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A Systematic Literature Review on Optimizing Mask Detection Systems Using Convolutional Neural Networks for Public Health and Safety

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ABSTRACT

COVID-19 pandemic significantly impacted public health and safety globally, necessitating strict implementation of health protocols, including mask usage. Monitoring mask compliance remains challenging, particularly in public spaces. This study conducts a systematic literature review on optimizing mask detection systems using Convolutional Neural Networks (CNN) for public health and safety. CNN demonstrates robust performance in recognizing facial patterns and accurately detecting masks, addressing challenges such as lighting variations, occlusions, and diverse facial orientations. The review highlights advancements in CNN-based architectures, dataset utilization, and real-time implementation strategies. The study utilized a dataset comprising images of individuals with and without masks, split into 80% training and 20% testing data, achieving high accuracy in identifying mask usage. Integration possibilities with access control systems, Computer Vision, and Internet of Things (IoT) technologies are explored for scalable, real-time monitoring. The findings contribute significantly to optimizing health protocol enforcement and mitigating COVID-19 transmission risks in public areas.

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1. INTRODUCTION

Pandemics, such as COVID-19, have placed unprecedented demands on public health systems globally. The outbreak of COVID-19 in late 2019 rapidly escalated into a global crisis, significantly impacting societal and economic systems [1]. Among the various preventive measures, wearing masks has emerged as a critical tool to mitigate the spread of the virus, particularly in public spaces [2]. However, enforcing mask compliance remains a significant challenge, necessitating innovative technological solutions.

Convolutional Neural Networks (CNN) have demonstrated remarkable capabilities in pattern recognition tasks, including facial recognition and object detection [3], [4]. Their robustness in handling diverse datasets makes CNN an ideal candidate for developing automated mask detection systems. These systems can enhance health protocol enforcement by accurately identifying individuals wearing or not wearing masks in real time, thereby supporting pandemic mitigation strategies.

Recent studies have explored the integration of CNN with Internet of Things (IoT) and Computer Vision technologies to create scalable solutions for public health monitoring. IoT-enabled systems offer real-time data collection and processing, enabling efficient surveillance in high-traffic areas [5], [6]. Such implementations have demonstrated the potential to not only enforce mask mandates but also improve security and safety in public and private spaces.

Despite advancements, challenges persist in optimizing mask detection systems for diverse environments. Variations in lighting, occlusions, and facial orientations can affect detection accuracy [7], [8]. Addressing these limitations requires robust datasets and enhanced CNN architectures capable of adapting to real-world complexities. This study systematically reviews literature focusing on the application of CNN for mask detection, emphasizing optimization strategies and integration with IoT technologies

The primary objectives of this study are to explore the latest developments in CNN-based mask detection systems, highlighting innovations in architectures, datasets, and optimization techniques. It also aims to identify challenges and limitations in existing systems, focusing on accuracy, scalability, and adaptability to diverse environmental conditions. Furthermore, the study proposes strategies for enhancing system performance, particularly in real-time applications and complex environments. An additional objective is to assess the potential of IoT integration in mask detection systems, offering scalable and connected solutions for monitoring public health compliance. By addressing these objectives, this study contributes to the growing body of research on AI-driven public health interventions, providing actionable insights for developers, policymakers, and researchers. It seeks to bridge gaps in current methodologies, paving the way for the implementation of effective, real-time mask detection systems that enhance public health safety measures during pandemics and beyond.

2. RELATED RESEARCH

In article This, researcher inspect data from study previously as point comparison, Good for deficiency or advantage Which There is. Besides That, to researcher filter journal study for information about hypothesis previously Which connected with topic for build runway theoretical for science.

1. Monitoring Usage Face mask On Visitors Stmic “Amikbandung” Use Algorithm Convolutional Neural Network (CNN). Method Which used for study This is Extreme Programming (XP). According to Kent Beck is method development device soft Which fast, efficient, risky low, flexible, predictable, scientific, And pleasant. XP Also is a model Which including in approach agile, method development Which identical with break up development become a number of iteration. Method development XP selected Because device soft Which will made No too complex And classified scale small And Also need time development Which No too long time.[5]
2. Detection Face mask Prevention Covid19 Use Convolutional Neural Network Based Android. Method study Which used use combination model sequential exploratory Where method This combine method study And development (research and development) Which normal used for develop And test system. Study done through two stages, level First with method qualitative so that can obtained plan system And study level the two with method quantitative (experiment) used for test effectiveness system Which produced.[6]
3. Identification Face mask on Face Detection with Use Method Her Cascade And CNN. Steps early Which done on study This is identify problem, analyze problem, determine objective, learn literature, gather data And analysis, designing system, do implementation with method Her Cascade And CNN, And test results research.[7]
4. System Detector Face Masked Basically Real Time Use Method CNN. Study This shared in 3 level, that is level training dataset, detection face, And testing regularly real time. On programming used Python And library Tensorflow, Hard, OpenCV, Imutils, Numpy, matplotlib, Scipy And Visual Studio Code as application Editor Code.[8]
5. Implementation Convolutional Neural Network (CNN) For Detect Usage Face mask On Picture. On study This, done development A model Convolutional Neural Network (CNN) for detect whether someone use face mask or No based on picture face. Method study This

covers analysis, architecture model, method Which used for solve problem, And implementation model CNN.[9]

6. Implementation System Detector Usage Face mask Based Raspberry Pi 4 Use Method Convolution Neural Network (CNN) on Process Screening Protocol Health COVID-19. On study This needed datadata form picture object Which used for detection usage face mask with format PNG. Data Which is required that is picture object man Which use face mask And picture Which No use face mask, with all kinds of things object like use glasses, wearing hijab, And use hat.[10]
7. Face Mask Detection Use Python And Opencv For Detect Violation Protocol Health Covid-19. Method Which used in study This is method qualitative with method collection data with observation field And studies library. Observation done on related with image processing Which utilise deep learning for learn feature special from each object especially in read object face Which use face mask And No use face mask. On study face mask detection there is two process that is Train Face Mask Detector And Apply Face Mask Detector.[11]
8. Development System Face Recognition Use Cloud Service, Raspberry Pi And Convolutional Neural Network. Technique testing Which done (a) Compare method detection face between CNN And Her Cascade (b) Compare model identification face between facenet And arcface. (c) Compare influence from intensity light.[12]
9. Comparison Method Detection Face Use OpenCV Her Cascade, OpenCV Single Shot Multibox Detector (SSD) And DLib CNN. study shared become three that is level planning, level you And level end. On level planning or level First, done studies literature about usage third method in detection face. As for a number of matter Which searching for is performance third method And Weaknesses channel publication Which Already exists.[13]
10. Detection Non-Spoofing Face on Video regularly Real Time Use Faster R-CNN. process collection material study Which relate with video, spoofing image, Faster R-CNN And Raspberry Pi form journal, conference And book support study others.[14].

3. RESEARCH METHODS

3.1 Systematic literature Review (SLR)

Systematic literature review (SLR) or survey systematic literature (SLR) identify, evaluate, And interpret all findings about problem studies Which checked for respond question study Which has been set. Definition extra SLR is studies scientific Which compare or supported by study previously And focused on subject certain.

3.2 Research Question

Specification topic Which selected taken into account moment formulate question study. Question study study listed Of down This:

RQ1: What just method Which often used for make planning system management extracurricular based web on year 2021-2023?

RQ2: What just advantage And deficiency system management extracurricular based web based on method Which used?

RQ3: Method from study which Which own results the best in do system management extracurricular based web?

3.3 Search Process

Use Google Chrome And address site web https://scholar.google.com/, process search used for identify source Which related with question study (RQ) And reference related other.

3.4 Inclusion and Exclusion Criteria

Procedure This used for determine whether data Which collected related with study. Studies will selected If criteria Of down This fulfilled:

a. Data Which used covers year 2021 until 2023.
b. Data Which used taken use URL site web https://scholar.google.com/.
c. Data Which used limited on System Management Extracurricular Based Web.

3.5 Quality Assessment

List summary problem works as base for assessment quality, or QA. Level review guarantee quality must covers all formulation problem. Information Which collected for study This will assessed use criteria following for measure quality.:

QA1: Whether literature the published on year 2021-2023?

QA2: Whether literature the discuss manufacture system management extracurricular based web?

Each response Which listed Of down This for questions Which mentioned Of above will receive score for each work literature.

AND (of) : in case literature Which in accordance with question assessment quality.

T (No) : in case literature Which No in accordance with question assessment quality.

3.6 Data Collection

Level This is Level collection data when information collected for study This. Following The steps collection data Which obtained use source https://scholar.google.com/.

a. Access page website https://scholar.google.com/

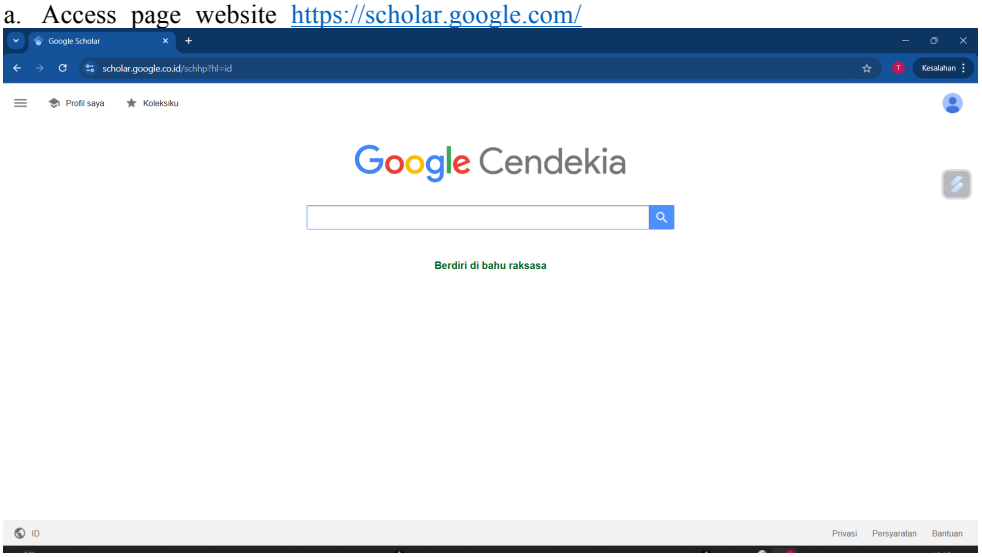


Figure 1. Google Scholar

b. Include keyword "Development System Detector Face mask Face Use CNN" on column search. On appearance screen corner left that is Custom Range, enter year 2021- 2023 for identify source year in recruitment literature Which relevant.

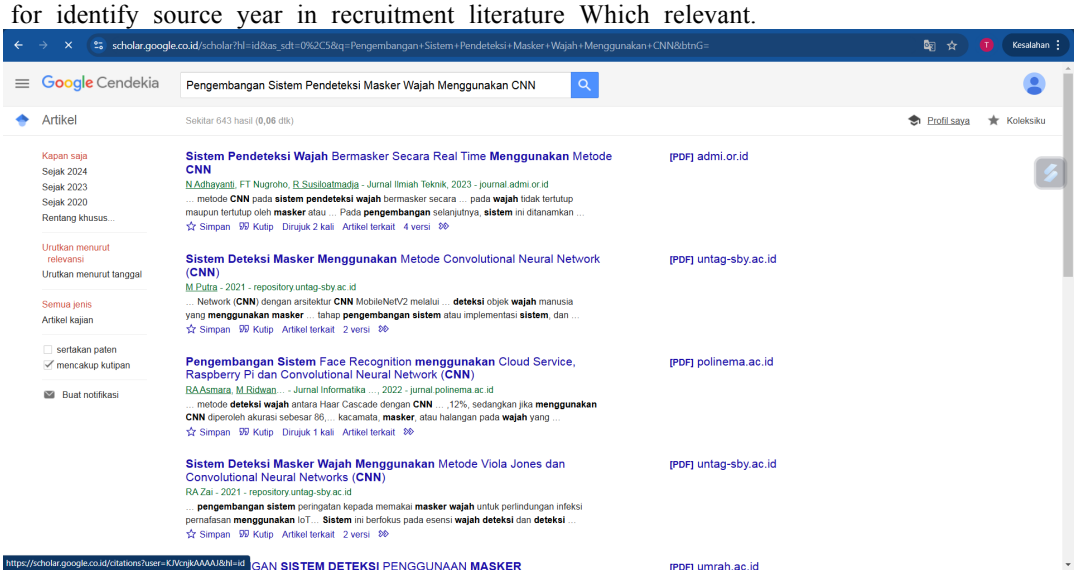


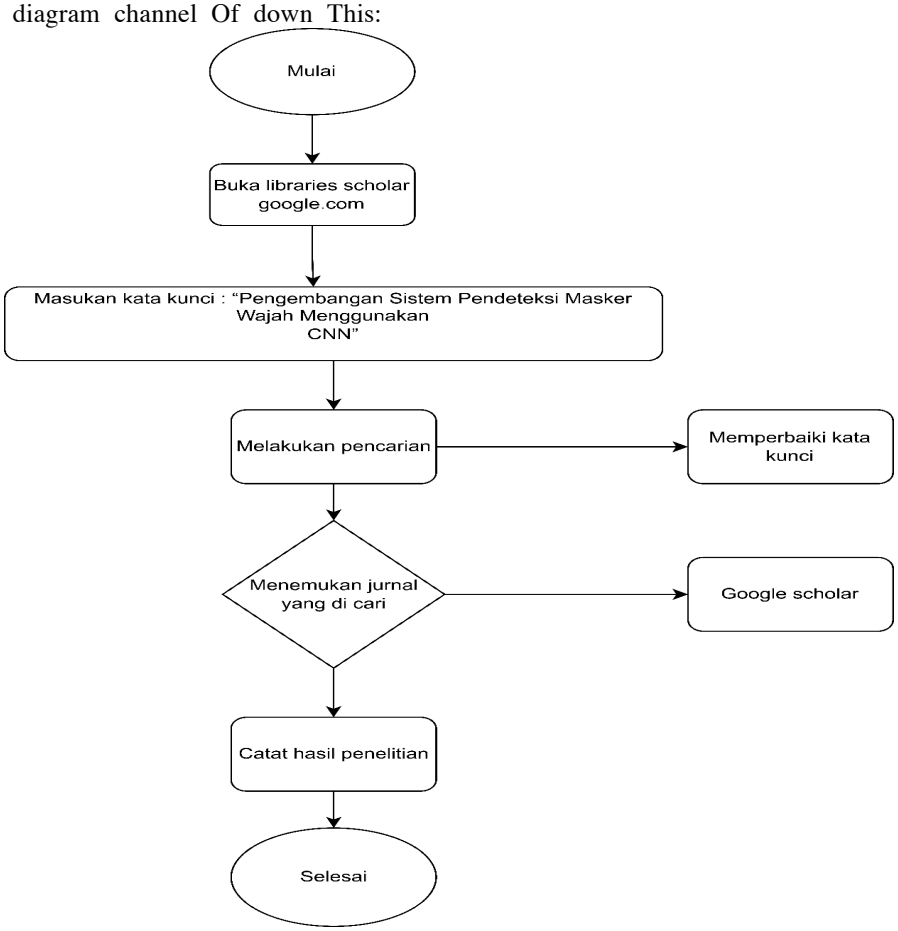
Figure 2 Results search "Development System Detector Face mask Face Use CNN"

3.7 Data Analysis

Question studies (RQ) will discussed on point This, together with results studies latest from 2021 until 2023.

4. RESULTS AND DISCUSSION

Results Search Process In process search journal Which relevant, results search is displayed on diagram channel Of down This:



Picture 3 Flowchart process search journal Which

4.1 Results Quality Assessment

Parameter (inclusion And exclusion) will used for choose results search. On level search process produce Lots journal, Then selected 10 journal Which remaining after level inclusion And exclusion. After That, scanning data will done On level next show results quality assessment to journal Which will entered the in study.

4.2 Results Quality Assessment (QA)

Results from quality assessment will determine journal used or No on study This. Picture following is results from Quality Assessment..

Table1. Quality Assessment

No	Writer	Title	Year	QA1	QA2	Results
1	Dawn Nazmi Fadillah,	Monitoring Usage Face mask On Visitors Stmic	2023	AND	AND	✔

	Khoirida Come on	"Amikbandung" Use Algorithm Convolutional Neural Network (CNN)				
2	Nyoman Purnama, The way Kusuma Country	Detection Face mask Prevention Covid19 Use Convolutional Neural Network Based Android	2021	AND	AND	✔
3	Vebri Pain	Identification Face mask on Face Detection with Use Method Her Cascade And CNN	2022	AND	AND	✔
4	Nurul Adhayanthiya, Fathan Triyanto Nugrohob, Romdhon Susiloatmadjac	System Detector Face Masked Basically Real Time Use Method CNN	2023	AND	AND	✔
5	Basil Ordinary Saputra, Davita Rasendriya Rizqullah Son, Muhammad Alaika Asylph	Implementation Convolutional Neural Network (CNN) For Detect Usage Face mask On Picture	2023	AND	AND	✔
6	Muhammad Abdullah, Sabilal Rashad, Niksen Alfarizal	Implementation System Detector Usage Face mask Based Raspberry Pi 4 Use Method Convolution Neural Network (CNN) on Process Screening Protocol Health COVID-19	2022	AND	AND	✔
7	Riza Syahrial, Tati Sukmawati, The river Swimming Goddess	Face Mask Detection Use Python And Opencv For Detect Violation Protocol Health Covid-19	2023	AND	AND	✔
8	Rosa Andrie Romance, Muhammad Ridwan, Gunawan Budi P3, Anik Only Handayani	Development System Face Recognition Use Cloud Service, Raspberry Pi And Convolutional Neural Network	2022	AND	AND	✔
9	His Farokh	Comparison Method Detection Face Use OpenCV Her Cascade, OpenCV Single Shot Multibox Detector (SSD) And DLib CNN	2021	AND	AND	✔
10	Sunario Megawan, Month Sri Lestari, Apriyanto Halim	Detection Non-Spoofing Face on Video regularly Real Time Use Faster R-CNN	2022	AND	AND	✔

4.3 Results Data Collection

After through level inclusion and exclusion get 10 journal, continued with level quality assessment (Quality assessment) journal Which can used for study This is a number 10 journal. Picture following will summarize about detail from each journal the.

Table 2. Results Data Collection

No	Title	Author/year	Method study	Results Study
1	Monitoring Usage Face mask On	Dawn Nazmi Fadillah,	Convolution Neural Network	Based on results development monitoring

	Visitors Stmic "Amikbandung" Use Algorithm Convolutional Neural Network (CNN)	Khoirida Come on 2023		usage face mask on visitors STMIK "AMIK BANDING" use algorithm Convolutional Neural Network (CNN) based web Which explained previously, obtained conclusion as following: Implementation classification get level accuracy rate by rate Of above 90% from two camera different, camera laptop Dell Inspiron 7567 (0,92MP) And camera Logitech C270 (0,9MP). Quality camera influence quality detection from system Which built. Distance effective detection moment This is at in range 0,82 meter until 1,80 meter with consideration intensity light Which Enough from installation camera. If pass distance effective, system classification will displays level accuracy predictions more low until No can detect face The same once.[4]
2	Detection Face mask Prevention Covid19 Use Convolutional Neural Network Based Android	Nyoman Purnama, The way Kusuma Country 2021	Convolution Neural Network	Based on study Which done with amount dataset as big as 600 image for 3 type face mask. Where 200 image used for training And 100 image for validation dataset. Then on process testing used 20 image Which taken regularly random as data testing for each image face mask. After done process training obtained mark accuracy the best with 200 image for data training And 100 image for data testing as big as 89.3%. Process training dataset done with application based

				Python. Whereas on part testing done on application mobile based android with use Android studio And framework Tensor flow. Architecture Which used on tensor flow This is mobileNet versi2. On study This produce mark accuracy as big as 90 %, recall for optimization ADAM And 80% for optimization Gradient Descent. Based on results from detection type face mask with method Convolutional Neural Network use optimization ADAM And gradient descent can assessed Work with good.[15]
3	Identification Face mask on Face Detection with Use Method Her Cascade And CNN	Vebri Pain 2022	Convolution Neural Network	Based on study Which has been done can withdrawn conclusion that identification face mask on face detection use method CNN get mark more Good that is with mark accuracy 100%, whereas use method Her Cascade mark accuracy Which obtained is 80%. Application Which built use Language programming python can walk with Good for implementation second method Which used that is Her Cascade And CNN.[16]
4	System Detector Face Masked Basically Real Time Use Method CNN	Nurul Adhayanthiya, Fathan Triyanto Nugrohob, Romdhon Susiloatmadjac 2023	Convolution Neural Network	System detector face masked with method CNN This succeed detect exists face Which use face mask or No use face mask on model dataset with accuracy 99%. Basically real time system This succeed detect with Good exists face Which use face mask or not use face mask on various position looks face. On face Which No use face

				mask but part nose And mouth closed with palm hand or arms hand system This succeed detect with Good that face No masked.[17]
5	Implementation Convolutional Neural Network (CNN) For Detect Usage Face mask On Picture	Basil Ordinary Saputra, Davita Rasendriya Rizqullah Son, Muhammad Alaika Asylph 2023	Convolution Neural Network	In study This, we implement Convolutional Neural Network (CNN) for detect usage face mask on picture regularly automatic. Dataset Which used consists from 3.828 picture people Which No use face mask And 3.725 picture people Which use face mask with total picture as much as 7553 picture. Process training model produce level accuracy as big as 93% on data test.[18]
6	Implementation System Detector Usage Face mask Based Raspberry Pi 4 Use Method Convolution Neural Network (CNN) on Process Screening Protocol Health COVID-19	Muhammad Abdullah, Sabilal Rashad, Niksen Alfarizal 2022	Convolution Neural Network	On study This tool detector usage face mask Of box screening protocol health covid-19 use method Convolutional Neural Network can walk with Good that is capable detect usage face mask to visitors Which will enter into the room, with use 120 data picture face Which masked And No masked But utntuk face mask Which patterned And colored black No can done detection by system the. And Also Deficiencies on tool This that is room scope for detection face mask Which No so wide in the box [19]
7	Face Mask Detection Use Python And Opencv For Detect Violation Protocol Health Covid-19	Riza Syahrial, Tati Sukmawati, The river Swimming Goddess 2023	Convolution Neural Network	Detection face use method Convolutional Neural Networks (CNN) own ability And performance Which very Good, matter This seen based on testing Which done to identification face mask

				face in condition Which possible can influence results detection face mask face. Accuracy approach face mask detection Which proposed with share dataset become two that is dataset Training And dataset Testing with data with_mask And without_mask. Prediction This produce number accuracy as much as 95% seen on line accuracy And training loss produce number as much as 5%.[19]
8	Development System Face Recognition Use Cloud Service, Raspberry Pi And Convolutional Neural Network	Rosa Andrie Romance, Muhammad Ridwan, Gunawan Budi P3, Anik Only Handayani 2022	Convolution Neural Network	Results from study This divided become three part ie results from comparison method detection face between her cascade with CNN, results from comparison identification face with model identification face facenet And arcface as well as results from performance from model identification face facenet And arcface.[20]
9	Comparison Method Detection Face Use OpenCV Her Cascade, OpenCV Single Shot Multibox Detector (SSD) And DLib CNN	His Farokh 2021	Convolution Neural Network	Results from study This is detection face use her cascade own more weaknesses from 5 data test only 1 Which in accordance so that own percentage performance 20% compared detection face use SSD And Dlib CNN. Results Performance SSD And Dlib CNN own performance Which The same in five condition liar Which tested, There is four Which in accordance so that percentage around 80%. Detection Lots face in One picture own weaknesses most big on lighting Which blur And face looks part. Study furthermore directed for compare algorithm other in deal with detection

				face with condition lighting Which not enough Good And face covered so that only looks a little.[21]
10	Detection Non-Spoofing Face on Video regularly Real Time Use Faster R-CNN	Sunario Megawan, Month Sri Lestari, Apriyanto Halim 2022	Convolution Neural Network	Based on results testing Which has been done, for can obtained conclusion that model implementation Faster R-CNN Which proposed can detect And classify non-spoof And spoof face on video with exactly regularly real-time use Raspberry Pi as camera with frame rate 1 fps.

4.4 Analysis Data Results

The results at this point will discuss the Research Question (RQ) and talk about research findings conducted between 2021 and 2023.

RQ1: What methods are often used to design web-based extracurricular management systems in 2021-2023?

Table 3. Method Advantages and Disadvantages

Method	Advantage	Deficiencies
Convolutional Neural Networks (CNN)	● Automatic Feature Extraction Capability ● High Performance on Image Data ● Modular Architecture ● Support from Software and Community ● Generalization Ability ● Effective for processing large amounts of data	● Need Data in Large Volumes ● Long Training Time ● Model Complexity ● Susceptible to Overfitting ● Difficult to Interpret ● High Resource Consumption ● Dependence on Data Quality

5. CONCLUSION

The impact of the Covid-19 pandemic has spread to many sectors, with the implementation of health protocols involving wearing masks as one of the main steps to prevent virus transmission. Computer Vision-based technology and the Convolutional Neural Networks algorithm from the Community Neural Network are actually effective in detecting the compliance of this method automatically through images. Convolutional Neural Networks detects facial areas using masks in real-time with a 50ms era to maintain compliance. This technology can even be integrated into access control systems such as SMART FINGERPRINT to improve compliance. However, researchers agree that this technology has a large data load and computing resources due to its image processing. It is stated that other technologies need to be developed to increase their efficiency and adaptability in facing more complex real world challenges.

6. Suggestion

There are several steps that must be taken to ensure the technology is effective. The first is to collect real-time data from a complete and diverse dataset, including data sources that may vary in room conditions, amount of lighting, viewing angles and other facial attributes. Identification problems must function under extreme conditions with accuracy. As we mentioned earlier, this should also apply to the case of self-recognition. The solution must operate in real-time and must be placed in places where the greatest number of people congregate, including offices, commercial properties, and shopping centers to a lesser extent. We also think it should be connected via IoT to devices such as temperature sensors and doors that open

automatically to improve surveillance. Facial sophistication must also be able to distinguish a real face from a doctored attempt

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Please attach clear photo (3x4 cm) and vita. Example of biographies of authors:
