

# **2022 IEEE 11th International Conference on Communication Systems and Network Technologies (CSNT 2022)**

**Indore, India  
23-24 April 2022**



**IEEE Catalog Number: CFP2218P-POD  
ISBN: 978-1-6654-8039-0**

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IEEE Catalog Number:	CFP2218P-POD
ISBN (Print-On-Demand):	978-1-6654-8039-0
ISBN (Online):	978-1-6654-8038-3

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# 2022 11<sup>th</sup> IEEE International Conference on Communication Systems and Network Technologies

## CSNT 2022

### Table of Contents

<i>Welcome from IEEE CSNT 2021 General Chairs</i> .....	<i>i</i>
<i>Welcome from IEEE CSNT 2021 Program Chairs</i> .....	<i>ii</i>
<i>Conference Committees</i> .....	<i>iii</i>

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#### **Track-A: Microwave Components and Wave Propagation**

<i>A Compact MIMO Antenna with High Isolation and Gain-Bandwidth Product for Wireless Personal Communication</i> .....	01
<i>Anita Rani; Bhawna Sharma; Nitin Saluja; Geetanjali Singla; Thennarasan Sabapathy</i>	
<i>Genetic Algorithm Optimized Gain Augmented Dual Band Printed Antenna for Cognitive eHealth Care (IoT) Applications</i> .....	06
<i>Ankush Kapoor; Ranjan Mishra</i>	
<i>Enhancement in the Network Capacity using MIMO and Antenna array in 5G Technology</i> .....	12
<i>Deepak Upadhyay; Pallavi Tiwari; Noor Mohd; Bhaskar Pant</i>	
<i>A Broadband U-Slotted 2x2 Array Antenna for Millimeter-Wave Energy Harvesting</i> .....	18
<i>Rajesh Das; Taimoor Khan; Gaurav Singh Baghel</i>	
<i>A Compact, Two-Port MIMO Antenna for mm-wave 5G Application</i> .....	22
<i>Manirathnam C.; Sourav Ghosh; Swati M V</i>	
<i>Ultra wideband MIMO antenna design with high isolation for THz application</i> .....	26
<i>Rohit Yadav; Ajay Parmar; Leeladhar Malviya; Dhiraj Nitnaware</i>	
<i>High Gain (1x4) Compact Arrow Shaped Patch Antenna Array using Quarter Wave Transformer for 5G mm Wave Applications</i> .....	31
<i>Harshit Bhatnagar, Shilpee Patil, Akshay Kumar, Abhay Sharma, Aditya Kumar Gupta</i>	
<i>Fifth Generation MIMO Antenna Array with Diversity and Mutual Coupling Reduction Technique</i> .....	36
<i>Mohit Pant; Leeladhar Malviya</i>	
<i>Dumb-bell shaped Defected Ground Structures Circularly Polarized MIMO Antenna for UWB Applications</i> .....	42
<i>Harshprabha Paliwal, Navneet Agrawal</i>	
<i>Sub-Terahertz MIMO array antenna for future wireless applications</i> .....	49
<i>Sneha Moghe; Rohit Yadav; Leeladhar Malviya</i>	
<i>Design of Bandstop Filter using Double Dumbbell Shaped CSRR in Ground</i> .....	54
<i>Shubham Mohker, Amit Naik, Ajay Parmar, Leeladhar Malviya</i>	

Design of dual-band MIMO antenna with inverted L-shaped arms for 5G applications .....	60
<i>Mantar Singh Mandloi, Ajay Parmar, Priyanshi Malviya, Leeladhar Malviya</i>	
Sub-THz high efficiency MIMO antenna for short range wireless communication .....	66
<i>Sneha Moghe; Leeladhar Malviya</i>	
Stepped patch antenna for GSM applications .....	72
<i>Sanjay Chouhan; Leeladhar Malviya</i>	

### **Track-B: Power Systems, Energy and Control System**

Evaluation of Energy Losses and Costs Based on the Location of PCC in Smart Grids .....	76
<i>Aloycius S Hauwanga, K.S. Sastry Musti</i>	
Estimation of Inductance and Capacitance Parameters of Single Phase Dual Winding Converter Transformer with FEM .....	83
<i>Shrikant Shantaram Mopari; Dagadu More; Pannala Krishna Murthy; Manendra Pal Singh Chawla</i>	
Improvement in Voltage Profile of Synchronous Generator Using PID Controller and Artificial Neural Network in Automatic Voltage Regulator .....	89
<i>Gitanjali Chadar, Sudeep k Mohaney, Pradeepti Lakra</i>	
A Combined Voltage and Frequency Stability Enhancement using Artificial Neural Network and Fast Voltage Stability Index Based Load Shedding .....	95
<i>Pradeepti Lakra; Anubha Gupta</i>	
Buck and Boost DC-DC Converters for industrial application with different load .....	102
<i>Arpit Nema, Siddrath Shukla</i>	
Metaphor-less RAO-1 Optimization Based Algorithm To Determine Shunt Capacitor Capacity in Distribution System .....	107
<i>Shrunkhala Shyamkant Halve; Rajesh Arya; Atul Koshti</i>	
Design and Implementation of a Desk lamp based on Intelligence and Health .....	113
<i>Haige Lin; Fu Yu; Xinxin Zhou</i>	
Protection Scheme for Utility Network with Wind Power Generation .....	119
<i>Abhishek Gupta; Om Prakash Mahela; Ramesh Kumar Pachar</i>	
Modeling and Simulation of Solar District Heating Systems.....	125
<i>Vera Njong; KS Sastry Musti; Johannes van der Walt</i>	

### **Track C: Digital Implementation and Application**

An Architecture for Efficient encoding of Quasi cyclic LDPC codes and its implementation in FPGA .....	136
<i>Sowmya Gudipati; Keerthi K; Lalitkrushna J Thakar; Srividhya S; Jothy Soman; Vanitha M</i>	
Analysis of power in SRAM cell with various pull up, pull down and pass gate transistors .....	141
<i>Chintaluri Arun Teja; Radha Subramanyam; Victor du John H; Nagabushanam Perattur</i>	
Implementation of FIR Adaptive Filter with FPGA.....	146
<i>Shital Ganorkar; Shekhar Sharma; Anjana Jain</i>	
An Invesstigation & Analysis of Interference in Multicore Environment .....	154
<i>Surendra Kumar Shukla, Upenra Dwivedi, Mukul Shukla, Bhaskar Pant</i>	
Random pattern generation and redundancy analysis in memories.....	341
<i>Kanipogu Balu Anudeep; Radha Subramanyam; J Jagannath D; Nagabushanam Perattur</i>	

## **Track D: Machine Learning, Deep Learning and Optimisation techniques**

Principal Component Analysis of VHO parameters .....	160
<i>Siddharth Goutam; Srijia Unnikrishnan; Archana Karandikar; Aradhana Goutam</i>	
Segmentation of Rice Seedling using Deep Learning Algorithm .....	164
<i>Avinash Kumar, Ashish Rajanand, Anurag Deep Kujur, Yogesh Rathore, Rekh Ram Janghel</i>	
Comparative Analysis of Machine Learning models For Early Detection of Fetal Disease using Feature Extraction.....	169
<i>Vinayak Singh, Rakshit Agrawal, Mahendra Kumar Gourisaria, Pradeep Kumar Singh, Himansu Das</i>	
Design and Development of Machine Learning Techniques for Disease Prediction.....	176
<i>Siddharth Swami; Hiten Kanwar; Anirudh Gambhir; Kaushal Kishor; Prabhishek Singh; Manoj Diwakar</i>	
Securing 5G Networks through Machine Learning - A Comparative Analysis .....	183
<i>Piyush Kulshreshtha, Amit Kumar Garg</i>	
Comparative Analysis of Machine Learning Techniques for Disease Prediction in Crops.....	190
<i>Vijay Choudhary; Archana Thakur</i>	
Application of Machine Learning for Sentiment Analysis of Movies Using IMDB Rating .....	196
<i>Sandeep Rathor; Yuvraj Prakash</i>	
Air Quality and Smog Detection in Smart Cities for safer transport using Machine Learning (ML) Regression Models .....	200
<i>Ayushi Mishra, Zuber Mohammed Jalaluddin, Chaitanya V. Mahamuni</i>	
Traffic Signs Recognition and Detection using Deep Convolution Neural Networks for Autonomous driving .....	207
<i>Abha M Bodas; Khushi Desarda; Prem Jadhav; Saylee Gulve; Roshani Raut</i>	
The Adoption of IoT in Disease Prediction using Machine Learning: A benefit to Healthcare system.....	215
<i>Md Ramish, Ankit Pankaj, Ankit Lakra</i>	
Liver Disease Prediction using Machine learning Classification Techniques.....	221
<i>Ketan Gupta; Nasmin Kiwani; Neda Afreen, Divyarani D</i>	
Cancer Prediction Using Random Forest and Deep Learning Techniques .....	227
<i>Muskan Ranjan, Akanksha Shukla, Kartik Soni, Sunita Varma, Megha Kuliha, Upendra Singh</i>	
Detection of COVID-19 and Prediction of Pneumonia from Chest X-Ray Images using Deep Learning .....	232
<i>Gouri S Deo; Jyas Totlani; Chaitanya Mahamuni</i>	
Age Prediction Model using Convolutional Neural Network.....	239
<i>Sandeep Rathor; Danish Ali; Shraddha Gupta; Ritika Singh; Harshita Jaiswal</i>	
Face mask Detection Analysis for Covid 19 using CNN and Deep Learning.....	244
<i>Dinesh Sharma, Geetam Singh Tomar</i>	
Q-Learning based Intelligent and Interactive Healthcare System.....	253
<i>Rashika Raina; Rakesh Kumar Jha; Ashish Suri</i>	
Prediction of OPTIMIZED Stock Market Trends using Hybrid Approach Based on KNN and Bagging Classifier (KNNB) .....	257
<i>T. Manimegalai, J Manju, M. Maria Rubiston, B Vidhyashree, R.Thandaiah Prabu</i>	
Implementing a Robust IoT Solution to Monitor Prone Position using Machine Learning Techniques .....	263

*Semagn Shifere Belay, T. Prince, Tizazu Bayih Beyene, Walelegne Yirdew Marew, Andebet Dessiewu Kebede*

Enumerable learning based machine learning techniques for sentiment analysis .....	270
<i>Deepti singh, Himanshu Yadav, Chetan Agrawal</i>	
classification of thinprep images of cervical precancerous cells based on deep learning models of alexNet and inceptionV3 .....	276
<i>Wikan Tyassari; Yessi Jusman; Slamet Riyadi; Siti Noraini Sulaiman</i>	

## **Track E: Data Analytics, Social Networking, Neural Networks and Automation**

Rice Leaf Disease Detection Using Mobile Net & InceptionV3.....	282
<i>Uday Pratap Singh; Prithvi Raj Kumar; Raj Kiran; Yogesh Rathore; Rekh Ram Janghel</i>	
Galaxy Shape Categorization Using Convolutional Neural Network Approach.....	287
<i>Amritesh Nandan, Vikas Tripathi</i>	
Efficient Approaches to Predict Neurological Disorder using Social Networking Sites .....	294
<i>Tejaswita Garg, Sanjay Kumar Gupta</i>	
A Hybrid Convolutional Recurrent (CNN-GRU) Model for Stock Price Prediction .....	299
<i>Rashi Jaiswal; Brijendra Singh</i>	
A Study on Classifiers for Temporal Data .....	305
<i>Rashi Jaiswal; Brijendra Singh</i>	
DsetGenS: An Automated Technique for Building Dataset from Speech with respect to Gujarati-English .....	314
<i>Margi Patel; Brijendra Kumar Joshi</i>	
Offline Handwritten Text Recognition Using Hybrid CNN-BLSTM Network .....	318
<i>Rahul Kumar Namdeo; Chetan Gupta; Ritu Shrivastava</i>	
Development of a Hybrid Model using Deep Neural Network and XGBOOST for Mortality Prediction of ICU Patient's .....	324
<i>Babita Majhi; Aarti Kashyap</i>	
Analysis of Eucalyptus Regnans Form Characteristics .....	329
<i>Pavan Mohan Neelamraju; Sunil Kumar Segu; Anirban Ghosh</i>	
An Integrated Methodology of Ranking Based on PROMETHEE-CRITIC and TOPSIS-CRITIC In Web Service Domain .....	335
<i>Shadab Khan; Lalit Purohit</i>	
CNN architecture for lung cancer detection .....	346
<i>Chintakayala Tejaswini; Priyadharshini Rajasegaran, P Nagabushanam, Palyam Rohith Johnson</i>	
Optimized Web Searching Using Inverted Indexing Technique .....	351
<i>Dilip Kumar Jang Bahadur Saini; Pratap Patil; Vinay Yadav; Sarvesh Kumar; Prabhishek Singh; Manoj Diwakar</i>	
A Convolutional Neural Network Approach for Diabetic Retinopathy Classification .....	357
<i>Nasmin Jiwani; Ketan Gupta; Neda Afreen</i>	
Blood Pressure Detection Using CNN-LSTM Model .....	362
<i>Ketan Gupta; Nasmin Jiwani; Neda Afreen</i>	
Heterogeneous Software Defect Prediction using Generative Models .....	367
<i>Sanjay Patidar; Bhavye Jain; Divya Sudershan</i>	
Study of Spiking Neural Network Architecture for Neuromorphic Computing .....	373

*Rahul Das; Chiranjit Biswas; Swanirbhar Majumder*

Convolutional Neural Network System for Discriminate Drug Target Interactions with over Sampling Technique SMOTE .....380

*Hanumantu Joga Rao; Balajee Maram; T Daniya*

Predicting Melancholy risk among IT professionals using Modified Deep Learning Neural Network (MDLNN).....385

*S. Rosaline, M.Ayesha Nasreen, P. Suganthi, T. Manimegalai, G. Ramkumar*

Fall Accident Detection System for Bicycle Riders using Support Vector Machines .....N/A

*Saurav Gupta; Ramanathan V; Sasithradevi Anbalagan*

A Toxic Content Detection Technique in Sentimental Analysis with Convolution Neural Networks .....398

*Varun Mishra, Monika Tripathi*

## **Track F: Network Protocols, Design, Algorithm and IOT Applications**

Reactive particle swarm optimization based global energy balance protocol .....403

*Avtar Singh; Supreet Kaur*

Modeling burst errors in a fading channel ..... 409

*Kundan Kandhway*

Location based routing in multi-hop clustering based network structure of VANET .....415

*Abhay Katiyar; Nikeet Kumar Keshari; Dinesh Singh; Rama Shankar Yadav*

Capacity Enhancement for Cellular System using 5G Technology, mm Wave and Higher order Sectorization ..... 422

*Deepak Upadhyay; Pallavi Tiwari; Noor Mohd; Bhaskar Pant*

Impact of Network Heterogeneity on Epidemic Mitigation Strategies ..... 428

*Jagtap Kalyani Devendra; Kundan Kandhway*

BER Performance using BPSK modulation over Rayleigh and Rician Fading Channel .....434

*Pushpalatha, Prathyusha, Sindhu, Mohd Javed Khan, Indrasen Singh, and Shubham Tayal*

Analyzing the best location for the central node placement for energy efficient and reliable WBAN .....438

*Neha Arora; Sindhu Hak Gupta; Basant Kumar*

A review of HEMT for low noise and high frequency applications Current status and Technology Comparison .....445

*Swati Dhondiram Jadhav; Aboo Bakar Khan*

Resource Aware Energy Efficiency Optimization by Using 6G Technology Based Advanced Virtual Multi-Purpose Embedding Algorithm .....453

*Ganti Sai Divya, Varadala Sridhar, K.V.Ranga Rao, Ch. Ashwini*

Spectral Efficiency Evaluation of Network Coded Cognitive Radio Networks .....459

*Anjali Gupta; Brijendra Kumar Joshi*

Application of DRL in Transformer Network for Traffic Signal Management using Fog Computing in ITS .....464

*Ananya Paul; Sulata Mitra*

The effect of frequency slot demand in elastic optical network .....470

*Gulafsha Baig; Anjulata Yadav; Dharmendra Singh Yadav*

Performance Analysis of SWIPT Enabled Decode-and-Forward based Cooperative Network .....476

*Deepak Kumar; Praveen Kumar Singya; Vimal Bhatia*

Performance Evaluation of Energy Harvesting aided NOMA-HCN in IoT .....	482
<i>Abhinav Singh Parihar; Pragya Swami; Vimal Bhatia</i>	
An Improved Intrusion Detection System using BoT-IoT Dataset .....	488
<i>Babita Majhi, Prastavana</i>	
Evaluation of Hard Fusion Sensing Techniques under AWGN and Rayleigh Flat-fading Channel for Cognitive Radio Network .....	493
<i>Aparna Kushwah; Vineeta Saxena Nigam</i>	
Resource Optimization using Improved Genetic Algorithm for Device-to-Device Communication Under Cellular Network.....	499
<i>Munna Jatav; Ashutosh Datar, Leeladhar Malviya</i>	
Prediction and Prevention of Water Pollution by Industries using IoT based Monitoring System .....	504
<i>Abha Porwal; Sambit Kumar Mishra; Arya Kela; Gargi Singh; Manish Panchal; Anjana Jain</i>	
Zonal Irregularity Drift Characteristics of Ionospheric Scintillations from two closely-spaced Global Navigation Satellite System receivers at an Indian Low Latitude location .....	510
<i>Ram Kumar Vankadara; Venkata Ratnam Devanaboyina; Sampad Kumar Panda</i>	
Prioritization for time slot allocation and message transmission in TDMA MAC for VANETs .....	515
<i>Suchi Johari; M. Bala Krishna</i>	
A Query driven Backbone based Routing for Mobile Sink based Wireless Sensor Networks .....	521
<i>Shushant Kumar Jain; M Venkatadri; Neeraj Shrivastava</i>	
Cross-Layer based Energy Efficient Reliable Data Transmission System for IoT Networks .....	527
<i>Manish Panchal; Raksha Upadhyay; Prakash Vyavahare</i>	
Medical Data Retrieval By Named Data Networking Of Things Architecture In Contiki NG OS....	533
<i>Alper K. Demir; Gökçe Manap</i>	
A productive Feature Selection Criterion for Bot-IoT Recognition based on Random Forest Algorithm.....	539
<i>R. Pavaiyarkarasi, T. Manimegalai, S Satheeshkumar, K. Dhivya, G. Ramkumar</i>	
Implementing a Robust IoT Solution to Monitor Prone Position using Machine Learning Techniques .....	N/A
<i>Semagn Shifere Belay, T. Prince, Tizazu Bayih Beyene, Walelegne Yirdew Marew, Andebet Dessiewu Kebede</i>	

## **Track -G: Network Security and Cryptography**

Blockchain Based Spectrum Sensing for Secured Cognitive Radio wireless networks.....	553
<i>Vuppupa Roopa, Himansu Shekhar Pradhan</i>	
Enhancing the Performance of Hash Function Using Autonomous Initial Value Proposed Secure Hash Algorithm 256 .....	560
<i>Bhagvant Ram Ambedkar; Pawan Kumar Bharti; Akhtar Husain</i>	
Optimized Dual-mode Security Encryption Chip Design Based on Hash Algorithm.....	566
<i>Wei Han Xu; Yongkang Xu; Guanting Huo; Yang Yang; Yufeng Jin</i>	
Proposal on NFT minter for blockchain-based art- work trading system .....	N/A
<i>Rupali Sachin Vairagade; Leela Bitla; Harshpal H. Judge; Shubham Dharpude; Sarthak Kekatpure</i>	
IT Attack Detection and Classification using Users Event Log Feature and Behavior Analytics through Fourier EEG Signal .....	577
<i>Anurag Sinha, Md Ramish, Jay Desai, Aditya Raj, Yuvraj Rajawat, Piyush Punia</i>	



Image forgery localization using image patches and deep learning.....	583
<i>Syed Sadaf Ali; Iyyakutti Iyappan Ganapathi; Ngoc-Son Vu; Naoufel Werghi</i>	
A Hybrid (Po-Thk) Method For Ids And Privacy-Preserving In Distributed Data Environment Using Metaheuristic Techniques .....	589
<i>D.Priyadarshini, Ajay Bale</i>	
A Key Escrow Free Anonymous Identity Based Encryption scheme using Ring Signatures.....	596
<i>Khaleda Afroaz; Subba Rao; Rukma Rekha N.</i>	
A Novel approach for Data mining Classification using J48DT Classifier for Intrusion Detection System.....	601
<i>T. Manimegalai, T. Nadana Ravishankar, L. Kannagi, K. Kannan , G Anitha</i>	
Secure and Traceable QR Code Using Blockchain enabled Certificates .....	608
<i>Robin Singh Bhadoria, Akshat goyal, Arka Prabha Das, Abul Bashar, Mohammed Aikria</i>	

## Track -H: Signal and Image Processing

Iterative Hard Thresholding Using Least Squares Initialization .....	612
<i>Bamrung Tausiesakul</i>	
Unscented Kalman Filter-Based Bayesian Filtering of RC Circuit.....	616
<i>Ranu Sharma; Rahul Bansal</i>	
Hardware implementation of lossless hyperspectral compression.....	623
<i>Neelima Vinjamuri; Sowmya Parameshwaran; Shantala SH; Chayan Dutta; Srividhya S; Jothy Soman; Vanitha M</i>	
A BPSO and Deep Learning Based Hybrid Approach for Android Feature Selection and Malware Detection .....	628
<i>Ravi Mohan Sharma, Chaitanya P Agrawal</i>	
Monitoring Social Distancing based on Regression Object detector for reducing Covid-19 .....	635
<i>Ruchi Jayaswal; Manish Dixit</i>	
Design Pattern Detection by Using Correlation Feature Selection Technique .....	641
<i>Seema Dewangan; Rajwant Singh Rao</i>	
SER Analysis of Generalized Frequency Division Multiplexing in Pulse Shaping Root Raised Cosine Filter .....	647
<i>Megha Gupta; Radheshyam Gamad</i>	
Hybrid Approach for Image Enhancement and Corner Detection Framework Using Contrast Enhancement Technique and Edge Preserving Filter .....	651
<i>Anand Jawdekar, Manish Dixit</i>	
Color Adaptive Robust DWT-SVD Watermarking Algorithm and Limitations: Color Space Comparisons.....	656
<i>Arun Kumar Patel; Prabhat Patel</i>	
Imagined Speech Classification using EEG based Brain-Computer Interface .....	662
<i>Dipti Pawar, Sudhir Dhage</i>	
Brain Tumour Detction using Image Processing.....	N/A
<i>Vivek Dhruv Ugale, Swati S. Pawar, Sheetal Pawar</i>	
<b>Author Index .....</b>	<b>673</b>

# Monitoring Social Distancing based on Regression Object detector for reducing Covid-19

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**Abstract**— To deal with the worldwide coronavirus epidemic situation, the procedure of pulling down the Covid-19 cases will be tough to handle, if people do not take steps to thwart the virus from spreading. One of the most significant strategies in this pandemic is to keep a safe distance among the persons in public areas. This paper aims to detect persons with social distance monitoring as a preventive technique in minimizing physical connection between persons. The workflow of this paper is to detect the people in the area of interest using the YOLOv5 model. The model is trained on the Open Images V6 dataset and takes categories of people and human faces. Further, a social distancing algorithm is applied to check the distance between two persons and mark the red boundary box if any person violates the rules. The network provides inference speed capable of offering real-time results with maximum accuracy. The accuracy is achieved 99% in real-time scenarios using the proposed work. In various contexts, the suggested social distancing strategy produces promising outcomes.

**Keywords**— *Social Distancing, Covid-19, Deep Learning, YOLOV5, CNN models, Human Detection*

## I. INTRODUCTION

Coronavirus is a contagious disease that can be turned out to be an pandemic, proclaimed by the WHO (World Health Organization). In late 2019, Wuhan, China, was the first place where this virus was reported. But then the COVID-19 global pandemic hits the world. As of 30<sup>th</sup> November 2021, there have been more than 261 million confirmed cases globally. According to the WHO report, some vaccines have been invented, and approximately 7 billion vaccine doses are administered until 28<sup>th</sup> November 2021[5]. Still, the second and third waves of COVID hit worldwide with new coronavirus variants, so all people must take preventive measures. The WHO has issued rules to limit people's exposure to the virus. Therefore, the government has taken strong and necessary steps to control the spread worldwide. To address the situation of Covid-19, the citizens must follow the guidelines of government such as wearing a mask and maintaining the social distancing in public areas like the shopping mall, public road, hospitals, schools, colleges, workplaces, metro stations, airports. This paper aims to make a framework for keeping the social distancing rules in public places, i.e., WHO's recommended solution to minimize the virus among people.

In other words, keeping a distance of at least six feet between persons is an effective strategy for avoiding physical contact with possible new variants of coronavirus

carriers. Figures 1 (a) and (b) depict the social distancing preventive measure taken in open areas with some signs on the roads that prevent people from gathering [1].

Artificial Intelligence(AI) can be useful in facilitating the monitoring of social distancing. Computer vision is a subclass of AI that has demonstrated its promise in CT-Scan, or X-ray-based Covid-19 detection[1] can also assist in social distance monitoring. Moreover, Deep Neural Networks

(DNN) help us to obtain perplexing features from images, allowing us to analyze and classify these features to provide a more accurate interpretation of the images. Social distance monitoring uses the person's detection algorithm to locate the persons accurately in the region of interest and then evaluate the distance among the detected people. Deep learning models such as Single Shot Detector, Mobilenet, Resnet, YOLO models, etc., can train the dataset to detect the objects in the real-time frames.



Figure 1. Social distancing enforced in public place a) Marked circle on road b) Marked line on the road

The study of this paper is to present a method of social distancing monitoring using YOLOv5 and demonstrate the analysis with CNN models and compare with the existing methods.

The organization of the paper is described in four sections. Section I presents the introduction part about social distance monitoring. Section II describes the research background of this work. The research methodology is described in section III. The experimental and result analysis with other methods is demonstrated in section IV. At last, Section V discusses the conclusion part.

## II. RELATED RESEARCH

### A. Object Detectors Based on Regression

Object Detectors based on Regression, such as Single Shot Detector (SSD) and You Only Look Once (YOLO), be substantially faster than region-based object detectors [3,6]. However, YOLO has been more widespread and produced more accurate recognition results among other similar object detectors. New versions of YOLO such as YOLOv3, YOLOv4, YOLOv5, and many more have been released with more detection accuracy. YOLO takes the complete image as input, unlike area-based detectors, which generate region predictions that are forwarded to the classifier. As a result, it is much faster than other detectors. The model workflow starts with an RGB image that has been split into  $G \times G$  grid cells. Each grid cell is crucial to determining B boundary boxes. Each bounding box is given five values: a, b, h, w, and k. The height and weight of a bounding box are h and w, respectively, whereas the coordinates of a bounding box's centre point relative to a grid cell are a, b. The presence of an object in a bounding box has a confidence score of k[6]. The object detector's output for class probabilities C is a shape tensor.

$$(G \times G \times (B \times 5 + C)) \quad (1)$$

### B. Object Detection based on Machine Learning

Viola and Jones [7] proposed a very common solution for object detection in 2001. Haar features are used extract features, and for categorization purposes, they used cascade classifiers with the Adaboost learning method. This technique is fifteen times faster than the traditional methods. By combining kinematic and visual characteristics, the author Fr-Chun Hsu et al [8] suggested a hybrid method for detecting the body parts(Head and Shoulders). They tracked down that the Histogram of Oriented Optical Flow (HOOF) descriptor is better for sectioning moving items in video streams. It can effectively control cluttered and obstructed contexts. The author Vijay et al. [9] presented a real-time pedestrian detection system for better driver support. The methods are Edgelet features and the 'k-means' clustering technique as a classifier used to boost accuracy and reduce system complexity. The authors [10] have proposed a human detection framework for city-wide surveillance via CCTV cameras. They used the background subtraction approach to segment moving objects, and HOG descriptor is used for features extraction while the Support Vector Machine method is employed for object categorization.

### C. Object Detection based on CNN models

Object detection through deep convolutional neural networks (CNN) has made substantial progress in recent years. CNN is a type of intense, feed-forward ANN that has proven effective in computer vision applications like object detection and classification. With the help of the convolution process, CNN can extract robust features. Its high attribute representation capability [11]. Pre-trained CNN-based networks are utilized for several object recognition applications. The authors of a related study [12] used the COCO dataset as a benchmark input. The result found that the Inception-resnet feature extractor

model has a maximum Mean Average Precision (mAP) score of thirty and a minimum mAP score of twenty. SSD Mobilenet is a faster model compared to the Inception Resnet model with a mAP score of nineteen but the Faster R-CNN Inception-resnet101 model produces an accurate result with a score of 34.2.

### D. Monitoring Social Distancing in real-time based on past research

Using a computer vision-based detection model, Khandelwal et al[13] used surveillance camera video to monitor masked faces and breach social distancing rules. MobileNet model is used for mask detection and SSD detector for monitoring social distancing. The authors [1] suggested a Mobilenet SSD object tracking model and OpenCV library for detecting the people in the region of interest. The distance between the people detected in the video footage will be calculated and compared to a set of pre-determined pixel values. The output is achieved between 56.5% to 68% for outdoor locations. Aquib Ansari[2] presented a human detection method using CNN-based detector and then evaluated the distances among each pair of the person detected. The validation accuracy of model 1 and model 2 have achieved up to 97% and 98%.

The author [4] discussed an automatic human detection using a YOLOv4-based object detector model in crowds in both inside and outside areas by surveillance cameras. When combined with a modified Inverse Perspective Mapping(IPM) method and the SORT tracking technique, the suggested deep-neural network model produces reliable human detection and observes people's distance. The experimentation was carried out in occlusion, partial vision, and varying lighting conditions with an mAP of 99.80% and a speed of 24.11 frames per second in real time

## III. RESEARCH METHODOLOGY

This study proposes a framework for monitoring social distancing in real-time environment. The idea is developed on the regression-based object detector, which uses Python3, Torch, Cuda, Tensorflow-keras, OpenCV frameworks. These are used to gain the visibility of image processing methods with faster computation. The methodology of this proposed architecture is to take a video from CCTV footage from public areas for human detection and compute the distance between the two persons and raise a red alert for violation the norms of social distancing. The terminology we used in this workflow has been discussed in this section.

### A. Dataset

The dataset used in this methodology is Open Images Dataset V6 for training the model. We have taken 15000 specific images of persons and human faces so that the model is trained only with the human category. Due to this, computation time and space complexity are balanced. Annotations of each associated image file are also downloaded from the database library. The bounding box co-ordinates and labels for each image are then take out from XML files and standardized to the image's width and

height. For testing the algorithm of social distancing, some images are crawled from the internet and tested the algorithm's robustness.



Figure 1. Sample images of Open Images Dataset V6

### B. YOLO V5 Architecture and its Functioning

YOLO's object detection method, which stands for "You Only Look Once," separates images into a grid structure. Each grid cell is incapable of detecting objects within itself. Due to its speed and precision, YOLO is one of the most well-known object detection frameworks. YOLOv5 version was released after YOLOv4, and it is written in the Ultralytics Pytorch framework in 18<sup>th</sup> May 2020. In a comparison of YOLOv4, YOLOv5s[18] is simpler to use and very effective in training the custom dataset. It is a lightweight model and trains quickly, inferences quickly, and performs well.

The architecture of YOLOv5 is shown in figure 2. It is a single-stage object detector and comprises three important fragments. First is Model Backbone, and the backbones can be running on CPU or GPU. The purpose of the backbone is to extract the prominent features from the input image. YOLOv5 incorporated the CSPDarkNet

(Cross Partial Network) into Darknet framework, ensuing in creating CSPDarknet as the spine of a network. CSPNet fixes the issue of recurrent gradient info in large-scale backbones by as well as gradient modifications into the mapping of features, lowering parameters, and the Floating-point Operations per second (FLOP), which assures the inference speed and accuracy, also reducing the size of the model. Speed and accuracy are crucial terms in social distance monitoring tasks, and the model's size dictates its inference efficiency.

The second is Model Neck which is specially used to produce feature Pyramids. The Feature pyramids network (FPN) aids in the simplification of models on an object ruler. It assists in recognizing the same object in various scales and sizes. The YOLOv5 used a Path Aggregation network (PANet) to optimize the information flow, and PANet uses a new FPN topology with an improved bottom-up approach to improving low-level feature propagation. Simultaneously, Adaptive Feature Pooling ensures that beneficial information from each feature level reaches the following subnetwork by connecting the feature lattice to all feature levels.

Lastly, for the final stage detection, the model head is applied. After applying anchor boxes to features, it creates final resultant vectors with probabilities of class, objectness values, and several bounding boxes.

The activation functions are Leaky ReLU and Sigmoid used in YOLOv5. The Leaky ReLU function is applied in the middle layers, and in the final detecting layer, the Sigmoid function is applied. In this work, we have used an ADAM optimizer for training purposes.

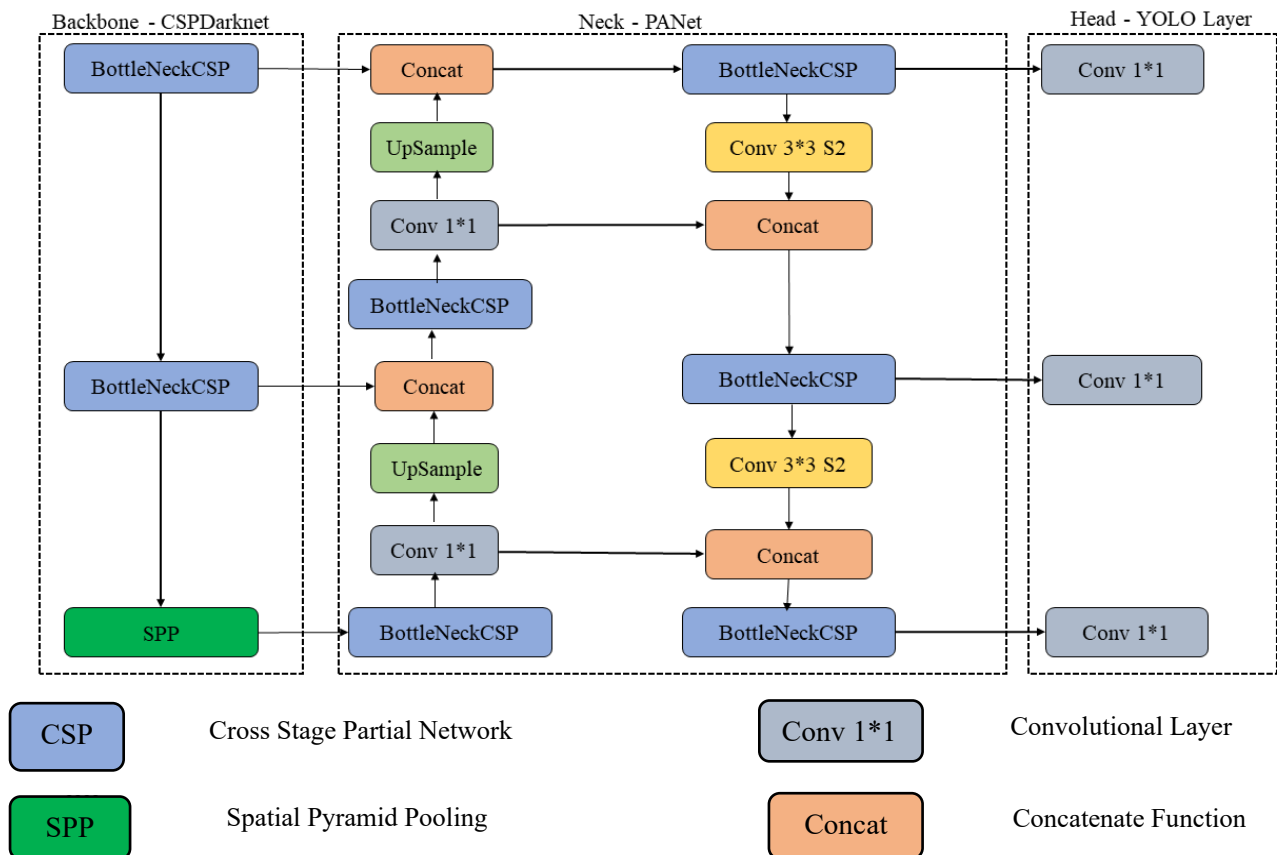


Figure 2. The architecture of YOLOv5 Model [18]

Identify applicable funding agency here. If none, delete this text box.



### C. Monitoring Social Distance

Monitoring social distance is the second stage of the working methodology. The algorithm is carried out with two foremost functions. The first function assists in determining the locations of persons available in an image. It employs a people detection method and offers coordinates of people location such as  $X_A$ (left),  $X_B$ (right),  $Y_A$ (top),  $Y_B$ (bottom). The centroid points ( $X$  and  $Y$ ) of different objects are evaluated from these coordinate values. Moreover, these points are forwarded to the following function to compute distance of people.

$$X = (X_A + X_B) * 0.5 \quad (1)$$

$$Y = (Y_A + Y_B) * 0.5 \quad (2)$$

The next function is utilized to measure the closeness among two objects through Euclidean metric. The distance is based on comparing this distance vector to a previously defined threshold value. Suppose the Euclidean distance [2] between two persons is fewer than a certain threshold or remarkable value. In that case, it is expected that persons are neither adhering to the rules of social distancing or nor created maximum distance among people. This study set 2 m to 2.5 m as a threshold limit and classified it in three categories. If the distance is less than 2m, it marks as a High Risk; if the value of the distance is in between the threshold limit, it marks as a Moderate Risk otherwise Safe Distance.

$$\{d = \sqrt{((X_2 - X_1)^2 + (Y_2 - Y_1)^2)} \quad (3)$$

Here,  $(X_1, X_2)$  and  $(Y_1, Y_2)$  are centroid values of two persons.

The workflow of the proposed methodology is described in a stepwise manner:

Input:  $V_D$ : Number of frames of size 512\*512 contained in the video.

Output:  $D$ : Mark the rectangles using distance vector  $d$  around the person.

Step 1: Collect the database of persons and human face categories.

Step 2: Train the image database with YOLOv5 architecture with changes in the configuration file.

Step 3: Load the trained model for the testing phase.

Step 4: Apply a social distancing monitoring algorithm to detect the distance between two persons.

Step 5: Draw the red rectangles around the person if the distance is less than the assigned threshold value.

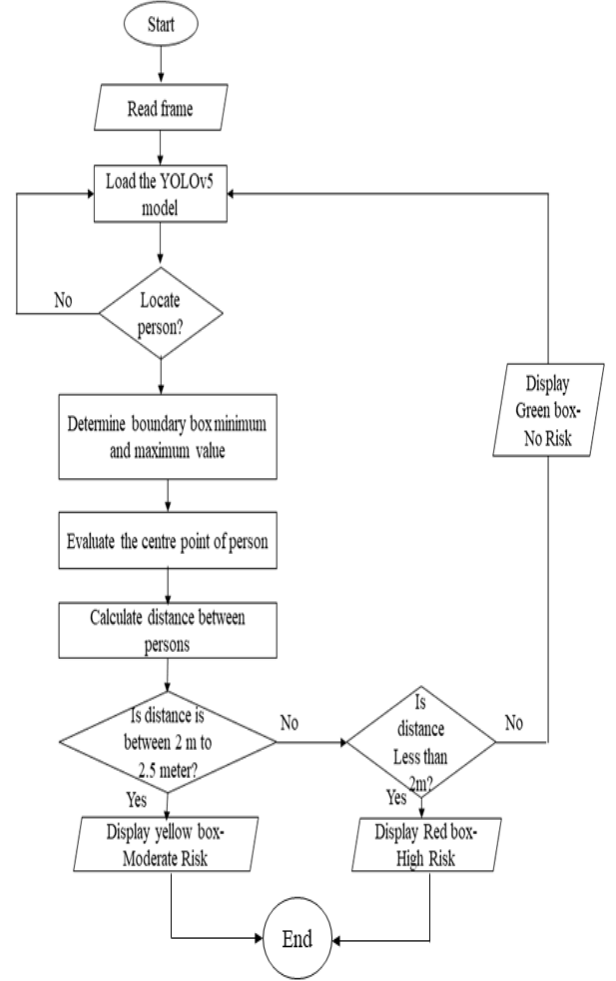


Figure 3. Flowchart of the proposed methodology

## IV. EXPERIMENTS AND RESULTS

### A. Experimental Setup

The model YOLOv4 was constructed on the PyTorch framework and trained the model on i7 processor with 4GB RAM GPU and utilizing the Cuda framework. Webcam and standard dataset videos are used for testing the system. The frame is set to a 512\*512 ratio.

### B. Metrics

Several measures are used to assess the system's performance. Here two metrics will be used to judge the efficiency of our solution, which are discussed below.

1) *Intersection over Union(IoU)*: The overlap between the two bounding boxes is determined by IoU. A result of 1 represents perfect prediction accuracy, while lower values indicate the least prediction accuracy[3].

$$\frac{area(P_B \cap G_B)}{area(P_B \cup G_B)} \quad (4)$$

Where  $P_B$  is the area or region of the Predicted Boundary Box, and  $G_B$  is the area of the Ground Truth Boundary Box.

2) *Accuracy*: The system's effectiveness is measured by accuracy(A)[14]. It can also be estimated in terms of positive and negatives. It can also be defined as the proportion of the number of truthful predictions and the total amount of predictions.

$$A = \frac{TP+TN}{TP+TN+FP+FN} \quad (5)$$

### C. Results Analysis

The accuracy of the social distancing system is tested on four distinct videos, including the TownCentre, VIRAT\_S, PETS2009[15-17], and videos captured from the webcam. Video footage from the webcam is captured in indoor and outdoor environments.

TABLE 1. PARAMETERS ESTIMATION DURING TRAINING THE MODEL

Model	Dataset	Training Accuracy	Validation Accuracy	Validation Loss	Training Time
YOLOv5	Open Image V6	0.99	0.98	0.02	23 h

TABLE 2. OUTCOMES DURING TESTING PHASE ON A DIFFERENT DATASET

Video for testing	Dataset	Testing Accuracy	Length of video	Testing Time
Self taken		98%	Continuous frames	0.02sec
TownCentre		98%	0.04sec	9.6s
VIRAT S		92%	24 sec	32.9s
PETS2009		95%	13 sec	42.21s
Epfl-Mpv		98%	1.58 min	136.54s

TABLE 3. COMPARISON OF EXISTING APPROACH WITH PROPOSED METHODS ON TOWNCENTRE VIDEO.

	Existing Approach		Proposed Approach
	Author[1]	Author [4]	
Training model	MobileNet SSD	YOLOv4	YOLOv5
System Accuracy	62.5%	98%	99%

### D. Outcomes on a different dataset



Figure 4. Persons violating the social distancing norms represent in red boundary box on dataset Virat\_S(Outdoor scene)

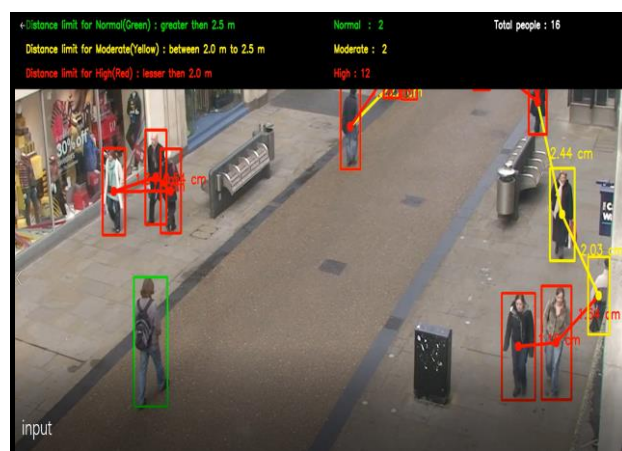


Figure 5. Persons violating the social distancing norms represent in red boundary box on dataset of TownCenter(outdoor scene)



Figure 6. Persons violating the norms represent in red line through webcam stream(indoor scene)



Figure 7. Persons violating the social distancing norms represent in red line on dataset of EPFL-Mpv(indoor scene)

The above outcomes represent the violation of social distancing norms in outdoor and indoor environments on different datasets and live webcam. The red line or boundary shows the high risk (i.e. less than 2m distance), yellow mark represents the moderate risk (the distance between the 2.0m to 2.5m) and the green mark shows the safe distance i.e., greater than 2.5m.

## V. CONCLUSION

Social distancing is one of the most significant safety measures in avoiding physical contact that could lead to the spread of coronavirus. Virus transmission rates would increase if WHO's norms were not considered. This study proposed a Deep learning-based object detection technique to observe the distance among people in a real-time situation. The system has been designed in Python and torch library to implement the functions. YOLOv5 is used to train the model on Open Images V6 dataset for persons and human face categories because the YOLO framework is the best architecture to detect the objects. Further, this model is used for maintaining the social distancing algorithm. This algorithm detects the stages of risk from the input frame and draws the red rectangle if a high-risk violation is found. This paper has seen to meet all of its objectives based on the overall results. The system effectively and efficiently detects the social distance between persons and generates an alert that can be controlled and monitored.

The future scope of this proposed model is to apply in advanced applications such as monitoring the human location and observing people's gestures. Human tracking is the ardent area for researchers like human action recognition, abnormal behavior recognition, and many more in the surveillance field.

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