Review of Social Distancing and Face Mask of Coronavirus Spread

Claudia M. Escobedo Alcázar[1,†], Jose E. Gutierrez Arias[1,†], Nataly J. Alvarez Cervantes[1,†], Rodrigo A. Canaza Pilco[1,†], Luz E. Gonzales Medina[1,†], Jhon E. Monroy Barrios[1,†] and Wilder Nina Choquehuayta[1,*,†]

[1]*Universidad Tecnológica del Perú, Arequipa, Perú*

Abstract

Development of artificial intelligence applications has let to reduce the spread of COVID-19 in many countries. The objective in this review is analysis of different solutions based on mask detection algorithms and social distancing methods to combat to COVID-19. Method applied is to search eight databases namely Ebsco, Dynamed, IEEE, IOP, Sage, Scopus, Science direct, Taylor, and Francis, and the run three sequences of search queries between 2019 and 2022. Results obtained using precise exclusion criteria and a selection strategy were applied to select the 8578 articles and then obtained 48 articles were fully assessed and included in this review, and this number only emphasized the insufficiency of research in this important area. After analyzing all the included studies, the results were distributed according to the year of publication and the commonly used deep learning and ML algorithms. The results found in all the papers were discussed to find the gaps in all the articles reviewed. Characteristics, such as motivations, challenges, limitations, recommendations, case studies, and characteristics and classes used were analyzed in detail. Conclusion is find showed that the growing emphasis on deep learning and ML techniques in field, can provide the right environment for change and improvement.

Keywords

Coronavirus, Social Distance, Mask Detection, Machine Learning, Face Mask Detection

1. Introduction

The outbreak of the novel coronavirus infection (COVID-19) has caused concern around the world as it causes illness, including death, and continues to spread from person to person in many countries [1] CoVs are a large family of viruses, including Middle East Respiratory Syndrome (MERS) CoV and Severe Acute Respiratory Syndrome (SARS) CoV [2]. On February 11, 2020, the World Health Organization (WHO) declared 'COVID-19' as a disease [3], Artificial intelligence (AI) is gradually changing practical medicine and recent advances in digitized data collection, making machine learning (ML), computing infrastructure and AI applications expand into areas previously reserved for human experts [4]. Therefore, the main objective of this research is to be able to analyze the use of recognition and detection systems that allow the identification of control measures established for the mitigation of SARS-CoV-2 contagion using masks and distancing as the main strategy of the study through the review of articles on image processing and computer vision, using algorithms for a clear understanding of the prediction and use of these computer tools in support of science and its application. The challenges and limitations encountered will allow us to propose opportunities for improvement and a clear focus on the main findings found in the information reviewed.

JINIS 2023: XXX International Conference on Systems Engineering, October 03–05, 2023, Arequipa, Peru

*Corresponding author.

†These authors contributed equally.

1012757@utp.edu.pe (C. M. E. Alcázar); 1512915@utp.edu.pe (J. E. G. Arias); 1626631@utp.edu.pe (N. J. A. Cervantes); 1626828@utp.edu.pe (R. A. C. Pilco); c16401@utp.edu.pe (L. E. G. Medina); c19315@utp.edu.pe (J. E. M. Barrios); c18795@utp.edu.pe (W. N. Choquehuayta)

0000-0002-4612-6050 (C. M. E. Alcázar); 0000-0001-7012-6459 (J. E. G. Arias); 0000-0002-4311-5292 (N. J. A. Cervantes); 0000-0002-0051-5878 (R. A. C. Pilco); 0000-0003-0402-8644 (L. E. G. Medina); 0000-0002-6676-9950 (J. E. M. Barrios); 0000-0002-6027-4973 (W. N. Choquehuayta)

2. Methods

This study followed the literature search style recommended by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) method [5], where uses 8 databases, namely Ebsco, Dynamed, IEEE, IOP, Sage, Scopus, Science Direct, Taylor and Francis. Trusted science and technology journals containing contemporary research papers in computer science, electronics, and interdisciplinary research. The results of this study can help researchers in the area of image processing and computer vision to know detailed information on technological advances with existing image detection and recognition systems.

2.1. Search Strategy

A bibliographic search in English was carried out in the eight academic repositories between the years 2019 and 2022, considering precise exclusion criteria. The selection of the research articles was due to the similar characteristics with our research, considering that the new methods identified require greater computational power. This research carried out a search strategy using several keywords related to the coronavirus and keywords related to the detection, diagnosis and classification of masks under the concept of AI and ML. We use these query methods to improve the search and investigation of distancing and mask applications for various AI and machine learning systems.

2.2. Inclusion criteria

- Articles are journals or conferences in English.
- The focus is on the development of various applications, systems, algorithms, methods and technologies in artificial intelligence and machine learning.
- Development focused on the detection and classification of masks and social distancing.

2.3. Exclusion criteria

- Articles minor to the year 2019.
- Less with less than 15 bibliographical references.

2.4. Study Selection

The process begins with the elimination of duplicate articles, Unique articles were screened by title and abstract to verify their compliance with our inclusion and exclusion criteria. The relevant articles have been carefully read. The process of collecting, extracting research data, and developing a review document.

2.5. Data extraction and classification

Given the multidisciplinary topic of this systematic review, data extraction and classification were performed for selected studies, including CoV data using AI applications, especially ML techniques, to assess the effectiveness of viruses in detection, diagnosis, prevention and classification. Enhanced data factors were extracted from the academic literature, including author nationality, publication date, number of articles per year, and number of articles in the database. To provide a comprehensive understanding of CoV, this study The discussed CoV and the growing scale of the global pandemic in the context of artificial intelligence are analyzed using various ML and data mining algorithms, such as classification, regression, and prediction. For each study, the document distinguishes the name of the significant characteristics, the evaluation methods used and the exact status of each method. From the analyzed literature, brief motivations, challenges, limitations and recommendations have been extracted to address the serious health problems associated with CoV.

2.6. Results

The results of the search query performed in this study are shown in Figure 1. During data collection, four queries were performed to cover all databases and search mechanisms. The first result included 8578 articles from eight databases. The number of duplicate articles in all databases was 626. The first process was to select articles based on a relevant keyword selection filter, which resulted in 1141 articles. The second process was to select articles based on title and then map inclusion and exclusion criteria, resulting in 351 articles. The third process carried out was to select articles by abstract, reading each one for its selection, which resulted in 275 articles. The final process was to read all the articles in their entirety, with only 48 articles meeting the inclusion and exclusion criteria.

Table 1
Three types of the Boolean search query

Seq.	Query Details Terms	Result of Databases	Final Results
1st query	(‘coronavirus’ OR ‘coronaviridae’ OR ‘covid’) AND (‘detection system’ OR ‘detection’) AND (’social distance’ OR ’social distancing’)	Ebsco = 151 Dynamed = 0 IEEE = 143 IOP = 38 Sage = 959 Scopus = 1981 Science direct = 2782 Taylor y francis = 1369	7423 - 508 (duplicate) = 6915
2nd query	(‘coronavirus’ OR ‘coronaviridae’ OR ’covid’) AND (‘detection’ OR ‘classification’) AND (‘machine learning’ OR ‘artificial intelligence’ OR ’AI’ OR ’ML’) AND (’mask detection’ OR ’face mask detection’)	Ebsco = 121 Dynamed = 0 IEEE = 160 IOP = 12 Sage = 113 Scopus = 385 Science direct = 44 Taylor y francis = 146	981 - 109 (duplicate) = 872
3rd query	(‘coronavirus’ OR ‘coronaviridae’ OR ’covid’) AND (‘detection’ OR ‘classification’) AND (’social distance’ OR ’social distancing’) AND (’mask detection’ OR ’face mask detection’) AND (‘machine learning’ OR ‘artificial intelligence’ OR ’AI’ OR ’ML’)	Ebsco = 15 Dynamed = 0 IEEE = 34 IOP = 0 Sage = 0 Scopus = 101 Science direct = 24 Taylor y francis = 0	174 - 9 (duplicate) = 165
Final result for all queries			**7952 articles**

3. Statistical results

The results of metodology from Figure 1 has 48 papers that then realizes a histogram of tecniques and datasets in each query. Each query delimited a group of interested acording to proposals and datasets, 1st query (red color) is only papers that proposal and datasets to social distance, 2do query (green color) is face mask and 3rd query (blue color) are proposal that include social distance and face mask. In the Figure 2 shows to summary of algorithms and methods used in the literature review for 1st, 2nd and 3rd query, when has techniques like YOLO V3, Faster R-CNN, YOLO V2, MobileNet, DensNet, YOLO V4, YOLO V5 and YOLO-LITE, where consideres that techniques with best result using mAP metric. The analysis from histogram shows that YOLO V3 is that more used with 12, 12 and 3 papers to 1st, 2nd and 3rd query respectively.

Acording to state of art YOLO V5 has better in accuracy and inference time compared YOLO V3 but in Figure shows that YOLO V5 is only uses in 1, 0 and 1 paper to 1st, 2nd and 3rd query respectively. For 3rd query that include both a proposal to face mask and social distance have 3, 1, 1, 0, 1 papers to

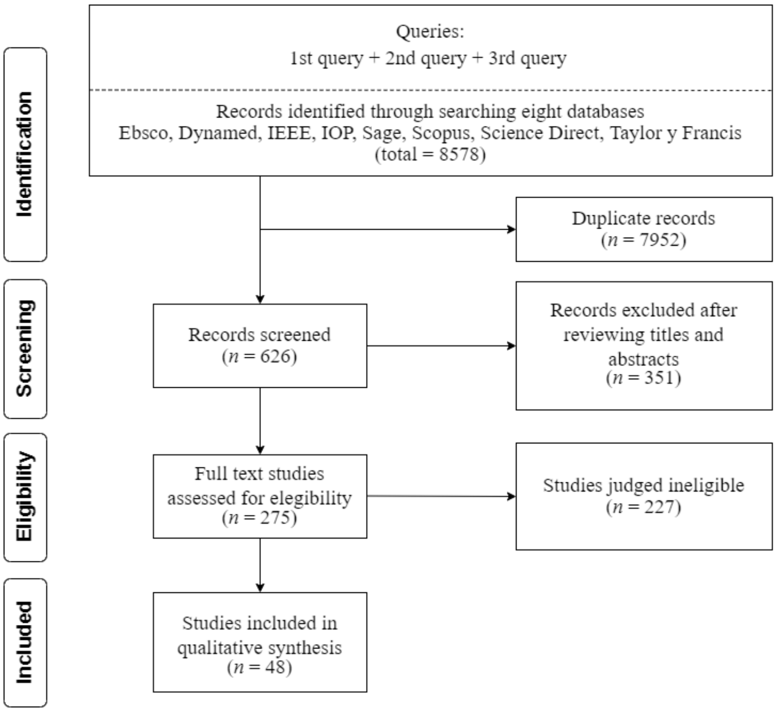

Figure 1: Schematic of the approach to identify, screen and include relevant studies.

YOLO V3 [6, 7, 8], Faster R-CNN [9], MobileNet [10] and YOLO V5 [11]. Analysing Figure 3, it shows to summary of datasets used in the literature review for 1st, 2nd and 3rd query, when has techniques like COCO, Oxford Town Center Dataset, KITTI 3D dataset, CCTV, RMFD, Medical Masks Dataset, Own dataset, Youtube, FaceMask, SAI-YOLO, Face dataset Kaggle, Benchmark mask dataset and Imagenet-21k. The analysis from histogram show that COCO is that more used with 5 papers to 1st query, Own dataset with 4 and 2 papers to 2nd and 3rd query respectively. For 3rd query that include both a proposal to mask fask and social distance have 1, 2, 1 papers to Own dataset [10, 8, 11] and Benchmark mask dataset [9].

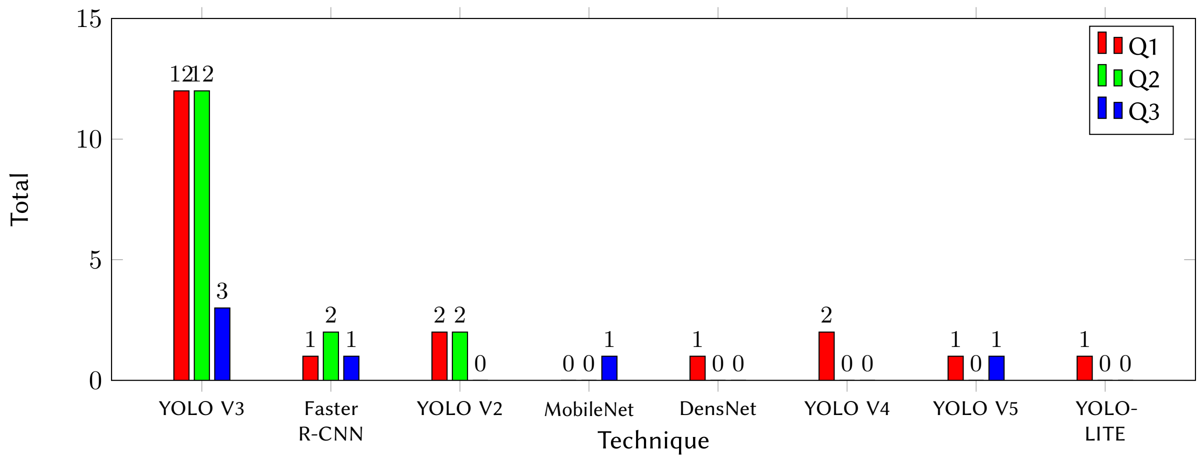

Figure 2: Histogram of algorithms and methods used in the literature review for 1st, 2nd and 3rd query

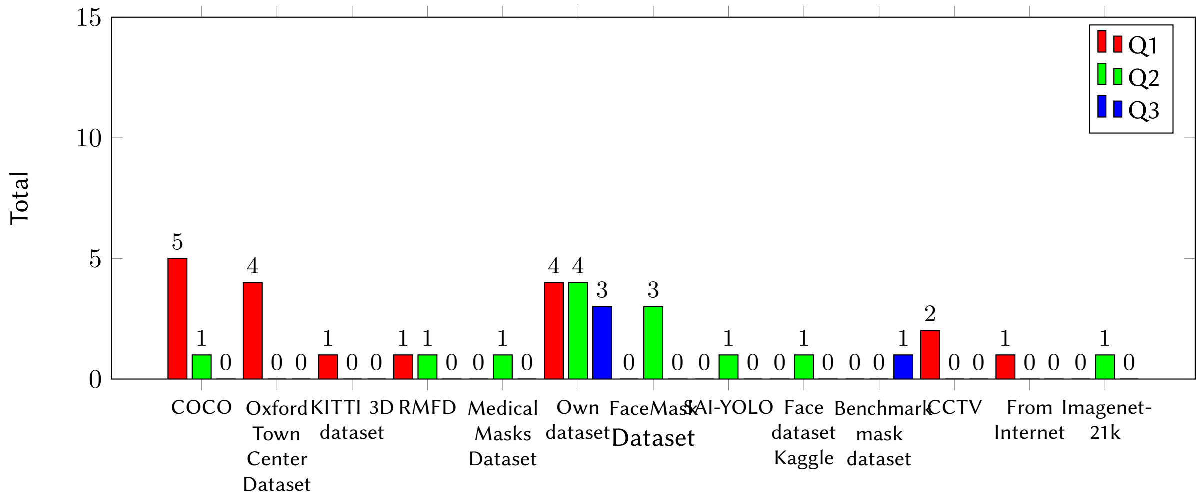

Figure 3: Histogram of datasets used in the literature review for 1st, 2nd and 3rd query.

4. Discussion

4.1. Techniques

In Table 2 shows results of analyzes techniques from 45 papers according to 1st, 2nd 3rd query from Table 1 using methodology in section of methods. The first 17 papers from Table 2 shows most used algorithms for the recognition of social distancing are YOLO, Faster R-CNN and SSD with evaluations oriented on the average accuracy (mAP) and FPS to compare which algorithm gives better results in different environments. [12, 13, 14, 15, 16, 17, 18, 10, 19, 20, 21, 22, 23, 24]. YOLO is the most used algorithm, with the percentage of use by versions being (YOLO V2 is with 5%, YOLO V3 with 75% and YOLO V4 with 10%), but those that use (F-RCNN and SDD) [25, 26, 24, 27, 21] go for the performance side and response time in FPS with higher results. Regarding the versions, it can be seen that there is a tendency to look for the latest updates.

Then 22 papers from Table 2 shows most used algorithms for face mask detection as YOLO, Mobile Net, ResNet, and topen-source computer vision library of python OpenCV. YOLO V3 [28], YOLO V4 [29] [30] and YOLO V5 [31] [11]; last one shows a high level of accuracy, major that 95%. After the analysis, it can notice the article [32] has the highest accuracy with 99.7%, the algorithm used was MobileNetV2 with the dataset Face-Mask-Detection. Last 6 papers from Table 2 shows about proposal that include face mask detection and social distancing where it is analyzed 4 of them work with YOLO V3 [9, 6, 7, 8], with an average of 94.5% accuracy corresponding to the test evaluation scope; Faster R-CNN algorithm [9], with an average accuracy of 99%; MobileNet algorithm [10] with an average of 99%, YOLO V5 [11], with a precision/recall of 0.6/0.98 and finally the ResNet algorithm [10, 7, 11], with an average of 98.5%.

4.2. Datasets

In Table 4 includes a short description of the research purpose of Face mask dataset. In addition, it shows the principal classes used, images, labels, total weight, metrics and access type. Next in Table 3 shows a brief of the main features of social distancing dataset as: Duration, resolution, weight, metric and access type.

4.3. Challenges and limitations

The studies carried out to develop applications that use artificial intelligence techniques present many challenges and limitations in research repositories that must be addressed with urgency and interest. The current challenges are related to the transmission and contagion of COVID-19 due to the lack of

Table 2
Algorithms and proposals of Social Distancing, Face Mask Detection and mixed in the COVID-19 context.

Ref.	ML Classification algorithms	Evaluation	Accuracy
[12]	YOLO V3, SSD and Faster RCNN	accuracy by mAP and FPS	46.5% and 55.3%
[13]	YOLO V3	-	-
[33]	Faster R-CNN, R-FCN and SSD	screen refresh rate	2 FPS
[14]	YOLO V3	detection with various angles	90%
[15]	YOLO V3	-	-
[16]	YOLOV3	mean average precision	57.9%
[17]	YOLO V3, Dist-YOLO V3 G and Dist-YOLO V3 W	mean average precision	74.3% and 77.1%
[18]	YOLO V2, Fast R-CNN and R-CNN	accuracy, precision and recall	86% and 96%
[19]	YOLO V4, YOLO V3 and Faster RCNN	performance metrics acurracy	0.96, 0.84 and 0.6
[20]	YOLO V3 and R-CNN	performance metrics FPS	0.5 and 0.45
[21]	YOLO V3, Faster RCNN and SSD	evaluation acurrancy	0.5, 0.59 and 0.35
[27]	YOLO V3, SSD and Faster RCNN	acurrancy	0.80, 078 and 074
[22]	YOLO V3 and YOLO V4	acurrancy	94.75% and 95%
[23]	YOLO-LITE, R-CNN and Darknet-53	-	-
[25]	OpenCV HOG	averaged error (cm)	6.72
[26]	YOLO V3 and MobilNetSSD	acurracy and Speedd comparison	30 / 26.66
[24]	YOLOV3, FPN FRCNN and SSD300	performance metrics mAP and FPS	55.3 / 59.1 / 41.2
[34]	MobileNet	accuracy	94.5%
[35]	Openpose and FMRN	accuracy daytime/nighttime	95.8% / 94.6%
[36]	MobileNet (HoG)	accuracy	95.67%
[37]	YOLO Nano approach and Gaussian Mixture Model	-	-
[38]	YOLO V3	accuracy	98%
[31]	YOLO V5	accuracy	97.9%
[29]	YOLO V4 and SpineNet-190	accuracy	94.7%
[30]	YOLO v4, Tiny and Lightweight	mAP/ AP	86% / 88%
[39]	Gabor Wavelet	accuracy	97%
[32]	MobileNetV2	accuracy	99.7%
[40]	OpenCV and TensorFlow	accuracy	97%
[41]	ResNet50 and ResNet101	accuracy	91%
[42]	OpenCV, Keras and TensorFlow	accuracy	97.05%
[11]	YOLO V5 and DBSCAN	accuracy precision and recall	85%, 97% and 80%
[43]	Computer vision	accuracy/ precision	9% / 89%
[44]	TensorFlow and MobileNetV2	accuracy	99.64%
[28]	Haar Cascade Classifier	connection speed (seconds)	0.001695977
[45]	ResNet50	accuracy	98.2%
[46]	Quantum Transfer Learning and ResNet-18	accuracy	99.05%
[47]	mAP, MaskedFaceNet and MaskedFaceNet Light	0.9813 / 0.9812	
[48]	ResNet-50	accuracy	98.74%
[49]	Pynq- YOLO-Net	accuracy	97%
[9]	Faster R-CNN and YOLOv3	Precision with mask/Without mask	0.99 / 0.88
[10]	MobileNet and ResNet	F1-score/sensitivity/ specificity/accuracy	0.99 / 0.99 / 0.99 / 1.0
[6]	YOLO V3	-	-
[7]	YOLO V3 and Resnet50	-	-
[8]	YOLO V3	accuracy/F1 score	0.9120 / 0.9079
[11]	YOLO V5 and Resnet50	Precision/recall	0.6 / 0.98

Table 3
Summary of Social Distaning Datasets in the COVID-19 context.

Dataset	Time	Resolution	Size	Best metric	Access
Oxford Town Center [50]	5 Min.	1920 X 1080	1.04 GB	79.71	public
Mall [51]	33 Min.	640 X 480	60.2 MB	79.41	public
Train Station [52]	33 Min.	720 X 480	140 MB	79.50	public
Ground truth Meter 1 [53]	1 Min.	720 X 480	300 MB	70.22	public
Ground truth Meter 2 [53]	1 Min.	720 X 480	253 MB	70.15	public
Ground truth Meter 3 [53]	13 Sec.	720 X 480	92 MB	70.05	public

Table 4
Summary of Face Mask Datasets in the COVID-19 context.

Dataset	Purpose	Class	Images	Labels	Size	Access
MAFA [54]	Mask wearing detection	Right face mask wearing Wrong face mask wearing No face mask wearing	24,603 1,204 3,645	24,603 1,204 3,645	2.32 Gb	Public
Multi Human Parsing [55]	People detection	Train - MHP Validation - MHP	2,500 2,500	2,500 2,500	-	Private
Celeb [56]	Facial attributes recognition	Train Test Validation	162,770 19,962 19,867	162,770 19,962 19,867	1.62Gb	Public
WilderFace [56]	Face detection with exposure variability	61 event types	32,203	393,703	-	Public
WMD [57]	Mask wearing detection	Face with mask	7804	26,403	673.1MB	Public
WMC [57]	Mask wearing detection	Face with mask and background	38145	-	154.9 MB	Public
FaceDataset [53]	Mask wearing detection	Train Validation	4054	16216	320.7MB	Public
MaskedFace-Net [53]	Mask wearing detection	Train - MHP Validation - MHP	2,500 2,500	2,500 2,500	-	Public

knowledge and complexity of this epidemic. Databases on COVID-19 are difficult for researchers to access and have characteristics that often do not meet the needs of researchers or are synthetic databases. Database construction requires the processing of large volumes of data that includes manual evaluation of unstructured data. Other challenges are related to the transparency of information from governments and public entities in charge of sanitary control, which could generate a bias in the results. Another challenge present in research is the similar behavior of COVID-19 with other traditional diseases. Points to take into account in the correct detection and accuracy given that there are inconveniences such as children or babies because most of the measurements are not detected within the 'person' regime. Another important point to take into consideration with the shadows, given that in some detections made by the angle of the camera, it is filtered as a person itself. These are cases that cause an impact within the percentage of final accuracy for applications.

4.4. Recommendations

The objective of this research is to help researchers learn about research on artificial intelligence issues and limitations and advances to mitigate the contagion of the pandemic generated by COVID-19 and thus be able to contribute to generating new research. Studies, such as the one by [32] propose a deep convolutional neural network (CNN) based on the MobileNetV2 architecture as a learning algorithm. The results show an accuracy of 99.7 % in mask detection with a run time of 1.54 s. Another study [46] uses ResNet-18; with 99.05% accuracy in the classification of protective masks. Finally [10] focuses on implementing a face mask detection and social distancing model as an integrated vision system. Pre-trained models such as MobileNet, ResNet Classifier, and VGG with an F1 score of 99%, a sensitivity of 99%, a specificity of 99%, and an accuracy of 100%.

5. Conclusions

The research carried out allows knowing the technological advances in the area of artificial intelligence aimed at solving problems generated by COVID-19. This research analyzed the different solution proposals based on mask detection algorithms and social distancing methods, considering the performance of machine learning models. Additionally, recommendations were established that will serve as a guide for the selection of research proposals in the area of artificial intelligence that try to solve problems of

COVID-19. Finally, it is suggested to use specific terms in database queries to obtain optimal results considering the quotes and logical connectors.

6. Acknowledgments

Thanks to the “Universidad Tecnológica del Perú (UTP)”, for supporting the development of technology and scientific research.

References

[1] D. Wu, T. Wu, Q. Liu, Z. Yang, The sars-cov-2 outbreak: what we know, International Journal of Infectious Diseases 94 (2020) 44–48.

[2] Y. Fan, K. Zhao, Z.-L. Shi, P. Zhou, Bat coronaviruses in china, Viruses 11 (2019) 210.

[3] C. for Disease Control, Prevention, et al., Centers for disease control and prevention coronavirus disease 2019 (covid-19) 2020, United States: Centers for Disease Control and Prevention (2020).

[4] K.-H. Yu, A. L. Beam, I. S. Kohane, Artificial intelligence in healthcare, Nature biomedical engineering 2 (2018) 719–731.

[5] D. Moher, A. Liberati, J. Tetzlaff, D. G. Altman, P. Group*, Preferred reporting items for systematic reviews and meta-analyses: the prisma statement, Annals of internal medicine 151 (2009) 264–269.

[6] S. V. Shetty, K. Anand, S. Pooja, K. Punnya, M. Priyanka, Social distancing and face mask detection using deep learning models: A survey, in: 2021 Asian Conference on Innovation in Technology (ASIANCON), IEEE, 2021, pp. 1–6.

[7] S. Subhash, K. Sneha, A. Ullas, D. Raj, A covid-19 safety web application to monitor social distancing and mask detection, in: 2021 IEEE 9th Region 10 Humanitarian Technology Conference (R10-HTC), IEEE, ????, pp. 01–06.

[8] S. Srinivasan, R. R. Singh, R. R. Biradar, S. Revathi, COVID-19 monitoring system using social distancing and face mask detection on surveillance video datasets, in: 2021 International Conference on Emerging Smart Computing and Informatics (ESCI), IEEE, 2021. doi:10.1109/esci50559.2021.9396783.

[9] S. Meivel, N. Sindhwani, R. Anand, D. Pandey, A. A. Alnuaim, A. S. Altheneyan, M. Y. Jabarulla, M. E. Lelisho, Mask detection and social distance identification using internet of things and faster r-cnn algorithm, Computational Intelligence and Neuroscience 2022 (2022).

[10] S. Teboulbi, S. Messaoud, M. A. Hajjaji, A. Mtibaa, Real-time implementation of ai-based face mask detection and social distancing measuring system for covid-19 prevention, Scientific Programming 2021 (2021).

[11] I. S. Walia, D. Kumar, K. Sharma, J. D. Hemanth, D. E. Popescu, An integrated approach for monitoring social distancing and face mask detection using stacked resnet-50 and yolov5, Electronics 10 (2021) 2996.

[12] M. M. Özbek, M. Syed, I. Öksüz, Subjective analysis of social distance monitoring using yolo v3 architecture and crowd tracking system., Turkish Journal of Electrical Engineering & Computer Sciences 29 (2021).

[13] G. Shalini, M. K. Margret, M. S. Niraimathi, S. Subashree, Social distancing analyzer using computer vision and deep learning, in: Journal of Physics: Conference Series, volume 1916, IOP Publishing, 2021, p. 012039.

[14] P. Somaldo, F. A. Ferdiansyah, G. Jati, W. Jatmiko, Developing smart covid-19 social distancing surveillance drone using yolo implemented in robot operating system simulation environment, in: 2020 IEEE 8th R10 Humanitarian Technology Conference (R10-HTC), IEEE, 2020, pp. 1–6.

[15] Y. C. Hou, M. Z. Baharuddin, S. Yussof, S. Dzulkifly, Social distancing detection with deep learning model, in: 2020 8th International Conference on Information Technology and Multimedia (ICIMU), IEEE, 2020, pp. 334–338.

[16] J. Shah, H. Gala, K. Pattni, P. Kanani, Arduino based temperature, mask wearing and social

distance detection for covid-19, in: International Conference on Internet of Things and Connected Technologies, Springer, 2021, pp. 148–161.

[17] M. Vajgl, P. Hurtik, T. Nejezchleba, Dist-yolo: Fast object detection with distance estimation, Applied Sciences 12 (2022) 1354.

[18] S. Saponara, A. Elhanashi, A. Gagliardi, Implementing a real-time, ai-based, people detection and social distancing measuring system for covid-19, Journal of Real-Time Image Processing 18 (2021) 1937–1947.

[19] J. Li, Z. Wu, The application of yolov4 and a new pedestrian clustering algorithm to implement social distance monitoring during the covid-19 pandemic, in: Journal of Physics: Conference Series, volume 1865, IOP Publishing, 2021, p. 042019.

[20] R. J. P. Garcia, J. N. Ronato, J. Flores Villaverde, Monitoring of people capacity in an establishment using yolov3 algorithm, in: 2021 The 6th International Conference on Information and Education Innovations, 2021, pp. 118–124.

[21] R. Magoo, H. Singh, N. Jindal, N. Hooda, P. S. Rana, Deep learning-based bird eye view social distancing monitoring using surveillance video for curbing the covid-19 spread, Neural Computing and Applications 33 (2021) 15807–15814.

[22] K. Bhambani, T. Jain, K. A. Sultanpure, Real-time face mask and social distancing violation detection system using yolo, in: 2020 IEEE Bangalore Humanitarian Technology Conference (B-HTC), IEEE, 2020, pp. 1–6.

[23] F. Mercaldo, F. Martinelli, A. Santone, A proposal to ensure social distancing with deep learning-based object detection, in: 2021 International Joint Conference on Neural Networks (IJCNN), 2021, pp. 1–5. doi:10.1109/IJCNN52387.2021.9534231.

[24] S. Das, A. Nag, D. Adhikary, R. J. Ram, B. Aravind, S. K. Ojha, G. Hegde, Computer vision-based social distancing surveillance with automated camera calibration for large-scale deployment, in: 2021 IEEE 18th India Council International Conference (INDICON), IEEE, 2021, pp. 1–6.

[25] H. Ziran, N. Dahnoun, A contactless solution for monitoring social distancing: A stereo vision enabled real-time human distance measuring system, in: 2021 10th Mediterranean Conference on Embedded Computing (MECO), IEEE, 2021, pp. 1–6.

[26] M. Ismail, T. Najeeb, N. S. Anzar, A. Aditya, B. R. Poorna, Using computer vision to detect violation of social distancing in queues, in: S. Smys, V. E. Balas, R. Palanisamy (Eds.), Inventive Computation and Information Technologies, Springer Nature Singapore, Singapore, 2022, pp. 771–779.

[27] N. S. Punn, S. K. Sonbhadra, S. Agarwal, G. Rai, Monitoring covid-19 social distancing with person detection and tracking via fine-tuned yolo v3 and deepsort techniques, 2020. URL: https://arxiv.org/abs/2005.01385. doi:10.48550/ARXIV.2005.01385.

[28] A. Rahmatulloh, R. Gunawan, H. Sulastri, I. Pratama, I. Darmawan, Face mask detection using haar cascade classifier algorithm based on internet of things with telegram bot notification, in: 2021 International Conference Advancement in Data Science, E-learning and Information Systems (ICADEIS), IEEE, 2021, pp. 1–6.

[29] Z. Cao, M. Shao, L. Xu, S. Mu, H. Qu, Maskhunter: real-time object detection of face masks during the covid-19 pandemic, IET Image Processing 14 (2020) 4359–4367.

[30] Z. Zhao, K. Hao, X. Ma, X. Liu, T. Zheng, J. Xu, S. Cui, Sai-yolo: A lightweight network for real-time detection of driver mask-wearing specification on resource-constrained devices, Computational Intelligence and Neuroscience 2021 (2021).

[31] G. Yang, W. Feng, J. Jin, Q. Lei, X. Li, G. Gui, W. Wang, Face mask recognition system with yolov5 based on image recognition, in: 2020 IEEE 6th International Conference on Computer and Communications (ICCC), IEEE, 2020, pp. 1398–1404.

[32] S. Chokri, W. B. Daoud, W. Hanini, S. Mahfoudhi, A. Makhlouf, Ai-based system for the detection and prevention of covid-19, International Journal of Advanced Computer Science and Applications 13 (2022).

[33] O. Karaman, A. Alhudhaif, K. Polat, Development of smart camera systems based on artificial intelligence network for social distance detection to fight against covid-19, Applied Soft Computing 110 (2021) 107610.

[34] S. V. Militante, E. L. M. Marin, G. V. Canja, G. J. B. Paglingayen, M. J. M. Saballa-Marin, Deep learning application of automated facemask classification and physical-distancing detection, in: 2021 Fourth International Conference on Vocational Education and Electrical Engineering (ICVEE), IEEE, 2021, pp. 1–5.
[35] H. Lin, R. Tse, S.-K. Tang, Y. Chen, W. Ke, G. Pau, Near-realtime face mask wearing recognition based on deep learning, in: 2021 IEEE 18th Annual Consumer Communications & Networking Conference (CCNC), IEEE, 2021, pp. 1–7.
[36] S. K. Dey, A. Howlader, C. Deb, Mobilenet mask: a multi-phase face mask detection model to prevent person-to-person transmission of sars-cov-2, in: Proceedings of International Conference on Trends in Computational and Cognitive Engineering, Springer, 2021, pp. 603–613.
[37] E. Nasiri, M. Milanova, A. Nasiri, Video surveillance framework based on real-time face mask detection and recognition, in: 2021 International Conference on INnovations in Intelligent SysTems and Applications (INISTA), IEEE, 2021, pp. 1–7.
[38] B. Sathyabama, A. Devpura, M. Maroti, R. S. Rajput, Monitoring pandemic precautionary protocols using real-time surveillance and artificial intelligence, in: 2020 3rd International Conference on Intelligent Sustainable Systems (ICISS), IEEE, 2020, pp. 1036–1041.
[39] P. Durga, G. Divya, D. Ayeshwariya, P. Sivakumar, et al., Gabor-deep cnn based masked face recognition for fraud prevention, in: 2021 5th International Conference on Computing Methodologies and Communication (ICCMC), IEEE, 2021, pp. 990–995.
[40] S. V. Militante, N. V. Dionisio, Deep learning implementation of facemask and physical distancing detection with alarm systems, in: 2020 Third International Conference on Vocational Education and Electrical Engineering (ICVEE), IEEE, 2020, pp. 1–5.
[41] B. Bhattarai, Y. Raj Pandeya, J. Lee, Deep learning-based face mask detection using automated gui for covid-19, in: 2021 6th International Conference on Machine Learning Technologies, 2021, pp. 47–57.
[42] G. Kaur, R. Sinha, P. K. Tiwari, S. K. Yadav, P. Pandey, R. Raj, A. Vashisth, M. Rakhra, Face mask recognition system using cnn model, Neuroscience Informatics (2021) 100035.
[43] G. T. Draughon, P. Sun, J. P. Lynch, Implementation of a computer vision framework for tracking and visualizing face mask usage in urban environments, in: 2020 IEEE International Smart Cities Conference (ISC2), IEEE, 2020, pp. 1–8.
[44] E. Kontellis, C. Troussas, A. Krouska, C. Sgouropoulou, Real-time face mask detector using convolutional neural networks amidst covid-19 pandemic, in: 1st International Conference on Novelties in Intelligent Digital Systems, NIDS 2021, 2021, pp. V–VI.
[45] S. Sethi, M. Kathuria, T. Kaushik, A real-time integrated face mask detector to curtail spread of coronavirus, CMES-Computer Modeling in Engineering and Sciences (2021) 389–409.
[46] C. Soto-Paredes, J. Sulla-Torres, Hybrid model of quantum transfer learning to classify face images with a covid-19 mask, International Journal of Advanced Computer Science and Applications 12 (2021).
[47] S. Prasad, Y. Li, D. Lin, D. Sheng, maskedfacenet: A progressive semi-supervised masked face detector, in: Proceedings of the IEEE/CVF Winter Conference on Applications of Computer Vision, 2021, pp. 3389–3398.
[48] E. Ryumina, D. Ryumin, D. Ivanko, A. Karpov, A novel method for protective face mask detection using convolutional neural networks and image histograms., International Archives of the Photogrammetry, Remote Sensing & Spatial Information Sciences (2021).
[49] Y. Said, Pynq-yolo-net: An embedded quantized convolutional neural network for face mask detection in covid-19 pandemic era, Int. J. Adv. Comput. Sci. Appl 11 (2020) 100–106.
[50] B. Benfold, I. Reid, Stable multi-target tracking in real-time surveillance video, in: CVPR 2011, 2011, pp. 3457–3464. doi:10.1109/CVPR.2011.5995667.
[51] K. Chen, C. C. Loy, S. Gong, T. Xiang, Feature mining for localised crowd counting., in: Bmvc, volume 1, 2012, p. 3.
[52] B. Zhou, X. Wang, X. Tang, Understanding collective crowd behaviors: Learning a mixture model of dynamic pedestrian-agents, in: 2012 IEEE Conference on Computer Vision and Pattern

Recognition, IEEE, 2012, pp. 2871–2878.

[53] Video dataset for covid-19 social distancing and human detection validation, https://data.mendeley.com/datasets/xh6m6gxhvj/1, 11 Nov 2020. doi:10.17632/xh6m6gxhvj.1.

[54] A. S. Joshi, S. S. Joshi, G. Kanahasabai, R. Kapil, S. Gupta, Deep learning framework to detect face masks from video footage, in: 2020 12th International Conference on Computational Intelligence and Communication Networks (CICN), IEEE, 2020, pp. 435–440.

[55] T. Meenpal, A. Balakrishnan, A. Verma, Facial Mask Detection using Semantic Segmentation, 2019 4th International Conference on Computing, Communications and Security, ICCCS 2019 (2019) 1–5. doi:10.1109/CCCS.2019.8888092.

[56] R. C. Atmudi, A. A. Rao, Covid-19 Face Mask Prediction using Machine Learning Techniques Covid-19 Face Mask Prediction using Machine Learning Techniques (2020).

[57] B. Wang, Y. Zhao, C. P. Chen, Hybrid transfer learning and broad learning system for wearing mask detection in the covid-19 era, IEEE Transactions on Instrumentation and Measurement 70 (2021) 1–12.