in research and practice in information technology series, vol 39, pp 165–174

Google Scholar

71. Tan S (2006) An effective refinement strategy for KNN text classifier. Expert Syst Appl 30(2):290–298

Google Scholar

72. Wan CH, Lee LH, Rajkumar R, Isa D (2012) A hybrid text classification approach with low dependency on parameter by integrating K-nearest neighbor and support vector machine. Expert Syst Appl 39(15):11880–11888

Google Scholar

73. Yoon JW, Friel N (2015) Efficient model selection for probabilistic K nearest neighbour classification. Neurocomputing 149:1098–1108

Google Scholar

74. Zhang H, Berg AC, Maire M, Malik J (2006, June) SVM-KNN: discriminative nearest neighbor classification for visual category recognition. In: 2006 IEEE computer society conference on computer vision and pattern recognition (CVPR'06), vol 2. IEEE, pp 2126–2136

Google Scholar

75. Zhang S, Cheng D, Deng Z, Zong M, Deng X (2018) A novel kNN algorithm with data-driven k parameter computation. Pattern Recogn Lett 109:44–54

Google Scholar

76. Khateeb N, Usman M (2017). Efficient heart disease prediction system using K-nearest neighbor classification technique. In Proceedings of the international conference on big data and internet of thing, pp 21–26

Google Scholar

77. Hashi EK, Zaman MSU, Hasan MR (2017) An expert clinical decision support system to predict disease using classification techniques. In: 2017 International conference on electrical, computer and communication engineering (ECCE). IEEE, pp 396–400

Google Scholar

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